Sidney Nolan and paint. A study of an artist's use of commercial, ready-made paints in Australia 1938-1953

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Submitted in total fulfilment of the requirements of the degree of Doctor of Philosophy

26 July 2013

The Centre for Cultural Materials Conservation
The School of Historical and Philosophical Studies

The University of Melbourne

Abstract:

This thesis examines the history of Sidney Nolan's art-making practice in Australia and his early and unprecedented use of commercial paint. The interdisciplinary approach includes a biographical study of Nolan's painting practice and a history of commercial paint technology in Australia combined with the scientific analysis of a unique collection of reference material from Nolan's Wahroonga studio. Instrumental analysis of a number of paintings confirms the ability to identify Ripolin paint based on the reference collection. It also demonstrates Nolan's use of other commercial paint types made with early synthetic alkyd and nitrocellulose paints. This study reveals that Ripolin was not Nolan's only commercial paint of choice. It also demonstrates that Nolan's use of these materials, while influenced by war-time shortage, was also driven by his preference for fast drying and brilliantly coloured commercial paint products above artists' paints. Nolan's take up of commercial paint products in the period from the late 1930s to the early 1950s provides a unique case study that broadly follows the trend away from naturally sourced paint ingredients and the emergence of synthetic paints.

This is to certify that

i. the thesis comprises only my original work towards the PhD except where indicated in the Preface,

ii. due acknowledgement has been made in the text to all other material used,

iii. the thesis is fewer than 100 000 words in length, exclusive of tables, maps, bibliographies and appendices

Signed

Paula Dredge

Dedication

This thesis is dedicated to my husband Laurence who has been my partner in every step of this enterprise and our lovely daughters Ellen and Ruth, who grew up while this thesis grew.

Preface

This research forms part of an Australian Research Council (ARC) linkage project (LP) titled *The twentieth century in paint*, which aims to make a contribution to a number of international projects looking at developments in paint technology in the twentieth century and its use by artists. This research informs conservators and art historians about the making of artworks and their ageing characteristics to assist in the decision making about their conservation and care and to expand our understandings of artistic choice and intent. To date there has been little research on developments in twentieth century paint technology related to the Australian context. The project aims to advance knowledge in this area.

The twentieth century in paint project brings together a diverse range of painting conservators, scientists and information technology specialists from Australia, South-East Asia, the USA and the UK working in the area to examine specific questions regarding artist practice in Australia and the South-East Asia and Pacific regions. The project is led by the Principle Chief Investigator (CI) Associate Professor Robyn Sloggett and the Centre for Cultural Materials Conservation at the University of Melbourne with collaborating institutions the School of Information Technology and Electrical Engineers and the Australian Institute for Bioengineering and Nanotechnology (AIBN) at the University of Queensland. Industry linkage partners include the Art Gallery of New South Wales (AGNSW), Artlab Australia, Getty Conservation Institute (GCI), National Visual Arts Gallery of Malaysia, National Gallery of Victoria (NGV), Queensland Art Gallery (QAG), the Tate Britain and SEAMEO-SPAFA Regional Centre for Archaeology and Fine Arts.

The study of Nolan’s paint mediums formed one component of this ARC LP with the Industry Partner AGNSW and the Centre for Cultural Materials Conservation, University of Melbourne, and was funded under the Australian Postgraduate Award (Industry) (APAI) scheme. The AGNSW partner contribution was provided by the AGNSW Friends of Conservation. The AGNSW granted three years leave to the Senior Paintings Conservator, Paula Dredge, to undertake this research. The Art

Gallery of New South Wales hosted the APAI and gave full access to the in-house analytical instruments and paintings from the collection for study.

Scientific collaborations for this Nolan research have include the conservation scientists Dr Tom Learner, Michael Schilling and Joy Mazurek from the Modern and Contemporary Art Research Group at the Getty Conservation Institute who undertook gas chromatography/mass spectroscopy (GC/MS) studies on a number of Ripolin and Dulux samples from the Wahroonga studio. The conservation scientists Dr Gwénaëlle Gautier and Dr Francesca Casadio from the Art Institute of Chicago also kindly shared information regarding their own research in Ripolin paint manufactured in France and undertook with this researcher some early GC/MS studies on the Ripolin paint from Nolan's studio. Funding for travel to the USA in November 2010 to undertake the GC/MS analysis with these two groups of scientists was provided by the ARC LP *Twentieth century in paint*, and the University of Melbourne under its TRIPS funding and the Getty Conservation Institute. These collaborations are acknowledged in the co-authored paper 'Lifting the lid on a collection of Ripolin paint from Sidney Nolan's studio' presented at the *From can to canvas: early uses of house paints by Picasso and his contemporaries in the first half of the 20th century* conference in Marseilles, France, 25-26 May 2011 and the subsequent paper was published in a special issue of the *Journal for the American Institute for Conservation* (Dredge et al. 2013). Author Collaboration Authorisation forms from the co-authors of this paper, to allow material from that paper to form part of this thesis have been completed. Funding for the author to present the paper at Marseilles was provided by the University of Melbourne under the Melbourne Abroad Travelling Scholarship (MATS) program and the ARC funding.

Two other peer reviewed papers were submitted by the author to the Bulletin of the Australian Institute for Conservation of Cultural Material (AICCM) during the candidature of this PhD. These include 'A history of Australian house paint technology from the 1920s to the 1950s, with reference to its use by Australian artists, particularly Sidney Nolan', *AICCM Bulletin,* 2012, vol. 33, pp. 53-61 and 'Sidney Nolan's adventures in paint An analytical study of the artist's use of commercial paints in the 1940s and 50s', *AICCM Bulletin* (submitted January 2013). A fourth publication by the author, 'Experiments with gloss paints', was published as a essay in a catalogue of an exhibition held at the Heide Museum of Modern Art, *Sidney Nolan: early experiments* 20 October 2012-28 February 2013. A short essay was also published by the author using the research undertaken during this thesis 'Colour and modern paints in the interwar decades' in the catalogue for the exhibition *Sydney Moderns. Art for a new world*, Art Gallery of New South Wales, 6 July-7 October 2013.

Other project partners of the ARC LP the APAI candidate Gillian Osmond and her colleagues at AIBN, University of Queensland, Professor John Drennan and Dr Ying Yu, undertook Raman Spectroscopy, Scanning Electron Microscopy and Xray Diffraction studies on a number of Ripolin samples. Furthermore Gillian Osmond, CI Dr Stephen Best and CI Dr Nicole Tse were all involved in the examination of Ripolin samples with the Infrared Beam-line at the Australian Synchrotron with scientists Dr Ljiljana Puskar and Dr Mark Tobin. PI Andrew Durham, Helen Weidenhofer and Gillian Leahy from Artlab Australia facilitated the analysis of the Ripolin colour chart in the collection of the State Library of South Australia and gave access to their instrumentation. Outside the ARC project team, Dr Richard Wuhrer at the Microstructural Analysis Unit at the University of Technology Sydney undertook scanning electron microscopy analysis on a number of Ripolin paint samples and samples from paintings by Nolan. The Heide Museum of Modern Art, increased the study group of Nolan paintings particularly from the critical years prior to 1946, when approached in 2010. Jason Smith, Director Heide Museum of Modern Art, Curator Kendrah Morgan and Collections Manager Katarina Paseta were all incredibly helpful and supportive of this process.

Sampling and testing of artworks undertaken during this study and associated permissions have been recorded on The Centre for Cultural Materials Conservation, University of Melbourne sampling agreement forms. Access to collections for analytical studies has been essential for the success of this project, but it is a special and rare privilege for an outside researcher. The access given by collection holders to the researcher reflects the strength of the *Twentieth century in paint* ARC LP and the value perceived for the anticipated outcomes.

Other primary historical research material generously made available for analytical study includes; the collection of paint colour charts held in the Caroline Simpson Library and Research Collection at Sydney Living Museums, the collection of early paint resins in the Powerhouse Museum collection, the Ripolin paint chart from the State Library of South Australia and the collection of Wahroonga studio material gifted by Jinx Nolan to the National Gallery of Victoria. In addition, a group of early paint cans from Dion's Bus Service in Wollongong NSW was lent during the course of the research.

Permission for use of the contents of Sidney Nolan's letters to Sunday Reed from the John and Sunday Reed papers in the collection of the State Library of Victoria was given by the Trustee of the Reed estate Richard Haese. Permission for the use of Nolan's words for this thesis and images of his artworks has been granted by the Trustees of the Sidney Nolan Trust.

Acknowledgements

There are many people who have given their support to make this project happen. Primary is the Art Gallery of New South Wales as ARC LP project partner and for providing the funding for participation through the Friends of Conservation. A number of people now retired, including the Director Edmund Capon, the Head of Curatorial Services, Tony Bond and the Head of Australian Art, Barry Pearce, were pivotal to the project beginnings. Other staff who have been part of the journey are Head of Conservation, Carolyn Murphy, Painting Conservators Simon Ives and Andrea Nottage and Michelle Wassall all of whom backfilled various roles in order for me to undertake this work, Curator of Asian Art Matt Cox, Curators of Australian Art Natalie Wilson, and Helen Campbell, Copyright and permissions, Donna Brett and Chair of Friends of Conservation Committee, Ray Wilson with other committee members. Thank you also to the many other colleagues at the gallery.

I wish to thank Associate Professor Robyn Sloggett for conceiving the ARC project, for bringing together such a diverse and wonderful group of researchers and for generously welcoming my participation. Thank you also to the ARC fellow Dr Nicole Tse for tirelessly managing the day to day details, for being so warm and supportive of my work and to them both for their supervision of my thesis. To other ARC project members, especially fellow PhD candidate Gillian Osmond who was with me for much of my time, supporting, encouraging and lending her extraordinary intelligence and knowledge especially in the area of zinc soaps, and for her support during many long sessions together at the Australian Synchrotron. To other project members in particular Dr Stephen Best. Artlab Helen Weindenhofer, Andrew Durham, Gillian Leahy and Professor John Drennan. Harriet Standeven was a mentor for me in her pioneering work on the history of the paint-making industry and throughout this project has generously shared her knowledge and experience.

Thanks are due to the many scientists who gave their expertise and time to parts of this project including The Modern Paint Project team at the Getty Conservation Institute Dr Tom Learner, Michael Schilling and Joy Mazurek and the Art Institute of Chicago conservators and scientists, Dr Francesca Casadio, Dr Gwenaelle Gautier and

Kim Muir for their generous sharing of information on the French Ripolin study and for hosting my visit in 2010. To Dr Richard Whurer and Dr Matthew Phillips for undertaking SEM studies without charge simply because they are interested in supporting research on cultural materials and they know how difficult it is to fund the science. The Australian Synchrotron scientists Dr Ljiljana Puskar and Dr Mark Tobin generously gave their time and support to the project and are continuing the work on the study of Dulux.

This project involved a number of collections that generously gave access to material for study including the Sydney Living Museums librarians Matthew Stephens, The Powerhouse Museum curator Erika Dicker, the Heide Museum of Modern Art director Jason Smith, curator Kendrah Morgan and collections manager Katarina Paseta. Painting conservators John Payne and Michael Varco-Cox arranged and facilitated access to the Nolan Wahroonga studio material in the collection of the National Gallery of Victoria. Dulux History Project archivist Trudy Scott and retired Dulux paint chemist Bruce Leary also made available their records, paint collections and expertise.

The Sidney Nolan Trust has been welcoming of this research and helpful in arranging permissions for use of images and words by Sidney Nolan. Anthony Plant from the trust has been particularly helpful in this regard.

A special acknowledgement of Jinx Nolan’s generosity and foresight in gifting the Wahroonga studio contents to the Art Gallery of New South Wales must also be given. The studio material has been both the inspiration and catalyst for the research and formed the central core of the work.

Finally a personal and heartfelt thank you to all the members of my family and in-laws especially Phillippa, Diane, Therese and Anthea who supported my work by giving generously of their time to help in so many ways.

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Chapter 1. Introduction

> *Kaleidoscopes, microscopes, stereoscopes, horoscopes. These in luminous paint!-feathers printed on architect's blue paper like cirrus clouds, cut outs, blackouts, handouts, any and every conceivable approach of eye and mind that could conceive Painting was engaged in with the agility of an athlete!*
>
> Neil Douglas on Sidney Nolan 1962 (cited in Clark 1987 p. 31)

The artist Sidney Nolan (1917-1992) is known for his use of ready-made paints intended for house decorating or advertising and other unorthodox material, in preference to artists' paint. Of particular interest has been his use of two brands of gloss paint; Ripolin® and Dulux®[1]. It has been the practice to describe the Ripolin used by Nolan as synthetic polymer paint, in the assumption that it was made from a modified polyester resin known as alkyd[2]. In the catalogue for an exhibition *Sidney Nolan's Wimmera: from Wail to Ballarat* for example, it was noted that 'synthetic polymer paint is a generic term for paints like Ripolin enamel as well as later paints made from acrylic' (National Gallery of Victoria 1999, p. 11). Recent research on Ripolin used by Pablo Picasso (1881-1973) has demonstrated that prior to the 1950s, Picasso's Ripolin was in fact oil-based,(Casadio & Gautier 2011). Dulux, conversely, has been identified in historical research as an alkyd paint product in the USA and UK (Standeven 2006). This thesis aims to address the uncertainty regarding these paint types with a historical survey of both Nolan's practice and a history of the Australian paint industry, combined with an analytical study of reference material and a group of paintings by Nolan dated from 1938 to 1949.

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[1] Brand names are typically accompanied by either ® indicating a current registered trademark, or ™ indicating an unregistered trademark. Ripolin is registered as a trademark by PPG Industries Australia Pty Ltd and should be accompanied by the symbol ®. Similarly Dulux is also a registered trademark owned by DuluxGroup (Australia) Pty Ltd and Duco is registered to PPG Industries Australia Pty Ltd. For the sake of text clairty only the first use of a registered or unregistered trademark will be accompanied by the correct use of trademark symbol.

[2] Also known as oil-modified polyester (Learner 2005) or glyptal (Leach 1937, p. 322)

1.1 Project beginnings

The impetus for this research came about during the preparation for the exhibition, *Sidney Nolan*: *a retrospective*, at the Art Gallery of New South Wales in 2007. As paintings were examined by the curators for cataloguing, questions were asked of the painting conservators regarding media descriptions. While this is a common subject for discussion between curators and conservators, the difficulties in providing answers based solely upon visual examination of Nolan's paintings quickly became apparent. While many works exhibited the gloss sheen, liquid application and self-levelling characteristics commonly associated with household gloss paint, there were often passages of matte paint on the same work. Others which had previously been catalogued as Ripolin enamel showed a less liquid application and wet in wet intermingling of colours with brush texture more usually associated with artists' oil paint.

The practice of altering media descriptions for Nolan's paintings after re-examination of the works by a new group of cataloguers, has led to different descriptions being applied to the same works over time, in some cases each time they were exhibited. For the Nolan retrospective exhibition in 2007 there were even a number of significant changes in medium descriptions between the published catalogue and those printed on the list of works given to viewers of the exhibition. For example the medium description for the painting *Luna Park* 1941 (collection: Art Gallery of NSW) (Figure 1) was described as 'enamel on canvas' in the catalogue and 'oil on canvas' in the printed list of works. Analysis of the painting during the course of this research demonstrated that this paint medium is in fact a different type of material altogether.

Figure 1. Sidney Nolan, *Luna Park*, 1941, enamel on canvas, 67.0 x 84.0cm, Art Gallery of New South Wales. Purchased with funds provided by the Nelson Meers Foundation 2003. © Trustees of the Sidney Nolan Trust

During the preparation for the exhibition, a collection of painting materials from Sidney Nolan's Wahroonga studio dating from the early 1950s was being unpacked and catalogued for the Artists' Materials Archive at the Art Gallery of NSW. The range of materials in the studio contents, mostly from commercial paint-makers supplied in cans, supported the growing realisation that the practice of assigning medium descriptions to paintings by Nolan without analysis was problematic. Undertaking analysis on paintings in the absence of reference material, however, was likely to compound the confusion regarding brand names of paint such as Ripolin and Dulux. The Nolan Wahroonga studio contents offered a unique opportunity for a thorough analytical study of paintings against material from the artist's own studio. The scale of research required was beyond the resources of the time and was put aside until the opportunity emerged several years later to be involved in an Australian Research Council Linkage project looking at twentieth century paint. The outcomes that emerged from this project demonstrate the type of broad interdisciplinary research which is required to establish context for the interpretation of scientific analysis of paintings.

1.2 Nolan's use of paint in cans

In the late 1940s a number of artists began using non-artist grade paints. In particular paintings by the American abstract expressionist artists Jackson Pollock (1912-1956) and Willem de Kooning (1904-1997) have provided exceptional case studies (Lake & Schilling 2010; Schilling, Mazurek & Learner 2007). De Kooning, like Nolan, had worked in advertising prior to becoming a painter. This experience provided both artists with first-hand knowledge of paints used in commercial work and was probably an influence in the continuing use of these materials on their artworks.

The use of these non-standard paints by artists prior to the Second World War period is more unusual. There are two notable examples which provide precedents for Nolan. Pablo Picasso was using the Ripolin brand of enamel paint from at least 1912 (McCully 2011). Nolan himself acknowledged Picasso's influence on his choice of Ripolin; 'I read that Picasso had said that Ripolin was a healthy paint and I thought, well why should I bugger around and torment myself when a wise man says its healthy paint. Okay, so Ripolin it had to be' (Nolan & Smith 1962).

Another artist admired by Nolan, David Siqueiros (1896-1974), had a well publicised exhibition of nitrocellulose paintings in 1940 ('Air brushed pictures in Duco' 1940, *Art News*, vol. 38, 13 January, p. 12). A recent analytical study of Siqueiros' paintings has identified nitrocellulose on a number of his paintings dating from 1935, but one of his earlier paintings, cited by the artist himself as nitrocellulose paint, *Proletarian victim*, 1933 (collection: Museum of Modern Art, New York), was found to be painted in oil (McGlinchey et. al. 2013). This surprising analytical result, which contradicts the artist's own record, is problematic but equally relevant to the study of Nolan's practice. It requires the careful weighing of evidence of the scientific results against the art historical record, and an examination of the factors which may have led to the discrepancy between the two.

For example the cataloguing of medium descriptions of Nolan's paintings using the brand name Ripolin, has been influenced by Nolan's own statements regarding his earliest use of this particular paint. In an interview from 1962, Nolan asserted that his first use of Ripolin was prior to his conscription into the Australian Army in 1942

(Nolan & Smith, 1962). Paintings by Nolan have been catalogued as Ripolin from as early as 1939 (Lynn 1979) and Nolan's biographer Brian Adams (1987) stated he was using it for painting on slate tiles in 1940. These dates of Nolan's use of Ripolin have been questioned as a result of the examination of the artist's extant correspondence with his financial partner and technical collaborator in the 1940s, Sunday Reed (1905-1981) (Kubik 2006). A series of letters written while Nolan was in the Australian Army 1942-1944, detail Reed's role in obtaining paints and supports, and preparing canvases and boards for painting (Nolan 1942-44). Reed also kept diaries for the years 1942 and 1943 in which she recorded the paintings that Nolan sent to her, including their dimensions and mediums (Reed 1942; Reed 1943). Nolan writes of receiving a package of Ripolin paint on the 31st January 1943 (Nolan 31 January 1943). Letters over the following days describe in detail Nolan's struggle to adapt to the paint, giving the strong impression that this was in fact his first use of Ripolin.

> You should have been here for the unveiling of the ripolin. Perhaps it is going to take longer to paint good pictures now, it seems like it when you have to dig deeper & perhaps it will be a while before I really know the paint. But the paint itself will take all the discipline in the world. Some day I feel I know what paintings will come from it.
> (Nolan 2 February 1943 pp.1-2)

Prior to the arrival of the Ripolin consignment in January 1943, Nolan's correspondence with Reed describe the use of other brands of commercial paint such as Dulux and Duco® (Nolan 27 October 1942). While this important distinction between pre-Ripolin and post-Ripolin centred around the date 31 January 1943, has not been broadly acknowledged, Warwick Reeder in the exhibition catalogue *The Ned Kelly paintings: Nolan at 'Heide' 1946-47* did note; 'the Kelly paintings were painted with Ripolin enamel, a medium the artist started to use in 1943' (Reeder & Sayers 1997 p. 66)

1.3 Paint in cans verses artists' paint in tubes

In the first half of the twentieth century, paints in cans intended for household use, decorating, advertising and coating cars became an area of rapid technological development. Previously, most house paints had been mixed by professional painters from pastes and seed oils and tinted with pigments by hand. As the need for paint to perform in specific ways was extended, the industry developed many different types of paints ready-prepared for the user. From the 1920s a number of paint binders were also chemically synthesised, many of which had particular advantages over traditional oil paints. The two most successful of these, nitrocellulose and alkyd, were gloss paint media developed initially for spray painting cars. The attraction of these fast drying gloss paints ensured that they were quickly reformulated for use as brushing paints for decorating and commercial art (Standeven 2011).

Conversely paint manufactured specifically for artists through this period continued to be oil-based and supplied in metal tubes. It was not until the 1950s that synthetic resins such as vinyls and acrylics were widely used in paints manufactured for artists[3]. Artists' oil paint has specific properties that are unlike other types of paint. Generally it is squeezed from a tube onto a flat palette for mixing with a brush, and has a thick, paste consistency which holds the texture of the brush or palette knife. Artists' paint is formulated for application to a vertical surface of a canvas without dripping or running. Slow drying allows for blending and working wet into wet. The pigments and oils used in artists' paint are generally of the highest rating of permanence for light fastness and durability and used in larger proportion to the binder giving a high pigment loading. As the paint is used in much smaller quantities than house paint, artists' paint manufacturers (called colourmen) can make use of expensive pigments without causing a significant increase in cost.

Paint in cans is liquid and fast drying. It needs to be fluid to allow spreading and ensure an even finish and coverage. After application it dries quickly to avoid dirt pickup and to enable recoating. Unlike artists' paint, retaining brush texture is not

[3] Magna™, acrylic resin in solvent solution, was the first acrylic artists' paint manufactured in the USA from 1947 and Liquitex® was the first artists' acrylic emulsion paint launched in 1954 (Learner 2004, p. 3).

desirable in most of these paints, particularly gloss ones, and so they are formulated to be self-levelling. While durability is an important concern, it is mitigated in part by the desire to keep the product cost low. Cheap, high tinting pigments are used in preference to the more expensive permanent pigments found typically in artists' paint. The larger volume also makes these paints more vulnerable to raw material shortage and the shifting politics of international trade. Their formulation is therefore more likely to change over time than that of artists' paint.

Despite the ready availability, issues with the different application and physical properties of household paints compared to artists' paint resulted in limitations for their use by most artists. Nolan however, valued them for these very reasons, their ready availability and low price making them accessible but also their working properties and appearance had characteristics that he admired.

Instrumentation such as micro-Fourier Transform Infrared Spectroscopy (μ-FTIR), with which three common commercial gloss paint types, oil, alkyd and nitrocellulose, can be identified, has enabled the distinction of these paint binders from each other (Learner 2005). Alkyds were not used as artists' paint until Winsor and Newton launched its Griffin® line in 1976 (Winsor & Newton 2003-2011). Nitrocellulose was never formulated as paint for artists. The presence of alkyd or nitrocellulose binders on a painting dating from the period of this study, 1938 to the early 1950s, therefore, would indicate the use of a non-artist grade paint. The positive identification of oil binder is less authoritative in this respect as its presence does not necessarily indicate the use of commercial paint over artists' oil paint.

While it has been known that artists sometimes used household, decorating and industrial paints on their artworks, until recently identification of these materials has been by visual characterisation and art historical research. Features such as a lack of stiff paint texture and the presence of paint flow and smooth surfaces caused by self-levelling, have been used to suggest the presence of non-standard artists' paint. This methodology is problematic as dry paint films made from oil enamels are visually indistinguishable from those made from alkyd. It has also been demonstrated that paint features such as self-levelling, inherent gloss and liquid application can be replicated by the addition of solvents, oils and resins to artists' oil paint (Carlyle 2011)

1.4 Terminology

The term 'commercial ready-made paints' as used in the title of this thesis to describe all types of non-artists paints is problematic, as artists' paints were also commercially produced and ready-made. The lack of an accurate broad term to describe the different types of paints supplied in cans is however, elusive. While household paint may describe a large number of the different paint types, it does not include those made for industrial, sign writing and decorative uses. In the absence therefore of a broad encompassing term for all these types of paints that excludes artists' paint in tubes, 'commercial paint' will perform this function in this thesis.

The issue of terminology is at the centre of continuing confusion regarding artist use of commercial paint. This is not only due to the lack of specific terminology, but the changing language for describing these paints as they were developed and the confusing use of trade names, company names and product lines to describe a range of materials.

The difficulty regarding the identification of Nolan's paint is also due to the artist's own terminology in his correspondence which is deeply rooted in the language of the period (Nolan 1942-44). Much of the understanding of the terms has changed over the intervening decades, leading to a lack of recognition of the specificity of Nolan's technical language.

Dulux for example was not the name of an Australian paint maker as it is today, but a specific product-line manufactured by British Australian Lead Manufacturers (B.A.L.M.) from 1932 (Todd 1998a, p. 187). As the association with lead in paint became unpopular in the 1960s, B.A.L.M. changed its name to BALM Paints and then to Dulux Australia in 1971 (Kolm 1988). This led a number of authors to erroneously assume that Nolan's use of the term Dulux indicated any type of paint manufactured by that company (Zimmer 1992, Kubik 2006)). As outlined in this thesis, from the 1930s to the early 1950s Dulux was exclusively an alkyd-based paint.

In the 1930s and 40s, ‘enamel’ was only used to describe oil-based paints. Alkyds such as Dulux, were differentiated from traditional oil enamel by the use of the term 'synthetic' (Figure 2). The difference between the terms enamel and synthetic during this period is illustrated by the label on a can of Dulux from Nolan’s Wahroonga studio which states it is 'the synthetic finish superseding enamels'. That is: not an enamel (oil) but a synthetic (alkyd) alternative considered to have better durability.

Figure 2. B.A.L.M. DULUX black 388 line. Collection: Sidney Nolan Wahroonga studio contents (SID 44146). Artists' Materials Archive, Art Gallery of New South Wales. Photo: Felicity Jenkins and Art Gallery of New South Wales

Another popular type of commercial ready-made gloss paint was nitrocellulose. Nitrocellulose paints were called 'lacquers' because they dried by solvent evaporation - not by oxidation and polymerisation like oil paint. In modern parlance 'lacquer' usually refers to a transparent coating and nitrocellulose was in fact a popular clear varnish coating for furniture up until the 1950s. But the term lacquer was also used to describe a pigmented nitrocellulose-based paint. The most popular brand of nitrocellulose paint was Duco and it was available in Australia from mid 1925 and manufactured locally by B.A.L.M. from October 1928 (Todd 1998a, p. 181.).

Table 1.1 describes the generic and specific terms commonly used from the 1920s to the 1950s for three gloss paint types with some examples of brands and products available in Australia. In general paint was labelled for the public using the generic term. The specific terms were reserved for use within the trade. Therefore, unless the consumer was well informed about the different paint, they might not know exactly what was in the can. While the presence of nitrocellulose would have been easily identified by the fast evaporating and odorous solvents, distinguishing enamels from alkyds would have been more difficult, as both used turpentine or mineral spirit solvent.

Table 1.1 Terminology of three common types of gloss paints available in Australia

Generic term	Specific terms	Some brand names (Manufacturer) [country of manufacturer]
Enamel	Oil Oleoresinous	Pure Prepared Paint (B.A.L.M.) [Australia] Ripolin® (Ripolin) [Holland, France, Britain]
Lacquer	Nitrocellulose Pyroxylin Banana oil Amyl acetate[4]	Duco® (DuPont) [USA] Duco® (B.A.L.M.) [Australia] Opex™ (Sherwin Williams) [USA] Opex™ (Lewis Berger & Sons) [Australia] Fascinac™ (Taubmans) [Australia] Lacquer (Spartan) [Australia]
Synthetic	Alkyd Oil-modified polyester resin Glyptal	Dulux® (DuPont) [USA] Dulux® (B.A.L.M.) [Australia] Synthelac™ (Lewis Berger & Sons) [Australia] Synthex™ (Brolite) [Australia] Revelite® & Enamelised Butex® (Taubmans) [Australia Ripolin Express (Ripolin) [Holland, France, Britain]

The period of the 1920s to 1950s was extraordinary in the development of new materials for paint media and pigments. In the interval between the use of nitrocellulose as a paint medium in the 1920s, to the introduction of acrylic and vinyl emulsion paints in the 1950s, numerous other types of materials were synthesised but the industry itself lagged in developing terminology for them. The end user of these materials probably had little opportunity to grasp their fast changing formulations. An historical study of the paint making industry in Australia during this period that surveys the developments of these products forms the content of Chapter 3.

[4] Term used by Arthur Boyd (Boyd c. 1980s) to describe nitrocellulose. Actually the solvent used in nitrocellulose lacquers.

1.5 Cataloguing media descriptions

The use of brand or trade names for materials used by artists is generally discouraged in museum cataloguing systems. In Australia conventions regarding media descriptions are outlined in the *Cataloguer's manual for the visual arts* (Varveris & Rowlison 1980). This guide was commissioned and published by the Australian Gallery Directors Council, Catalogue and Information Retrieval Committee to assist with a national approach to cataloguing gallery collections. It outlines an agreed convention developed in the period during which museum and art galleries were commencing projects to computerise and standardise cataloguing. The guide offers a 'Glossy of terms used in the description of painting, sculpture and drawing media' in which trade names such as Duco and Dulux are dismissed in preference for lacquer and enamel. Enamel is described as a 'hard gloss shiny paint generally oil based' and alkyds, polyvinyl acetate and acrylic are all substituted for the generic term 'synthetic polymer paint' (Varveris & Rowlison op. cit. pp.87-93). Nitrocellulose is not well differentiated as it is a semi-synthetic and the term lacquer proposed in the guide is not suitable as it says it may be a natural or synthetic resin, but principally it is a varnish.

The widespread substitution of specific terms for the generic term 'synthetic polymer paint' in cataloguing media descriptions has led to an unfortunate loss of acknowledgement of the very different types of paints based on polyester (alkyd), vinyl and acrylic plastics that were developed in the mid-twentieth century. It has also led to difficulty in describing glossy commercial paints which may be either synthetic, oil or nitrocellulose. The term, 'synthetic polymer paint' also fails to recognise the handling properties and conservation issues that each of the different types of paints may present.

As the capacity to analyse paint media has increased significantly since the 1980s, so too has the ability to catalogue paint media with greater certainty. The lack of clarity regarding the use of the terms enamel and lacquer, as their meanings have changed over the past half century, means that they are not good descriptors on their own for the various paint media. The specific terms outlined in Table 1.1; oil, nitrocellulose and alkyd are more informative. The use of both specific and generic forms such as for example ‘oil enamel’, ‘nitrocellulose lacquer’ and ‘alkyd synthetic resin’ offers clarity to researchers and art historians, while also outlining a clearer definition for the general public.

The exclusion of brand names from catalogues when known is also a loss of critical information. The brand name term 'Ripolin' has been used to describe and catalogue paintings by Nolan since his Kelly paintings were first exhibited at the Velesquez Gallery in 1948 (*The ‘Kelly’ paintings of Sidney Nolan 1946-1947*, 1948). The association of Nolan with Ripolin paint, although it may not have always been accurately applied to every picture, has given a more complete record of his practice than may have occurred if they had been described only as enamel or oil. A number of Australian art galleries have changed the long-standing use of Ripolin as media description for his paintings from the 1940s and many are now more simply catalogued as enamel. This is an unfortunately loss of meaning. Names such as Ripolin, Duco and Dulux have specific meanings, historical relevance and resonance beyond the description of a brand.

1.6 Interpretive theoretical framework and methodology

The study of an artist’s techniques and materials, called ‘technical art history’, is most often led by the scientific and physical examination of an artist’s artwork alongside associated documentation (Bomford 2008).

> It is principally concerned with the physical materials and techniques and structures of works of art and how they are prepared, used, combined and manipulated. But — and this is what makes technical art history so intellectually satisfying — it also interests itself in how an artist arrived at the finished, or indeed unfinished, work. It charts the stages of invention, development, realization, elaboration and revision: in short, it is a route into, and our access to, the heart of the artist’s intentions and changing ambitions
> (Bomford *ibid*, p. 199.)

The principal methodologies that yield the most useful information for technical art history include those of conservation, conservation science and art history. It is the conservator who brings experience with analysing the surface of paintings, questioning process, observing materials and their application techniques. The conservation scientist offers specialisation in the analysis of materials and understanding of material science. The curatorial and art historical disciplines consider the historical context based on the study of primary and secondary source materials and the influence of predecessors and peers on the artist's processes. The combination of these separate disciplines engaged in parallel studies of art works produces powerful multidisciplinary research into an artist's materials and techniques.

It was the National Gallery of Art in London that set the standard for these early multidisciplinary studies with *The National Gallery Technical Bulletin* published from 1977. In this pioneering publication research of paintings by conservators, curators and scientists are reported. These include findings regarding artists' materials and techniques as determined by the combination of the process of undertaking conservation treatments, historical research on artists' sources and scientific analysis of samples from painting. A series of three exhibitions at the National Gallery of London under the title *Art in the making* were possibly the first major exhibitions in which art movements were re-examined in the light of technical and scientific study of the materials of the paintings. Central to the *Art in the making* exhibition publications was an acceptance of the idea that art making is limited by the materials available at the time, and that new art movements often occur alongside technical advances (Bomford 1989, 1990; Bomford, Brown & Roy 1988).

The scientific evidence that has emerged from the multidisciplinary study of paintings is a powerful tool for research into an artist's materials and processes. However, the instrumental identification of components within paint films is not sufficient in itself to answer questions regarding dates of use or methods of application: neither is it sufficient to examine motivations of use. At a conference in the Netherlands in 1995, *Historical painting techniques, materials, and studio practice* Leslie Carlyle noted the need for a broader study to engage with these issues.

> Although scientific instrumental analysis is a highly sophisticated branch of the inquiry in itself, results from it alone are not sufficient. It is only in partnership with other forms of investigation that we can hope to unravel the meaning behind what we find through analysis. Now, nearing the end of the twentieth century, having penetrated much of the 'mystery' and converted it into truth, we find that the gifts of science are not enough. It is to 'multidisciplinary information' that we turn in order to understand the purpose of the material we find.
> (Carlyle 1995 p.1)

Technical art history has evolved since 1992 from a *multidisciplinary* subject in which new findings about artworks emerged from the parallel research of conservators, art historians and conservation scientists, into an *interdiscipline* as defined by Tanya Augsburg, in which these separate fields have begun to blend the practices and assumptions of each (Augsburg cited by Scott 2008, p. 122). According to Marcelle Scott (2008), the practice of conservation in particular, has emerged as both a discipline and an interdiscipline. This is because conservators seek answers to questions regarding artistic process from both historical primary documents and the analytical findings of conservation scientists. Conservators often have a background in another discipline that assists with this large and broad interdisciplinary aspect of the work.

Some of the most successful interdisciplinary technical art history projects have derived from a single researcher. For example Carlyle examined nineteenth century British artists' manuals and handbooks to rediscover contemporary recipes, terminology and concerns regarding durability. This project unlocked a previously unexamined source for conservators and curators looking and working with paintings of that period (Carlyle 2001). Carlyle's work demonstrated the merit in examining historical technical sources to re-evaluate the influence of textbooks used by artists. It enabled the re-discovery of historic terminology to describe effects seen on paintings of the period, leading to greater understanding of historical records that describe particular painting techniques and materials and how these contribute to the aesthetics of the finished work.

Further gains in technical art history have been made by the research into the trade of the artists' paint manufacturers (colourmen), such as the cataloguing and research of the account book of the English artists' colourman Roberson and Co. and more recently the Winsor and Newton Archive, both held at the Hamilton Kerr Institute in Cambridge (Churchman, Woodcock & Hamilton Kerr Institute 1997). These records often require considerable work to unpack the use of coded references but have been invaluable guides to artists' requests from their colourmen for materials to assist them in their search for specific effects.

A recent study of direct relevance to the subject of this thesis, is Harriet Standeven's research into twentieth century commercial paint developments in the USA and UK which outlines the complex developments and formulations of paint materials for household use (Standeven 2011). This research revealed the rich history of the commercial paint industry and provides an essential catalogue of components and dates of production for materials that might be found through instrumental analysis.

This thesis aims to examine the assumptions that have been made regarding Nolan's paint media and to demonstrate an interdisciplinary methodology for their accurate description and cataloguing. This involves a study of the artist's correspondence and associated papers and interviews, a history outline of developments in the Australian paint industry during the period of the 1920s to 1950s, a study of the materials retained in Nolan's studio in 1953 and an analytical study of fourteen paintings by Nolan dating from 1938 to 1949.

1.7 Primary research sources

The three primary research sources investigated in this thesis are; the group of materials from Nolan's Wahroonga studio; the correspondence and diaries from the John and Sunday Reed papers 1924-1981 in the State Library of Victoria, and paintings by Nolan from the collections of the Art Gallery of New South Wales and the Heide Museum of Modern Art.

1.7.1 A collection of Nolan's painting materials

In 2006 Nolan's daughter Jinx Nolan donated the contents of her father's studio at Wahroonga, Sydney, to the Art Gallery of New South Wales (Figure 3). These now form part of the Artists' Material Archive in the Conservation Department of the Art Gallery of NSW.

Figure 3. Sydney Nolan with daughter Jinx in the Wahroonga studio, *Architecture and Arts*, February 1954, p. 36

The collection of over 100 items, paints, solvents and other assorted materials from Nolan's studio in Wahroonga, Sydney, in use 1949-1953, is the source for reference material for this study that will be examined in detail in Chapter 2 and 3 (Figure 4). Although the studio material contains a large amount of Ripolin there is also a significant number of other items suggesting a far greater technical engagement by Nolan with house paint mediums, pigments and driers than previously considered. A small number of items from the Wahroonga studio were separated from the main group at the time of the gift in 2006 and given to the Conservation Department at the National Gallery of Victoria (Figure 5). Apart from a can of Dulux surfacer, these do not form part of the material analysed in this thesis although they are itemised in Appendix ii.

Figure 4. Contents of Sidney Nolan's Wahroonga (Sydney) studio. Collection: Artists' Materials Archive, Conservation Department, Art Gallery of New South Wales. Gift of Jinx Nolan 2006. Photo: Felicity Jenkins and Art Gallery of New South Wales

Figure 5. Sidney Nolan Wahroonga studio contents. Collection: National Gallery of Victoria. Gift of Jinx Nolan 2006. Photo: Paula Dredge

The Wahroonga studio contents offer the opportunity to study an artist's practice based on a unique collection of reference materials. Unlike a number of other studies of artists' studio materials, such as those from the studios of Francis Bacon (1909-1992) (Russell et. al 2012) and Jackson Pollock (Lake, Ordonez & Schilling 2004) that were preserved at the time of death of the artists, Nolan's Wahroonga studio is dated to an earlier period of the artist's working life. The timing of Nolan's move to the UK and the closing of the Wahroonga studio in 1953, is a significant date marker for Nolan's use of materials as it predates his use of polyvinyl acetate (PVA) binders for paints from 1957 (Crook & Learner 2000, p. 24) and the development of synthetic emulsion paints based on acrylics.

There are a number of difficulties regarding identification of particular paints manufactured by a company within a work by an artist. Due to large batch quantities commercial paints are likely to have changed formulation over time with developments of new pigments and binders, and with shortages especially in times of war. This study corresponds with three distinctive manufacturing periods, pre-Second World War (1938-1939), war-time (1939-1945) and post-war (1945-1953), all of which involved difficulties with raw material shortages and dramatic developments of new technologies in paint and pigment manufacture. The identification of the types of developments and material shortages which may have impacted on paint formulations during these periods are investigated in Chapter 3.

Questions regarding the dating of the Wahroonga studio materials are addressed in this thesis by examining the histories of paint manufacture in order to provide date markers. Analysis of the contents of cans and bottles and identification of components provides additional references for dating.

1.7.2 Correspondence between Sidney Nolan and Sunday Reed

There is a large body of published literature on the subject of the life and work of the artist Sidney Nolan (Adams 1987: Burke 2005: Haese 1983: Lynn 1979: Pearce 2007: Reeder ed. 1997). This material, although engaged with Nolan's technical interests and working practice, particularly in his use of Ripolin paint, is often unclear and contradictory in the description of his materials and dates of use. This is unsurprising as although Nolan often discusses materials in his correspondence and interviews, meanings have become confused by changes in the use of terms over time.

Primary correspondence has proved to be a valuable source for information on Nolan's materials and practice. The artist's original letters, particularly those dating from his time in the Australian Army from 1942 to 1944 contain a wealth of information as Sidney Nolan and Sunday Reed exchange detailed information on the types of materials they were sourcing and problems with war-time supply (Nolan 1942-44). These letters, in addition to providing information on Nolan's practice of the time, also make reference to his earlier use of various materials. There are several issues to be acknowledged in the use of correspondence. First, the extant ‘conversations’ are one-sided when only one correspondent’s letters are retained, and so an important contextual link may be missing. Secondly, letters are always firmly placed in a particular time, and care must be taken not to relate them broadly to the whole of an artist’s working life. Both of these issues relate to the study of Nolan’s correspondence with Sunday Reed. Only Nolan’s side of the correspondence is extant, and the period of the letters in which materials and technical information is discussed is from the short few years he spent in the Australian Army from 1942 to 1944.

Study of an artist’s correspondence can nevertheless be an important source of technical information. Often when letters are published the technical aspects of the correspondence are excluded. For example *Nolan on Nolan: Sidney Nolan in his own words* reproduces few parts of Nolan’s letters detailing his paints and methods (Nolan & Underhill 2007). It concentrates instead on the aspects regarding the context of place and relationships.

The John and Sunday Reed Papers 1924-1981 collection also contains several diaries kept by Sunday Reed in which she records the paintings received from Nolan in 1942 and 1943 (Reed 1942; Reed 1943). These have previously been described as notebooks of materials sent to Nolan (Burke 2005). When examined in the original, it was found that there were three diaries one from 1942 and two from 1943 in which Sunday Reed noted the dates she received letters and paintings from Nolan while he was in the Army. She has carefully described each work with dimensions and the medium. A detailed discussion of these letters and diaries are given in Chapter 2.

Correspondence of several other artists associated with Sidney Nolan has yielded useful information, in particular the correspondence between Joy Hester (1920-1960) and Sunday Reed. After Hester left Melbourne and moved to Sydney in April 1947, she communicated with Sunday Reed about paints in which Nolan may have been interested (Hester, Burke & Reed 1995). Albert Tucker (1914-1991) is also a close technical ally with Nolan, but most of his extant correspondence with Nolan dates after 1947. The complete correspondence between these two artists is published by Patrick McCaughey (2006), but by the time their correspondence begins Nolan is less communicative about technical issues. An interview with Albert Tucker from 1994 does contain some references to Tucker’s own early influences and his years as a commercial painter including working, as did Nolan, for Fayrefield Hats (Tucker 1994).

Arthur Boyd (1920-1999) is also an important contributor of technical expertise to this group of artists which revolved around the Reeds' house at Heidelberg, called Heide in the early 1940s. As a young man Boyd worked in a paint making factory (Boyd 29 April 1983). According to a letter he wrote to Sharon Towns in 1983 this equipped him with the knowledge and confidence to grind his own paints using dry pigments and oil and wax from about 1940 (Boyd 9 August 1983). He also discusses the influence of two technical manuals on his practice. These were Max Doerner *The materials of the artist and their use in paintings with notes on the techniques of the old masters* (1934) and Ralph Mayer *The artists' manual of materials and techniques* first published in 1940 (Mayer 1970). Both of these texts were also Nolan's technical guides in the 1940s.

1.7.3 Paintings by Sidney Nolan from 1938 to 1953

The Art Gallery of New South Wales granted access to Sidney Nolan's paintings from its collection for research and analytical study. This examination of paintings forms the subject of Chapter 5. At the beginning of this project there were sixteen paintings within the period of this study 1938 to 1953 but only one of these works, *Luna Park* 1941 (Figure 2) was dated prior to the hypothetical date of the arrival of the Ripolin paint on 31 January 1943. During the period of the investigation (2009-2013) the Art Gallery of New South Wales acquired the painting, *First-class marksman*, 1946 (Figure 6). This was painted at the same time as the other paintings by Nolan on the Ned Kelly subject, now in the collection of the National Gallery of Australia. Unlike the other Kelly paintings which were all painted at the Reeds' house at Heide, *First-class marksman* was painted in the studio of Danila Vassilieff (1897-1958) and may not bear absolute correspondence to materials with those painted at Heide.

Figure 6. Sidney Nolan, *First-class marksman*, 1946. Ripolin enamel on hardboard. Collection: Art Gallery of New South Wales, Purchased with funds provided by the Gleeson O'Keefe Foundation, 2010. © Trustees of the Sidney Nolan Trust

An early work by Nolan also emerged during the period of this research. *Untitled-abstract* circa 1939-40 was a bequest to the Art Gallery of NSW in 2006 (Figure 7). It had been catalogued as 'attributed to Sidney Nolan' and has remained in this state of uncertain attribution for many years. It was decided that this work would enable an opportunity to test some of this study's findings and analytical pathways to assess their value in attribution questions regarding Nolan's paintings.

Figure 7. Attributed to Sidney Nolan, *Untitled-abstract*, c.1939-40. Oil on photograph. 28.0 x 34.4cm. Art Gallery of New South Wales. Bequest of Gwen Frolich 2006. © Trustees of the Sidney Nolan Trust

As the project developed it became increasingly apparent that paintings by Nolan completed while in the Australian Army from 1942 to 1944, were critical to potentially dating his take-up of Ripolin. The Heide Museum of Modern Art has an extensive collection of paintings by Nolan from this period. The Museum was approached to be involved in the project and generously agreed to permit examination and micro-sampling of a number of their paintings from this period. The paintings which form part of this study from both the Art Gallery of New South Wales and the Heide Museum of Modern Art are listed in Appendix iii.

The rationale for the selection of paintings analysed for this study was a combination of circumstance, those that were available and also with areas of the paint surface in suitable condition for samples, as well as those it was considered might assist with answering some of the central questions of this thesis. A selection of fourteen paintings from both collections underwent instrumental analysis. As the paintings from the Heide collection were sampled *in situ* and the samples were taken back to the Art Gallery of New South Wales for analysis, the paintings could not be examined with portable X-ray Fluorescence (pXRF). Here the difference in analytical approach was circumstantial. In any case, not all the paintings involved in this study were scrutinised with every available analytical tool. Analysis of all the paintings was restricted by the availability of paintings, instruments and time, but systems were chosen that best suited the issues and questions raised by each work of art. In this way this thesis does not offer a meticulous technical and analytical study for each work examined, but assesses the value of alternate systems to look at specific questions.

1.8 Secondary research sources

1.8.1 International household paint manufacture and use by artists

In the last decade a number of researchers have been developing histories of twentieth century industrial and household paint manufacture, particularly in relation to artist use. These histories are critical in providing dates of material processes and their availability to artists. They present a solid framework for this thesis and assist in understanding the complex nature of these paints in comparison to artists' paints.

The impact of modern paints, by Jo Crook and Tom Learner (2000), provides an historical background of the development of many of the synthetic paints in the twentieth century. It also outlines a number of case studies of artworks in the collection of the Tate Gallery, London, including an example of Sidney Nolan's use of polyvinyl acetate (P.V.A.) dating from the early 1950s. Harriet Standeven's PhD thesis (2004) on the history of gloss enamel paint from 1910 to 1960 outlined the technological shift in the paint-making industry from natural oil and resin enamel into a number of synthetic paints. Standeven focused particularly on the development of Duco (nitrocellulose) and Dulux (alkyd) by DuPont in the USA and Imperial Chemical Industries (I.C.I.) in Britain, using the resources of the DuPont Archive Hagley Museum and Library, Wilmington, Delaware, USA. The connections with these developments to Australian paint manufacture will be explored in Chapter 3. Stuart Croll (2006) offers an important addition to the histories of paint development in his discussion of early emulsion type household paints including Kem-Tone™, a natural oil and glue emulsion paint from the 1940s which is present in the Sidney Nolan Wahroonga (Sydney) studio materials. Standeven's most recent work is a technical resource encompassing all types of household paint in the first part of the twentieth century including oil-based enamels and interior emulsion and distemper type paints (Standeven 2011).

Fotini Koussiaki (2003) offered an early case study of the use by Pablo Picasso of French-made household paint including Ripolin. Koussiaki in her study of the Ripolin company archives suggested that Ripolin did not contain alkyd resins until the late 1950s. It has subsequently been shown that the Ripolin company made alkyd paints as early as 1936, but these were, at least in France, clearly differentiated from their standard enamel in several lines of paint called Ripolin Express and Ripolin 500 (Casadio & Gautier 2011 p. 136). In her attempt to discover a unique feature of Ripolin enamel paint that could be used to distinguish it from standard artists' oil paint, Koussiaki (2003) suggested that the clearest indicator was the use of zinc and barium-based whites over lead whites, but no definitive marker was at that time identified.

A more recent research project at the Art Institute of Chicago involving a number of conservation scientists and art historians, looked at artist use of pre-synthetic household paints, in particular Picasso and his use of Ripolin. This research group identified that Ripolin was manufactured originally in Holland and then from 1897 in France (Raeburn 2011). They published several articles identifying the pigments found in the French Ripolin gloss paint range by the analysis of the paint swatches on 28 paint colour cards and over 80 cans of Ripolin paint (Gautier et al. 2009, Casadio & Gautier 2011). These colour cards enabled analysis of the full range of available colours of the French-made range of Ripolin from the early 20th century to mid century.

The Art Institute of Chicago, in combination with a number of Picasso scholars published a book examining Picasso’s use of Ripolin paint during the period of this thesis research titled *Ripolin express* (2011). This compilation of articles takes as its study group the paintings from the Antibes Museum and includes essays on the history of the Dutch and French Ripolin companies (Raeburn 2011), an historical survey of Picasso’s use of Ripolin (McCully 2011), and scientific examination of Ripolin paint charts compared to samples from paintings from Antibes (Casadio & Gautier 2011). Although Picasso became well known for his use of Ripolin paint it would appear that his use began in 1912 on only a small part of a number of cubist paintings. Georges Braque (1882-1973) on seeing the Ripolin canvases commented sanguinely ‘the weapons have changed’ (McCully 2011). One of these 1912 Ripolin paintings has been identified by Marylin McCully as *Spanish still life* (collection: Musèe d'Art Moderne, Villeneuve D'Ascq, Daix) (Figure 8) in which she suggests the red and yellow bull fighting ticket at the lower right is rendered in Ripolin paint (McCully 2011).

Figure 8. Pablo Picasso *Spanish still life*, 1912. oil and enamel on canvas, 46 x 33cm oval. Collection: Musèe d'Art Moderne, Villeneuve D'Ascq, Daix. Gift of Geneviève and Jean Masurel, 1979. © Succession Picasso

This painting was among a group of works Picasso referred to in his correspondence with his dealer Daniel-Henry Kahnweiler as; ‘Ripolin enamel paintings, or Ripolin-like paintings’ (Picasso to Kahnweiler June 20, 1912 cited in McCully 2011). In making a distinction between Ripolin and Ripolin-like paintings there is a suggestion that Picasso was, even in 1912, manipulating his paints to give them the appearance of Ripolin.

It would appear the documented trail for Picasso’s continued use of Ripolin paint becomes more difficult to unravel after 1912. What is emerging from recent scientific and curatorial studies on Picasso’s early use of enamel paints, is that he often mixed it with other paints or confined its use to selected passages of a painting (Casadio & Gautier 2011), although the recent investigation of *The red armchair* by Picasso dated 1931 (collection: Art Institute of Chicago) does demonstrate fairly widespread use of Ripolin (Muir et. al 2013). Picasso also is recorded by Roland Penrose (1900-1984) in 1932 as mixing matte Ripolin with standard artists’ oils (McCully 2011 p. 132). He used additions of pigments, mediums and diluents, and is photographically documented with brands of enamel paint other than Ripolin (Casadio & Gautier 2011 p.140). The quest for scientific certainty with regards to examples of Picasso's use of Ripolin paint is proving difficult, but the Picasso case study confirms the inadequacy of attempting to identify Ripolin paint by its visual appearance alone.

David A. Siqueiros, a Mexican painter living in the USA in the 1930s was greatly admired by Nolan (Burke 2005 p. 233). Siqueiros became very interested in the possibilities offered by quick drying brightly pigmented, high-gloss paint based on nitrocellulose resin. As a supporter of revolution and modernism, Siqueiros was excited by nitrocellulose's pedigree as an industrial modern paint medium and its association with explosives as it is derived from guncotton (McGlinchey et. al. 2013). Siqueiros' is quoted as saying that without modern techniques it is not possible to have modern art, '…si en nuestra teoria no estuviera el principio de que sin técnica moderna no puede habar arte moderno' (cited by McGlinchy et al 2013 p. 279).

In 1936 and 1937 Siqueiros taught the use of nitrocellulose as a paint medium to artists in New York City in the Siqueiros' experimental workshops in which paintings were produced by a number of artists working together. One of these works was *Collective suicide* 1936 (collection: Museum of Modern Art, New York). It is a huge work painted with nitrocellulose which was both poured onto the surface and sprayed through stencils (Figure 9).

Figure 9. David Siqueiros *Collective suicide* 1936 , lacquer on wood with applied sections, 124.5 x 182.9cm. Collection: Museum of Modern Art, New York. Gift of Dr. Gregory Zilboorg. © 2012 Siqueiros David Alfaro / Artists Rights Society (ARS), New York / SOMAAP, Mexico

Other detailed case studies of artists' use of household paints include a number of articles looking at Jackson Pollock's use of enamel paints in the 1940 and 1950s which include analysis of paint cans left in his studio on his death (Lake, Ordonez & Schilling 2004). Michael Schilling, Joy Mazurek and Tom Learner (2007) found pentaerythritol (PE), (a component of post-war alkyds) in paintings by Pollock dated 1949. In the 1930s Pollock had participated in the Siqueiros experimental workshop in New York in 1936. A lithograph with over paint applied by Pollock in 1936-7 has also been analysed and identified as nitrocellulose paint (McGlinchey et. al. 2013).

Sarah Hillary has published several articles on the use of household paints by the New Zealand artist Colin McCahon (1919-1987). She found alkyd resin paints on works by McCahon dating from 1954 (Hillary 2006). A more recent publication looking at a number of paintings by McCahon with badly cracked paint areas, were found to be alkyd-based paints containing rosin (Hillary, Learner & Rivenc 2007). A research project looking at the materials left by Francis Bacon in his studio reconstructed in Dublin are reported by Joanna Russell, Brian Singer, Justin Perry and Anne Bacon (2012) but these paints are generally considered to date from the 1960s.

A series of investigations of materials used by a number of twentieth century artists is currently being published by the Getty Conservation Institute. The first of these is an extremely detailed analytical study on a number of paintings by Willem de Kooning (Lake & Schilling 2010). De Kooning shared with Nolan a background in commercial art practice and a continuing interest in the use of commercial paint products in his paintings. The earliest use of alkyd resin paint by de Kooning, was found in a black paint used on *Woman*, 1948 (collection: Hirshhorn Museum and Sculpture Garden, Smithsonian Museum).

1.8.2 Australian household paint manufacture and artist use

There is little recent published literature outlining the Australian paint manufacture industry from the 1920s to 1950s. One of the few resources is an on-line directory of Australian industry that includes a chapter on the chemical industry in a publication called *Technology in Australia* 1788-1988 (Kolm 1988). This gives a brief introduction to key paint and resin manufacturers with descriptions of dates of formation of companies and major changes. Little detail on production is given. One of the few articles detailing the manufacture of synthetic paint resins in Australia is that by Jan Todd (Todd 1998a). Todd located several critical sources for primary information, including the British Australian Lead Manufacturers (B.A.L.M.) file, in the DuPont Archive Hagley Museum and Library, Wilmington, Delaware, USA. Todd's article unravels the complex history of synthetic resin development in Australia as driven by the car manufacturing industry. She provides key dates for the introduction of various resins into the Australian market. During the course of this research, Todd made available several unpublished manuscripts she had been commissioned to write by several key paint manufacturers in Australia, A.C. Hatrick and Taubmans (Todd 1998b; Todd 1990). These proved to be the most comprehensively researched texts available on paint manufacture in Australia.

An on-line resource is provided by the National Environment Health Forum Monographs in its publication, *Paint film components* by Mike van Alphen (1998). Reference material providing critical dates for this publication are primarily provided by Kolm (1988) and international publications. There is some difficulty, therefore, in finding dates of the introduction of various Australian processing and manufacturing innovations. The most comprehensive resource located for information on the Australian manufacturer of new synthetic paint binders and pigments was a trade journal *The Decorator & Painter for Australia & New Zealand* (1924-1953). This expansive monthly journal continued publication through the Second World War period and provides the main source for information outlined in Chapter 3 on the history of Australian paint manufacture. This journal also contains numerous articles by experts in the field on issues such as wartime shortages (Boland 1944-45) and regular reports on volume of imported and locally manufactured paint products for each year.

The issue of wartime restriction of paint is of central concern to this thesis as Nolan writes often in his correspondence of his efforts to procure paint and problems with the availability of products. A publication *The Australian Department of War Organization of Industry: what it is and what it does* (1943), is a guide to the types of restrictions on production which occurred during the Second World War including building materials, paint and cloth (canvas). A year book published by *The Decorator*

& Painter for Australia & New Zealand (1953) is a catalogue of all household paint products available in Australia in that year with details of types of paints, makers, and some information on binders and pigments. As 1953 is the final year of Nolan's residence in Australia and the cut off date for this study, it forms a guide as to the full range of products available to Nolan on the eve of his departure from Australia. A history of linseed oil production in Australia, written by a descendent of Harold Meggitt, (a major producer), provides an interesting insight into the difficulties of procuring linseed oil in the post war period and the use of a locally grown substitute product (Meggitt 2000).

'Digitised newspapers and more 1803-1954', *Trove* (National Library of Australia 2008-2013) is useful for keyword searches of advertisements for particular paint products and manufacturers giving information on dates of availability and types of use. Yearly reports by the Tariff Board published in Australian newspapers are also a source of information on supply of raw materials and finished products, particularly the report for 1934 which describes in detail issues relating to the import of raw materials and finished paint products to Australia ('Tariff board reports' 1934, Sydney Morning Herald, 14 December 1934, pp. 16-7).

Paint colour charts, in addition to information regarding colour range, often include some manufacturing information of the types of resins oils and pigments contained within the range. The Caroline Simpson Library and Research Collection at Sydney Living Museums hold a large collection of these early charts including, importantly for this research, several Dulux and Dynamel™ charts. The Powerhouse Museum also holds some paint charts, particularly those for Kem-Tone. More information on paint products is found in diaries and special issue booklets put out by a number of manufacturers which contain information on company history and development of synthetic resins for paint (B.A.L.M. 1954).

The development of synthetic paint resins in Australia was of interest to Arthur de Ramon Penfold (1890-1980), curator, and later director, of the Technological Museum in Sydney (now the Powerhouse Museum). Penfold began his working life as a book-keeper in an English paint-making company and retained a connection with the industry. As a scientist, he examined the potential of a number of indigenous plant resins for paint, particularly the use of Xanthorrhoea (grass tree) gum in black stove paint, which was a short lived Australian-based industry in the 1920s (Penfold 1931). After the Second World War and during the linseed oil shortage crisis, he undertook a fact finding tour of American and British paint resin manufacture and on his return promoted the local development of castor and soya bean oil industries. In 1931 Penfold curated the first exhibition in Australia of synthetic plastics and included a selection of resins manufactured by B.A.L.M. The B.A.L.M. resins are visible in the foremost glass cabinet in a photograph taken of the exhibition (Figure 10). These early synthetic resins, and an additional group of paint resins given to the museum in 1937 by Beck Koller & Co (USA), later renamed Reichhold, are the only known samples of manufacturers' resins of the period and were examined as part of this thesis.

Figure 10. First *Australian plastics exhibition, Turner Hall, Sydney Technical College,* 26-28 September 1934. black and white photograph. Collection: Powerhouse Museum, Sydney

There is little published information on the subject of the use of household paints by Australian artists. Jenny Zimmer (1992) gives an Australian perspective on love of the hardware shop and 'make-do' in the post-war period when artists' materials became difficult to obtain. She outlines some of the solutions to problems of supply that artists employed to overcome lack of materials. She also proposes that a uniquely Australian sensibility included a love for home renovation and a great willingness for innovation. There is no technical examination of artworks to support her subject.

Anne Stephens in her catalogue for the exhibition *Modern times: the untold story of modernism in Australia* (2008), discusses interior paint and its interest to Australian artists from the 1920s. Stephens identifies Margaret Preston's (1875-1973) use of the name of a household paint colour manufactured by Sydney paint maker Major Bros. as the title for her painting, *Implement blue,* 1927 (collection: Art Gallery of New South Wales). It is not suggested however, that the paint itself was used by Preston in her art works (Figure 11).

Figure 11. Margaret Preston, *Implement blue*, 1927, oil on canvas on hardboard, 42.5 x 43.0cm. Collection: Art Gallery of New South Wales. Gift of the artists 1960. © VISCOPY

Grace Cossington Smith's (1892-1984) painting *The lacquer room* 1935-1936 (collection: Art Gallery of New South Wales) takes as its subject the brilliant gloss interior of the Soda Fountain Café in the David Jones department store (Figure 12). The title of the painting suggests it was a nitrocellulose lacquer paint that had created this brilliant high-gloss finish that was so attractive to the artist. The medium used for the painting itself is matte and has the appearance of a standard artists' oil paint.

Reflections suggested by the interior paintwork are created with colour and texture alone, not with the use of gloss paint.

Figure 12. Grace Cossington Smith, *The lacquer room*, 1935-6, oil on paperboard on plywood, 74.0 x 90.8cm. Collection: Art Gallery of New South Wales. Purchased 1967. © VISCOPY

The appeal to artists of the brilliant colours available in nitrocellulose paints in the 1920s is also demonstrated in a pamphlet dating from 1928 in which three Australian artists, George Lambert (1873-1930), Sidney Ure Smith (1887-1949) and Thea Proctor (1879-1966), were commissioned by the Ford Motor Company of Australia to design several colour combinations each for consumers overwhelmed by colour choices (Figure 13).

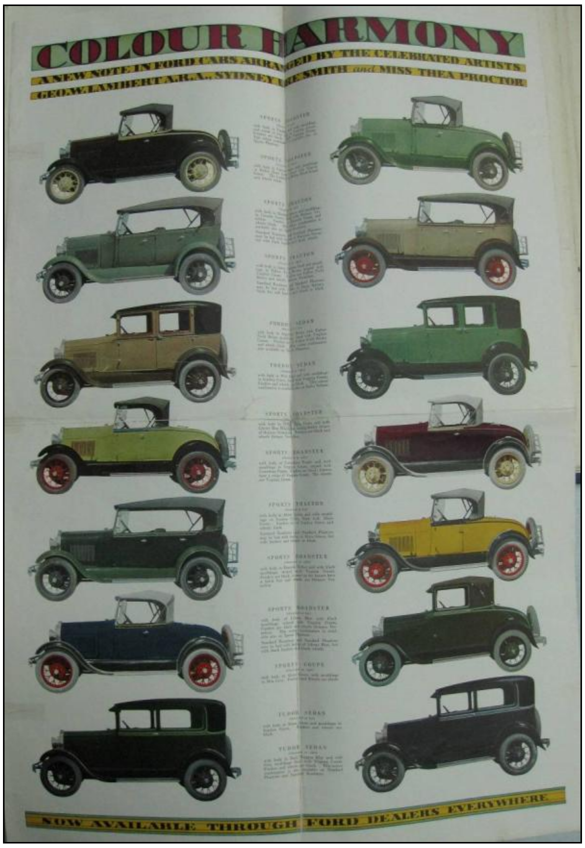


Figure 13. Ford Motor Company of Australia, Colour harmony. An entirely new note in Ford cars dictated by well known Australian Artists, 1928. Collection: State Library of NSW, Lambert Family Papers 1874-1942

No evidence of an artist's use of commercial paints has yet been found analytically on paintings dating from the 1920s, but it is clear that many Australian artists were excited by the transformation in colour and texture that these new paints made to buildings, cars and interiors (Dredge 2013).

1.8.3 Analytical systems

In the last ten years there has been a growing field of investigation from researchers in the UK and USA into commercial paint developments and use by artists. This has been facilitated by increased access to bench top analytical systems to examine either minute samples from artworks or non-invasive techniques. These systems are becoming common within museums and art galleries in Australia, and the development of analytical skills, standards and historical studies to provide context for results is being established. A broad outline of the most useful techniques for the examination of commercial paints used on paintings is given in Table 1.2.

Table 1.2 A selection of instrument techniques for the analysis of paint samples

Instrument	Use	Sampling
micro-Fourier Transform Infrared Spectroscopy (μ-FTIR)	Identification of some organic materials (binders and pigments) and some inorganic pigments and extenders	Micro-scraping of surface or material from a cross-section sample
portable X-Ray Fluorescence (pXRF)	Identification of metallic ions with mass number 13 (ie: aluminium) and above	No removal of samples required.
Polarising Microscopy (PM)	Identification of crystalline pigments by shape, colour, refractive index and polarising characteristics	Micro-scraping of surface or material from a cross-section sample
Cross section microscopy with incident and fluorescence light	Identification of layer structures and dispersions of materials within layers.	Micro-sampling of painting through all layers
Scanning Electron Microscope with Energy Dispersive X-Ray analysis (SEM-EDX)	Identification and mapping of metallic ions with mass number 6 (ie: carbon) and above.	Micro-sampling of painting through all layers
Raman Spectroscopy (RS)	Identification of some pigments and their crystalline form	Micro-scraping of surface or material from a cross-section sample
Synchrotron sourced or portable X-Ray Diffraction	Identification of crystalline pigments	Micro sample or non-sampling instruments
Gas Chromatography/Mass Spectroscopy (GC/MS)	Identification of large chained organic materials	Micro-scraping of surface or material from a cross-section sample
Synchrotron sourced Infrared spectroscopy	Identification and mapping of some organic materials (binders and pigments) and some inorganic pigments	Micro-scraping of surface or material from a cross-section sample prepared either as thin section

Micro-Fourier Transform Infrared Spectroscopy (μ-FTIR) can be an effective technique for the identification of oil, alkyd and nitrocellulose resins in paints (Learner 2005). Commercial paints are particularly well suited to this analytical technique as the high proportion of binder used to produce liquid, brushing paints and to impart gloss, give ample opportunity for its identification. In contrast, drying oils used in pigment-rich artists' paint are in much lower proportion and can be very difficult to detect in μ-FTIR without pre-processing and removal of the pigments. Many pigments used in paint also give spectral responses under μ-FTIR. Prussian blue for example is readily detected by the strong C=N absorbance at 2094cm^{-1} (Learner 2005). However, the identification of pigments using μ-FTIR can be made difficult by the complex mixtures of pigments and the occurrence of overlapping spectral peaks.

An essential and practical guide to the use of FTIR for the study of cultural artefacts is provided by Derrick, Stulik & Landry, *Infrared spectroscopy in conservation science* (1999). This publication includes an extremely useful chapter on the preparation of samples for μ-FTIR analysis, and reference spectra of materials commonly found in artworks. *The infrared and raman users group (IRUG) spectral database* (2007), is an on-line library of infrared spectra contributed by conservation scientists from all over the world gives standard spectra for materials commonly found in artworks. Access to an uploaded database of the IRUG spectra is obtained by membership of the IRUG group and peer reviewed contributions to the library of spectra.

Portable X-ray Fluorescence (PXRF) is a useful partner instrument to the μ-FTIR for the identification of pigments. It is a non-sampling technique in which low energy X-rays in a small beam are targeted directly at a colour area of a painting. The energy fluorescence emitted is measured and shown as spectral peaks assigned to specific elements. Limitations with PXRF occur when metallic elements with low mass numbers such as aluminium are present. Some pigments cannot be distinguished from each other by PXRF because they contain similar metallic ions to each other. An excellent guide to PXRF for the analysis of paintings that outlines some of these difficulties is given by McGlinchy (2012). Ready-made commercial paints may incorporate many different pigments to make colours. In these instances polarising microscopy (PM) is a useful additional tool for identifying pigments by colour, morphology and refractive index.

While μ-FTIR can effectively identify the presence of an oil binder in paint, the type of oil can be difficult to resolve. Oils are composed of a glycerol 'backbone' with attached side chains of fatty acids. The oils used in pain- making due to their ability to form cross-linked and oxidised 'dry' structures, are distinguished from other non-drying oils, by the presence of unsaturated fatty acids, particularly linoleic (9, 12-octadecanoic) and linolenic (9,12,15-octadecatrienoic) acids. These particular acids reduce quickly in oil paint films as they are converted during the drying and oxidation process. Other fatty acid groups found in drying oils are more stable and valuable for identification purposes, including palmitic (hexadecanoic) and stearic (octadecanoic) acids.

Pioneering studies of fatty acids in oil paint using Gas Chromotography/Mass Spectroscopy (GC/MS) were undertaken by the conservation scientists John Mills and Raymond White at the National Gallery, London (Mills and White 1994). Mills and White proposed that oil types can be identified by the ratio of palmitic to stearic acid (P/S) measured after analysis with GC. The three main types of drying oil used in old master paintings have P/S ratios in the region of 1.5 for linseed, 3 for walnut and 5 for poppy oil. The difficulty with the use of this technique for the identification of oil types in twentieth century paintings is the increased range of oils that may be present. Many of the alternative oils such as tung and dehydrated castor have P/S ratios in the region of 1 which is close to that of linseed oil. It is also probable that many commercial ready-made enamel paints were formulated using a mixture of oil types and therefore assigning oil type by P/S ratios is not possible in these instances. Some types of oils do have identifying fatty acid markers. For example, castor oil modified by dehydration to make it a better drying oil, has an acid called ricinoleic (12-hydroxy-9-octadecenoic) in a significant quantity and can be identified by its presence in GC/MS. Tung oil has a fatty acid called eleostearic (cis,trans,trans-9, 11, 13 octadecatrienoic acid), but in practice it appears difficult to find in dried films examined with GC/MS. Unfortunately, linseed oil does not have a fatty acid marker and cannot be positively identified in this way.

Other useful fatty acid comparisons in dry oil-based paint films include the ratio of azelaic to palmitic acid (A/P) which can indicate the degree of polymerisation of the paint matrix. According to Corbeil, Helwig & Poulin (2011 p. 69) azelaic acid is formed when the oil polymer undergoes chain scission. A high A/P therefore would suggest a high degree of polymer breakage and produce a weaker, less polymerized and softer paint film. This might not just be related to the presence of poor drying oil types, but could equally be due to particular pigment interaction such as bone blacks that are known to make paints which are slow and poor driers.

Finally, comparison of the fatty acid proportions suberic to azelaic (Sub/A) can indicate the presence of heat-bodied oils when they are above the ratio of 0.4 (J.D.K. van den Berg, J.K. van den Berg & Boon 1999). This can be a useful indication in the study of enamel paint as oils were often thickened by pre-cooking. This gave better brushability to the paint and enabled a high proportion of oil to be used to give gloss effects. Unfortunately, stand oil, a type of heat-bodied oil, is also used in artists' paint so the presence of heat bodied oil can not uniquely identify a commercial paint.

Several pre-processing procedures for samples undertaken prior to GC/MS, have been identified more recently as useful in the study of oil paints. Meth-prep II is a reagent (m-trifluoromethyl-phenyltrimethylammonium hydroxide (TMTFTH)) used with GC/MS in a chemical pre-processing technique that gives reproducible results for the study of accurate ratios of fatty acids in oil based paints. Other GC/MS techniques have been developed to provide a more complete breakdown of the larger polymers typically present in synthetic based paints such as alkyds. These can involve pre-processing of the sample by pyrolysis (Py-GC/MS) in which the sample is heated and broken into smaller volatile components. A system in which alkyd paint samples are initially chemically broken apart using tetramethylammonium hydroxide in methanol and then introduced to Py-GC/MS, was pioneered by a forensic scientist John Challinor (1998) and adapted for use by conservation scientists. This technique of thermally assisted hydrolysis and methylation (THM-GC/MS) is an effective method for distinguishing between alkyds manufactured with glycerol and those using pentaeyritritol (Cappitelli 2003).

The identification of natural resins in paint films can be difficult. Hard fossil resins such as copal are processed for addition to paint by heating at very high temperatures in order to melt the resin, then added or 'run' into hot oil. The analysis of resins that have not undergone such intense heat treatment when compared with paint samples might not, therefore, provide useful standards. K.J. van den Berg and colleagues have done extensive work in GC/MS analysis on different types of copal resins and have identified some useful markers, along with some distinguishing molecules to suggest types of copals which may be present (van den Berg, van der Horst & Boon 1999; van den Berg, Ossebaar & van Keulen 2002).

The analysis of metallic soaps found within paint films is also relevant to this study. These soaps may either be added to paints to aid drying, or form as a result of interaction between metallic pigments and oils inside the paint film. A useful discussion of metallic soaps in paint and their identification is given by Laurianne Robinet and Marie-Claude Corbeil (2003). A more detailed study of a large number of different soaps found in paint films and their characteristic peaks for identification with μ-FTIR and X-ray Diffraction is provided by Corkey (2004).

There have been a number of developments in infrared techniques that attempt to provide a system for mapping infrared spectra across an embedded paint sample. These are useful in examining the distribution and placement of organic components within paint films, particularly mobile materials such as metallic soaps. Analytical mapping studies of dry paint films are increasingly providing new chemical models that suggest a more dynamic environment within dry paint films than has previously been acknowledged. It is increasingly reported that materials continue to be transformed and migrate in old dried paint films (Keune & Boon 2011: Ferreira et. al. 2011: Osmond et. al. 2012). Previously this was associated with the use of solvents or interaction with the environment at either surface (front or back). The study of soap formation and movement provides a case to suggest that there may be a number of inherent mechanisms involved that continue well after the paint film has dried (Ferreira et. al. 2011).

Focal Plane Array (FPA) infrared imaging was examined as a mapping system for use with paint samples (Spring et al. 2008). This allowed for multiple spectra of adjacent areas to be combined to form a map 64μm square with each sampled area 3-4μm. This was applied by the author to three cross-section samples to detect distribution of organic materials in pre-twentieth century paint films. The size of the total area surveyed by this technique was however small in comparison to the size of most paint cross-sectional samples, more usually in the area of 100-200μm. Importantly this technique was used alongside Scanning Electron Microscope (SEM) backscattered images in order to locate the area being examined by the FPA, as determination of the exact area under analysis is difficult.

Even more recently success in infrared analytical mapping became possible using synchrotron sources for infrared. Gregory Smith (2003) outlined the potential for synchrotron sourced infrared for the examination of paint films. As the synchrotron sourced infrared beam is extremely powerful, it can be used at small apertures, as low as 5μm. Its usefulness for the examination of paint films is its ability to analyse adjacent areas up to 100 samples in two dimensions, giving potentially a total mapping area of 500µm square. A study of the potential of synchrotron-source infrared spectral mapping of a paint cross-section using a reflectance technique on an embedded cross-section was undertaken by Robyn Sloggett, Caroline Kyi, Nicole Tse, Lijiljana Puskar and Stephen Best (2009). Problems were encountered, with indentation of the sample by the Attenuated Total Reflectance (ATR) crystal. Success in overcoming these shortcomings was found during this study with the use of the synchrotron sourced infrared in transmission mode using thin sections cut from paint cross-sections.

High end instrumentation such as GC/MS and synchrotron sourced infrared imaging are rapidly expanding our understanding of the complex systems involved in the interactions within paint films between binders, pigments and solvents. These systems do, however, require considerable expense and expertise to build a useful catalogue of standards and optimisation for the type of materials particular to paint films. µ-FTIR and PXRF while less informative, are cheaper and more readily accessible instruments with less establishment issues. While this thesis takes the opportunity to engage with detailed analytical techniques in the study of the materials from the Nolan studio in Chapter 4, the more 'front-line' instrumentation was used in the study of the paintings by Nolan outlined in Chapter 5. This was to assess the ability to identify the materials found on the paintings for the purposes of cataloguing media. The more detailed study of the studio materials provided useful standards for the identification of these materials on the paintings by Nolan.

1.9 Summary

The identification of different brands and types of commercial paints on works by Nolan is a challenging but valuable enterprise. While these types of paints are commonly associated with post-Second World War Abstract Expressionism in which they were poured, sprayed, dripped or broadly brushed, Nolan's earlier use of them for figurative works applied with a painterly blended and modulated technique is unique.

This thesis works across a number of disciplines to attempt to unravel Nolan's use of materials and their complex history. Chapter 2 examines Nolan's life and his choice of paint materials; employing both primary resources of artist correspondence, a historical survey of his paintings and discussion regarding influences on his art making practice. A history of the technical developments in commercial paint manufacture in Australia forms the basis of Chapter 3. It draws largely upon articles found in paint journals of the period. While this chapter engages with historical sources, its main focus is the chemistry of the commercial paint industry with its complex and rich history. Chapter 4 is firmly embedded in cultural materials conservation and includes an analysis of the collection of painting materials left in Nolan's studio in Wahroonga, Sydney that were gifted by his daughter Jinx Nolan to the Art Gallery of New South Wales in 2006. The examination and analysis of this material provides rare and valuable analytical standards for known materials. These form useful comparative reference standards with the scientific analysis of samples from painting by Nolan undertaken in Chapter 5. Chapter 6 brings these different strategies together to build an interdisciplinary, evidence-based understanding of Nolan's use of commercial paint.

Chapter 2. Sidney Nolan's paint biography

> *Some people like to squeeze oil paint out of the tube, they love that. I like it too, but I also like to dip the brush in the tin. But perhaps that is because when I was in a factory at fourteen.*
> Nolan 1980 (cited in Klepac 2007 p. 80)

2.1 Introduction

The early period of Nolan's life as an artist from 1938 to 1944 was the most dynamically experimental and is consequently the most challenging for the identification of his paint media. This chapter attempts to unravel some of the central threads of these experiments and to identify the key issues to be addressed in the following chapters. Records of Nolan's life and influences are examined in order to build a guide to Nolan's paint biography. Throughout his life Nolan was intensely engaged with the discovery of new paint materials and the evidence of his choices and efforts to secure these are found in a number of forms. These include interviews with the artist and in particular an interview with Bernard Smith in 1962 about his early years in Australia (Nolan & Smith 1962). There are references to specific materials within a body of correspondence he engaged in with Sunday Reed during his time in the Australian Army 1942 to 1944 (Nolan 1942-44). Diaries kept by Sunday Reed during this same period are also valuable records (Reed 1942; Reed 1943). The extant painting materials, including labelled cans and receipts for materials left in his Wahroonga studio on his departure for the UK in 1953, are informative as they provide insight into the products Nolan used (Appendix ii). The visual examination of Nolan's paintings, inscriptions, labels and details of supports and process are also key pieces of evidence of Nolan's practice. Bringing these dispersed records of evidence together, this chapter lays a solid contextual foundation for the identification of key issues and questions that might be answered by the analytical examination of the materials left in the Wahroonga studio (Chapter 4) and the analytical results from paintings offered in Chapter 5.

2.2 Commercial artist 1930-1937

Sidney Nolan was born in Melbourne in 1917 and his childhood and youth coincided with the financial difficulties and privations of the interwar years. Despite these limitations, Nolan appeared to approach education and his early working life with a single minded determination to pursue his parallel interests in art making, writing and bicycle racing. At about ten years of age Nolan went to Brighton Technical School and then at the age of fourteen he transferred to Prahran Technical School in order to undertake more drawing classes than had been on offer at Brighton (Nolan & Smith 1962).

Sidney Nolan's technical education and first jobs were in the area of advertising art (Nolan & Smith 1962). This equipped him with a rich practical experience of commercial paint products and techniques, not strictly the province of fine art painters. While the lack of artistic training may have been a limitation in Nolan's painting career, the influence of his commercial art background equipped him with a different sort of knowledge regarding painting techniques and materials.

His first job at fourteen years of age, in about 1931, was with a company called Solaflex, making commercial signs for cars. Recalling this work in 1962, Nolan said that his job with Solaflex involved cutting letters out of lead foil which were then used to mask up glass panels (Nolan & Smith 1962). The glass panels were spray painted with transparent enamel and fitted into mirror backed boxes attached to the tops of commercial cars (Figure 14). Sunlight or car head lights at night would then 'illuminate' the letters as the light was reflected back through the lettering by the mirror. Recalling his time at Solaflex, Nolan stated that he had 'pilfered a great deal of transparent enamel paint with which I painted a number of paintings years later' (Nolan & Smith 1962). Nolan stated that his ongoing interest in transparent paint was a result of this formative early experience at Solaflex painting on glass.

Figure 14. Advertisement for Solaflex, *The Argus* February 10, 1928 p. 16

After the collapse of the Solaflex Company, some time in 1932, Nolan had a number of short term jobs including a period working for Leyshon White (1894-1962) who ran an art studio and art school called the Melbourne Technical Correspondence School. It was however a job which Nolan started in 1933 in the art display department of the Fayrefield Hat Company in Abbotsford that gave him a more thorough grounding in commercial art practice and materials (Figure 15). Nolan's work at the Fayrefield Hat Company included many 'spray gun things' (Nolan & Smith 1962). The 1930s was the decade of the spray gun due to the popularity of nitrocellulose lacquer paints. Nitrocellulose paints were usually applied by spray rather than brush due to the fast evaporation of the solvent carrier that made achieving an even finish with brush difficult. It would have been nitrocellulose paint therefore that Nolan was referring to when he talked of 'spray gun things. Nolan's work in advertising and display art in the 1930s initially fulfilled his need to make art, and he wanted to pursue other interests, poetry and writing, ' ...my art set up you see was in a way satisfied by the commercial art aspect of it' (Nolan & Smith 1962).

Figure 15. Display of men's hats, Brisbane, c. 1937, John Oxley Library, State Library of Queensland

It was an epiphany Nolan experienced in 1937 after seeing reproductions of works by Vincent van Gogh (1853-1890) and Picasso that changed his focus, and he was afterwards attacked by a passion for abstraction, modernism and the desire to become an artist.

> Almost everything happens in the same year I think. About ’37. And I became intolerable about it. Looking back on it you know, I shoved it down everybody’s throat. I would, I was sent, I got the message. And it was quite multiple. I mean the distance between van Gogh and Picasso and everything else all came in six months. The whole changeover you know. I can’t describe it, but I became obsessive about it.
> Nolan 1962 (Nolan & Smith 1962)

After leaving Fayrefield Hats in late 1937, Nolan actively sought a patron for financial support in order to establish himself in a new artistic career. This financial and creative support he found in the Reeds, John and Sunday. It is in the year following that Nolan met and befriended other artists known to the Reeds including Albert Tucker, Joy Hester and Arthur Boyd. Albert Tucker was a strong technical influence on Nolan. They discovered they had both worked at Fayrefield Hats in the display advertising area. As they later realised, Nolan had started at Fayrefield Hats shortly after Tucker left in 1933. It was from the older artist, that Nolan sought answers for his technical questions. In writing to Sunday Reed later in 1943, Nolan deferred to Tucker's knowledge on technical matters saying, in regard to priming paint he had just purchased, 'I expect you will have to ask Bert if it is worthwhile' (Nolan 4 February 1943). It was also Tucker who introduced Nolan to Max Doerner *The materials of the artist and their use in paintings with notes on the techniques of the Old Masters*, first published in 1934 and which Nolan was said to carry with him wherever he went (Kubik 2006). And it may have indeed been Tucker who first experimented with the alkyd-based Dulux as a paint medium and engaged Nolan's interest in its use. A photograph of a painting by Albert Tucker pasted in a scrapbook of his work is titled; 'Dulux painting in possession [of] Guy Reynolds Oct '40 Melbourne' (Figure 16) (Tucker October 1940).

Figure 16. Albert Tucker, *Dulux painting in possession [of] Guy Reynolds Oct '40 Melbourne*. Collection of contact prints, depicting aspects of the artist's life and the artistic community in Melbourne 1930-1945. Heide Museum of Modern Art and State Library of Victoria.

Arthur Boyd was another artist in the 'Heide' group who had previous experience with commercial paints, but in Boyd's case it was through working in a paint factory. This appears to have equipped Boyd with the confidence to make his own oil paint from 1940. Using a pottery wheel which he adapted as a paint grinder and purchasing dry mineral pigments from pottery suppliers he knew through his father's work and synthetic coal-tar pigments from Imperial Chemical Industries (I.C.I.), Boyd applied a depth of technical knowledge of paints that would have contributed substantially to the Heide group experiments (Boyd 9 August 1983).

2.3 Picasso and the 1939 Herald Exhibition of Modern Art

The discussion regarding the influence of the work of Pablo Picasso (1881-1973) is central to Nolan's early painting development, but perhaps Nolan himself became weary of the comparison. In recollecting the effect of seeing paintings by Pablo Picasso in the 1939 Herald Exhibition of Modern Art, Nolan appears to have barely recalled them amongst works by other artists.

> I remember a Sutherland there, quite well, for instance. Kind of Wales or not Wales. Quite a big one, a tawny one. Some other extraordinary Dali's we saw for the first time, painting on the blood drops and things. The Picasso's I think yeah and the Bonnard's I rather thought were, I was against them in principle but I loved them nevertheless, you know what I mean?
> Nolan 1962 (Nolan & Smith 1962)

The Herald Exhibition of French and British Contemporary Art, shown in Melbourne in 1939, has been attributed to exposing local artists for the first time to the work of major European modern painters such as Picasso, Braque, Paul Cezanne (1839-1906) and Henri Matisse (1869-1954). However in an extensively researched book on the exhibition, some of the mythology regarding its influence on Australian artists is re-examined and the authors argue that it was just one of a number of avenues for Australian artists to absorb the works of European modern artists prior to the Second World War (Chanin & Miller 2005).

In support of this notion, Nolan said that he had seen prints of works by a number of French artists including van Gogh and Picasso before viewing paintings by those two artists at the 1939 Herald exhibition of Modern Art. In fact he insists that by the time he saw them in this exhibition he was already committed to the cause of abstraction.

> As soon as I saw-I can remember the first thing I saw of van Gogh's it was a small half plate reproduction, about two inches by two inches in a book someone had up at the Gallery, and it was of some cottages and the roof kind of tilted-and the moment I saw it, the fact that the roof had been tilted out of the familiar, you know, I got it instantly. It was just like meeting somebody. So that was my position, about '37 of feeling the revolution from abroad in its purest and most violent form.
>
> Nolan 1962 (Nolan & Smith 1962)

It is not easy to corroborate if the Herald show, as Nolan's first opportunity to see the radical use of surface texture and gloss in paintings by Picasso as compared with printed reproductions, had a powerful affect on him. There were nine paintings by Picasso in the exhibition but not all the works were illustrated in the catalogue and their current locations have not all been determined in order to enable retrospective examination. One work by Picasso *Guitare et vase de* fleurs, 1934 (collection: St Louis Art Museum) was featured in a number of press photographs of the exhibition (Figure 17)

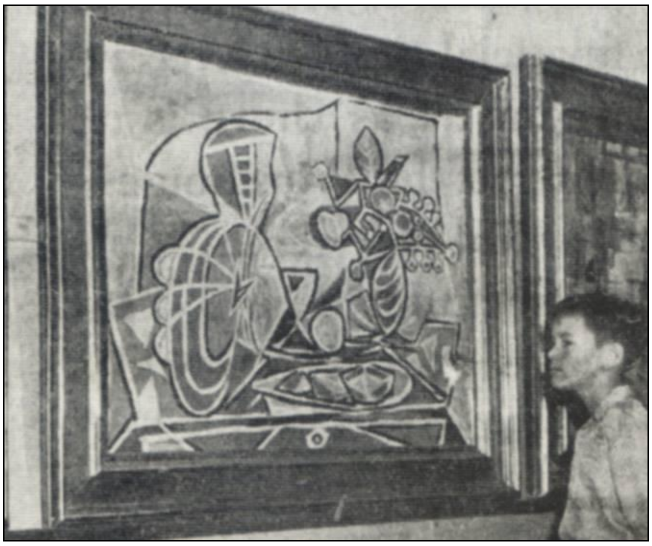


Figure 17. Sunday Telegraph, School boys assessing modern art, (reproduced in Chanin, E. & Miller, S. 2005, p. 19)

It is a startling painting which it is hard to imagine would not have impressed Nolan (Figure 18). Without examining the work in life, however, it is not possible to comment on the textural effects of paint that Nolan would have observed first hand in 1939.

Figure 18. Pablo Picasso, *Guitare et vase de fleurs, (Mandolin and vase of flowers)*, 1934, oil on canvas, 81.9 x 100.3cm. Collection: St Louis Art Museum, Saint Louis, (purchased 1944 from Paul Rosenberg). © Estate of Pablo Picasso/Artists Rights Society (ARS), New York.

Even though Nolan minimised the impact the Picasso paintings had on him when recalling the show in 1962, he openly acknowledged the influence of Picasso's use of the Ripolin brand of paint as a painting medium.

> I read that Picasso had said that Ripolin was a healthy paint and I thought, well why should I bugger around and torment myself and a wise man says its healthy paint. Okay, so Ripolin it had to be.
> Nolan 1962 (Nolan & Smith 1962).

Nolan's noting that Ripolin was healthy paint was a reference to Gertrude Stein's *Autobiography of Alice B. Toklas* first published in 1933, in which she wrote that Picasso had said Ripolin was 'la santé des couleurs, that is they are the basis of good health for paints' (Stein 1955, p. 141). Nolan probably already knew something of Ripolin through his commercial art background. The endorsement of that particular paint brand by Picasso would have found resonance in his already well-developed affection for commercial paints.

2.4 The theatre and other early works 1939-1940

In 1939 Nolan was commissioned by The Original Ballet Russe to design the set and costumes for a new one act ballet *Icare* to be performed during their Australian tour. A collection of photographs of the Icare performance in 1940 by Hugh Hall gives some sense of Nolan's set and costumes (Figure 19). Unfortunately, in black and white it is impossible to determine if any background colour exists on the set, or detect any type of surface finish that might suggest the use of gloss paint. According to Brian Adams (1987 p. 49) the Sydney artist Frank Hinder (1906-1992) assisted Nolan in the painting of the set. Frank Hinder was another artist engaged in the use of household paints, although his interests appear to have been more in the area of matte internal paints such as distemper and casein (McCarthy 2004).

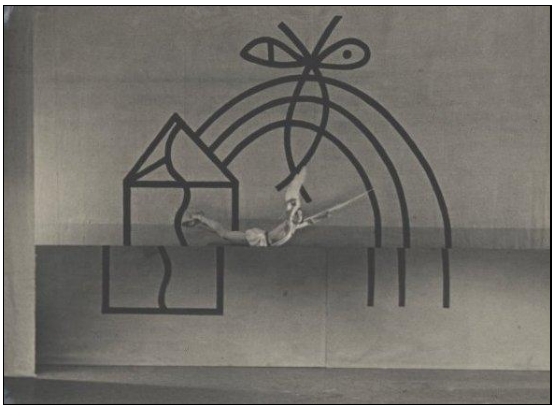


Figure 19. Hugh P. Hall, *Roman Jasinsky as Icare, in Icare, The Original Ballet Russe, Australian tour, His Majesty's Theatre, Melbourne, May 1940*. Black and white photographic print, 19.5 x 24.8cm. Collection: National Library of Australia

An early version of the composition and ideas for the theatre set for *Icare* by Nolan can be seen in a number of drawings and works on paper including an ink drawing with pencil notations (Figure 20). *Untitled-abstract*, offers an additional work in the series that developed Nolan's ideas for the *Icare* set (Figure 7).

Figure 20. Sidney Nolan, *'Icare' - Design for the ballet,* March 1939, ink on paper. Collection: Private © Trustees of the Sidney Nolan Trust

When compared with the drawings of the *Icare* subject by Nolan, the association of the unattributed work to Nolan is made clear. The painted elements of this work are applied over an older photograph that can be more readily viewed in reflected infrared light, and suggests the sitter is wearing a Victorian era dress dating from the late nineteenth century (Figure 21). When the painting is rotated ninety degrees, the photograph under the paint layer can be seen to have guided the composition of the painted layers. This is particularly the case in the use of the sitter's left eye, which the artist has allowed to be seen in the centre of the composition and is retained in the ink drawing. The sun shape at the upper left of *Untitled-abstract* is also seen in the drawing for the set shown in Figure 20. The use of a found image, in this instance an old photograph, as both support for a painted layer and also retained elements from the lower image, are a common technique used by Nolan in this early period. The evolution of the composition from the *Untitled-abstract* painted photograph into the set design for *Icare* gives strong evidence for the authorship by Nolan of *Untitled-abstract*. *Untitled-abstract* is potentially, with formal acceptance of the attribution, the earliest work by Nolan in the collection of the Art Gallery of New South Wales.

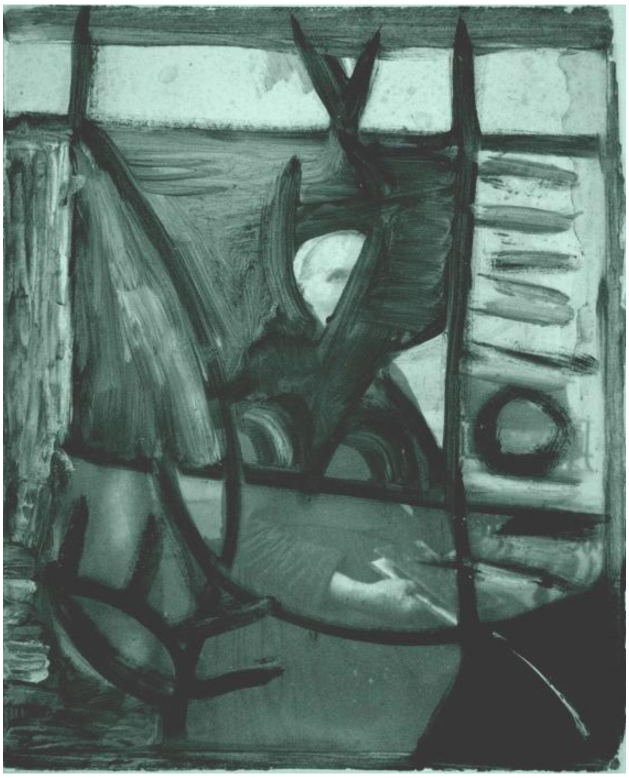


Figure 21. Reflected infrared image of *Untitled-abstract* rotated 90 degrees to orient photographic image. Photo: Paula Dredge and Art Gallery of New South Wales

The paint film on *Untitled-abstract* is of a hard, thick, paste type that has retained the brush application texture in a way generally associated with the use of standard artists' tube oil paint. Nolan's work in designing the set for *Icare* was done while he was living with his wife Elizabeth Nolan at Ocean Grove on the Mornington Peninsula. Elizabeth Nolan was also a painter and had trained at the National Gallery of Victoria School. During the time at Ocean Grove the two shared a studio in their house. Elizabeth Nolan would have been using artists' oils and no doubt the two would have shared materials.

The paint film on *Untitled-abstract* bears some similarity in appearance to that used on another work by Nolan from this same period, *Head of Rimbaud* (collection: Heide Museum of Modern Art) (Figure 22). It also exhibits the typical paste-like, thick build-up of artists' oil paint although it appears to have been applied in this instance with a tool such as a palette knife. When examined in 2011 the coloured paint film on *Head of Rimbaud* was extremely hard, as expected for a pigment-rich artists' oil paint.

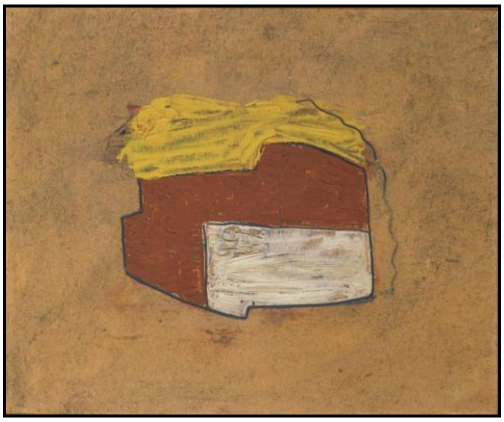


Figure 22. Sidney Nolan, *Head of Rimbaud*, 1938-39, oil and boot polish and pencil on cardboard, 26.9 x 34.3cm. Collection: Heide Museum of Modern Art, Melbourne. Purchased from John and Sunday Reed 1980. © Trustees of the Sidney Nolan Trust

According to Nolan's biographer, Adams the background of *Head of Rimbaud* was smeared with shoe polish (Adams 1987). In describing Head of Rimbaud he says; '…looking like an abstract three-tiered cake, painted on cardboard with a background rendered in Kiwi boot polish, an innovative device that gave the effect of a rich stain when rubbed into the surface.' (Adams 1987, p. 43.) The smeared appearance of some of the pencil lines and the background would support this description, but if the boot polish was originally tinted, the colour has since faded.

Nolan was interested in unorthodox materials for painting in this early period and saw the inevitable deterioration of the materials as a kind of fey liberation.

> …I was using boot blackening and everything under the sun because I believed at that stage that the more perishable the materials or more unstable the better. So there are practically months and months of work on tissue paper, with the deliberate intention that, because I liked doing it, but also the perverse kind of thing that ultimately it must perish, you know, for sure; that kind of attitude.
> Nolan 1962 (Nolan & Smith 1962)

2.5 Gloss paint and recycled supports 1940-1942

War was declared in September 1939 and Nolan, who had been living at Ocean Grove, moved back to Melbourne. Working nights in a hamburger restaurant, Nolan continued painting in his spare time. In 1940 he held his first exhibition in his studio above a greengrocer's shop at 325 Russell Street. Nolan describes this exhibition of two hundred items as completely abstract, with 'thousands of little bits of scribbly paper and everything all over the place…' (Nolan & Smith 1962).

Nolan was an admirer of the Mexican/American artist David Siqueiros. In the 1930s Siqueiros had taken up painting in glossy nitrocellulose lacquer, enjoying the paint's pedigree deriving from the explosives industry and its commercial and industrial roots. In 1936-7 Siqueiros ran a number of experimental workshops in New York to teach other artists, including a young Jackson Pollock, the method of painting with this fast drying liquid medium. Nitrocellulose lacquer was poured and spray applied through stencils. In 1939 Siqueiros held a well publicised New York exhibition of his spray painted Duco paintings which was reviewed in January 1940 ('Air brushed pictures in Duco' 1940, Art News, vol. 38, 13 January, p. 12). It was January 1940 that Nolan first painted in gloss paint mediums on the slate tiles from the roof of his studio. We do not know exactly what international art magazines the Reeds subscribed to in 1940 as the Heide library was no longer intact after their deaths, but Nolan's conversion to commercial gloss paints is striking for its timing coinciding as it did with the Siquerios Duco exhibition and its subsequent international reviews.

In addition to the use of gloss paint mediums, Nolan continued the practice of painting on recycled supports with pre-existing images. *Abstract (St Kilda reflections)* c. 1939, (collection: Heide Museum of Modern Art) is painted on a piece of plywood salvaged from a box (Figure 23). The nails retained along both vertical edges, (not unlike the tacks along the sides of a conventional artist's stretched canvas), deliberately betray the recycled nature of the support. Nolan has used the stencilled black and white paint from the original box and applied his own paint in the pale blue sea and the black lines of the piers. Nolan's applied paint layers are in a gloss paint applied by brush with soft flowed edges, whereas the pre-existing white and black background areas are in a matte paint and are sharply delineated. This painting would appear to be one of the earliest examples of Nolan's use of gloss paint. The painting is unvarnished and allows for surface distinction between the matte pre-painted areas of white and black, and the glossy blue and black paints applied by Nolan. The catalogued paint medium description given to this painting is Ripolin, however, this has not been analytically tested.

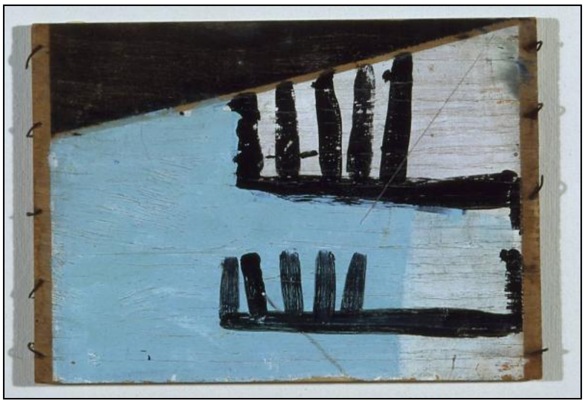


Figure 23. Sidney Nolan *Abstract (St Kilda reflections)* c. 1939, Ripolin on board, 19 x 27cm. Collection: Heide Museum of Modern Art. © Trustees of the Sidney Nolan Trust

Another painting from the Heide Museum of Modern Art collection more effectively hides its recycled support, which is revealed only by careful examination of the differences in paint texture, application and colour. *Untitled (Big Dipper)* c. 1941 (collection: Heide Museum of Modern Art) appears to be painted on a canvas with another painting underneath (Figure 24). This lower painting is in brown paint colours carefully applied with a small, flat brush. The lower paint medium holds the stiff texture of the brush application suggesting an artists' oil paint. It is painted on an artists' quality canvas with a commercially prepared ground layer. The use of an artists' prepared canvas is in itself unusual on paintings by Nolan, and gives some clues as to its 'second-hand' status.

Figure 24. Sidney Nolan *Untitled (Big Dipper)* c. 1941, enamel on canvas, 35 x 40cm. Collection: Heide Museum of Modern Art. © Trustees of the Sidney Nolan Trust

The lower painting, visible through the archways of the Luna Park Big Dipper roller coaster, suggests flowers with radiating petals and black centres and is in contrast to the brightly coloured gloss paint layers applied by Nolan. It is probable that Nolan used another artist's painting for his own because it was a good quality support and rather than hiding the previous artist's work Nolan has incorporated elements of the pre-existing painting into his own image as he had done in *Untitled-abstract* and *Abstract (St. Kilda reflections)*.

As the Second World War progressed into 1942, Nolan's preference for recycled supports and commercial gloss paint products became a versatile and necessary strategy as his circumstances became more constricted and supplies more difficult to procure. Nolan's interest in transient and fugitive materials was however changing and he began to value more durable options.

2.6 The Army and the Wimmera 1942-1944

Nolan was drafted into the Army on April 15, 1942. He spent several weeks in training at Seymour then was sent as a Private in the Supply and Personnel Column to Western Victoria, to the area known as the Wimmera. Although his tasks seem to vary, letters written to Sunday Reed over the period 1942 to 1944 suggest he was mostly guarding supplies. Through 1942 Nolan moved around travelling between Horsham, Ballarat, Dimboola and Hurstbridge with occasional weekends on leave back in Melbourne with the Reeds. He had separated from his wife Elizabeth and

Sunday Reed had become his lover and painting assistant. Regular letters to Sunday Reed are filled with thoughts of the heart, longing to be with her, descriptions of the country and Nolan's explorations within it. The Wimmera although blasting hot in summer and cold in winter, appealed to Nolan and he writes of walking in the evenings, his love of the line of mountains on the horizon, the bird life and the colour of places. The unusual red colour of the water hole at Nhill caused by red algae (now a site for producing a distinctive pink table salt) held particular interest.

> Darling found a very exciting color tonight. On the swamp there are acres of an underwater plant or moss growing. As it projects above the surface it becomes a beautiful dull red much like those layers of color you found in the dam. From the distance it becomes very intense. The same sort of feeling as the purple of the desert. It is a primeval(?) carpet if ever there was one. Hundreds of what I should think are wild duck are sitting in it & starting up leaving trails of water through the color. Also saw four lovely herons. Sitting on stumps out in the middle with soft grey wings & flying up showing their yellow feet. No other birds I can name but I think there must be lots here. Country in many ways is different, perhaps it is the continual gray skies & cold, but I think the Wimmera country reached its height about Dimboola. The flour mill is more flimsy than the silos, maybe a more practical shape to live in though, from up on the road by the swamp this evening, the sun caught it & it showed up like a white ship with the trees around it very dark & green as they get when the sun is setting. Still quietly awaiting my leave. Love from a lovely rogue
> (Nolan 17 January 1943)

Nolan writes often to Sunday Reed of his efforts towards being reassigned as a war artist. In addition to giving him a non-combatant role, this would have enabled him to be engaged fully with painting and have access to difficult to obtain art materials. All efforts towards this aim were to come to nothing. In August 1942 writing from Horsham he expresses relief at being at least engaged to camouflage trucks.

> On the move again darling end by being a gypsy painter. Down to Ballarat while the results of the report go through whatever they are. Camouflaging trucks I [thank] God to believe. Well I feel its a start anyway & the break here had to come.
> (Nolan August 1942)

Despite Nolan being unable to find a professional role within the Army for his artistic skills he was painting his own works prolifically during the period of his service. In the first six months these efforts were principally in the more portable mediums of watercolour, chalk, and ink on paper. A record of Nolan's production and his paint mediums during this period is provided by information in Nolan's letters to Sunday Reed (Nolan 1942-44), but also in several diaries from 1942 and 1943 in which Reed recorded the works that Nolan sent to her from the Army (Figure 25) (Reed 1942; Reed 1943).

Figure 25. Sunday Reed's diaries for 1942 and 1943. Collection: State Library of Victoria. John and Sunday Reed papers. MS 13186 Box 6/18 Folder 9 and Box 8/18/ Folder 9

The two diaries from 1943 have previously been catalogued as recording the materials that Sunday Reed sent to Nolan, but there are very few such entries. More consistently they note the date that letters arrived from Nolan, the telephone calls she received from him, his whereabouts and leave, and importantly for this research, the date Reed received paintings from Nolan, titles, dimensions and medium descriptions (Figure 26). The diary from 1942 was catalogued as belonging to Nolan, but comparison of handwriting style and content demonstrates that this diary is also Sunday Reed's, recording Nolan's movements and paintings.

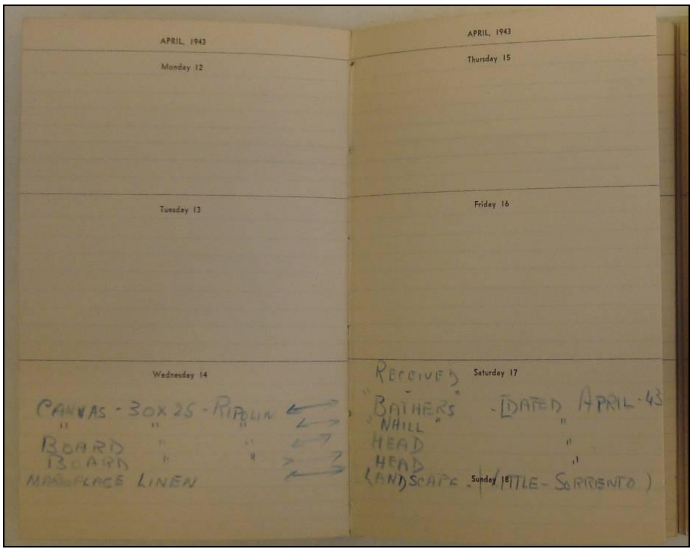


Figure 26. Sunday Reed diary 1943. Entry for April 1943. John and Sunday Reed papers MS 13186 Box 6/18 Folder 9

Beginning her first entry on April 15, 1942 with the declaration, 'Nolan went to war', Sunday Reed went on to note under the date headings in the diary, paintings and drawings sent to her from Nolan for safe keeping (Reed 1942). These entries from December 1942 also include the dimensions and mediums for each work. The detail of these records allows a correlation to be established between Nolan's paintings from this period and their dates and mediums as recorded by Reed. A listing of the diary entries from 31 October 1942 to May 1943 with matches with paintings is provided as Appendix i[5].

Beginning in August 1942 there is a suggestion that Nolan is beginning to paint in solvent-based paints on a small scale as he sends three small black and white paintings on tin to Sunday Reed on 24 August (Reed 1942). On 8 September Sunday Reed notes 'received lacquer and sketchbook' suggesting that she may have sent him some solvent-based paint, possibly nitrocellulose, and on 26 September she notes a painting in lacquer on the back of an envelope. While a number of small paintings are described as being received through October, it isn't until the end of October that Sunday Reed begins specifically to note the medium and titles of works. The first of these is on 26 October in which she notes he is painting 'Going to school' and several small lacquers (Reed 1942, entry for 26 October). On 31 October 1942 she lists a work titled 'Lightning' which she also describes as a lacquer (Reed 1942 entry for 31

[5] The large number of works on paper are not included as they do not form a direct part of this study.

October). This diary entry is a good match with a work in the collection of the Heide Museum of Modern Art called *Lightning, Dimboola* 1942 which has an inscribed date '31-10-42' (Figure 27). Whether Reed in these early records is referring to nitrocellulose paint which is specifically a ***lacquer*** remains unclear until these paintings have been analytically tested.

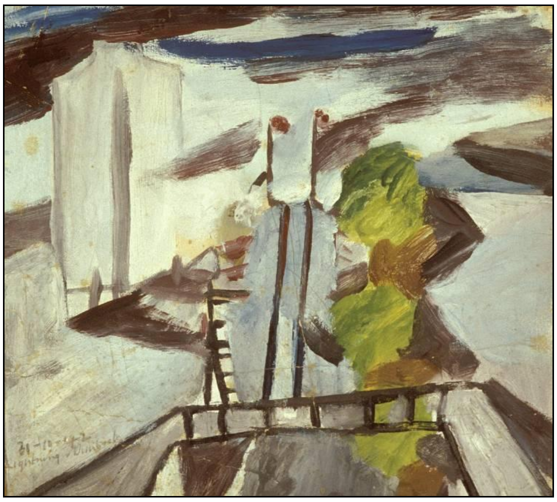


Figure 27. Sidney Nolan, *Lightning Dimboola*, 31st October 1942, synthetic polymer paint on paper. Collection: Heide Museum of Modern Art. Bequest of John and Sunday Reed 1982. © Trustees of the Sidney Nolan Trust

The decision to start painting in solvent-based mediums in October 1942 corresponded with a change in Nolan's army circumstances. His move to Dimboola in October 1942 marked his promotion to Lance Corporal. His new, more settled lodgings, assisted possibly by the advance in ranking, enabled him to start to paint in media that required a more permanent setup. Shortly after arriving in Dimboola, Nolan advises Sunday Reed; '…I wrote to Ron to ask Bilby to bring my paints with him. There is a room next to the office here empty & I can start all over again, travelling painter no 1.' (Nolan c. October 1942, p. 1).

Shorty after settling into Dimboola in October 1942 Nolan asks Sunday Reed to try to find some supplies of Dulux. He suggests she purchase just the three primary colours and black and white.

> Their three best colors, strongest, brightest, are lemon yellow, cobalt blue & the red I've forgotten but you can tell it easily enough on the color card. Those three colors & black & white & thinner give a pretty complete range.
> (Nolan 27 October 1942, p. 2)

If not Dulux, then he suggests another brand of gloss paint might be Dynamel (manufactured by Taubmans). Sunday Reed must have succeeded in locating Dulux for Nolan as she records in her diary the arrival of the first works painted in Dulux on 9 December 1942 (Reed 1942). According to Reed's diary these Dulux paintings continued to arrive at Heide through December 1942 and January 1943.

Considerable difficulties were faced by Nolan and Sunday Reed in obtaining not just paint, but canvas and boards to paint on, as well as brushes at this stage of the war. By 1942, as discussed in detail in Chapter 3, pre-wartime stock had began to dry up, and the reduction in import and local production made obtaining materials and tools problematic. British art material manufacturers that supplied the Australian market, such as Winsor & Newton and Rowney, were in extremely limited production during the war as these industries were switched to essential war supply. The house paint industry was also severely curtailed as supplying paint for war equipment became the higher priority and supplies for local painting were regulated. The making of paint using synthetic resins such as alkyd and nitrocellulose for domestic use was prohibited as was the import of ready-mixed paints under the *Commonwealth Paint Orders* issued in January 1942 (Australian Government 1942). Nolan's tendency to stockpile large quantities of paint throughout his life may have been a result of these difficulties during the Second World War. 'The ripolin is going to go a long way I think but I have in the back of me the feeling we are going to need a lot of color before the new age.' (Nolan 4 February 1943 p.1)

Limitations of supply appear to have spurred Nolan and Sunday Reed into action as they scoured hardware and paint shops and salvaged wood and Masonite® in their determination to find the materials Nolan needed for painting. The most miraculous success of all was the location of a supply of the high quality Ripolin enamel paint in

January 1943. Beginning in October 1942, Nolan suggests to Sunday Reed that they begin to look for a supply of Ripolin paint.

> There must be a stock of Ripolin somewhere in the country, there was a Ripolin House in Sydney, but Bert [Albert Tucker] said they were no go. If you could get their adress [sic] from him I'll give them a fling anyway. However Dulux it is right now.
> (Nolan c. October 1942)

Success in their quest was announced by December as Nolan wrote 'You must have had a long job with priming all the masonite & now the ripolin has arrived…' (Nolan c. December 1942 p. 3). A month later Nolan, now living in Nhill, wrote to Sunday Reed saying that he had the Ripolin in hand. 'I collected the canvasses [sic] this morning from the station this morning [sic] but I am almost frightened to open the ripolin in case it disappears in a cloud of fumes.' (Nolan 31 January 1943)

In the midst of the Second World War it was remarkable that a supply of Ripolin was available anywhere in Australia and it is probable that Nolan's Ripolin paint was old stock. The most likely source for the Ripolin was in fact, as Albert Tucker had suggested, Ripolin House. The Australian distributor for Ripolin paint from at least the 1910s was Lindsay McCormick in Sydney who owned Ripolin House at 25-27 Clarence Street from 1930 (Sands 1930). He was still in business at the same address in 1939 offering Ripolin paint at a discount, suggesting there was at least good stock in Australia at the outbreak of war (Figure 28).

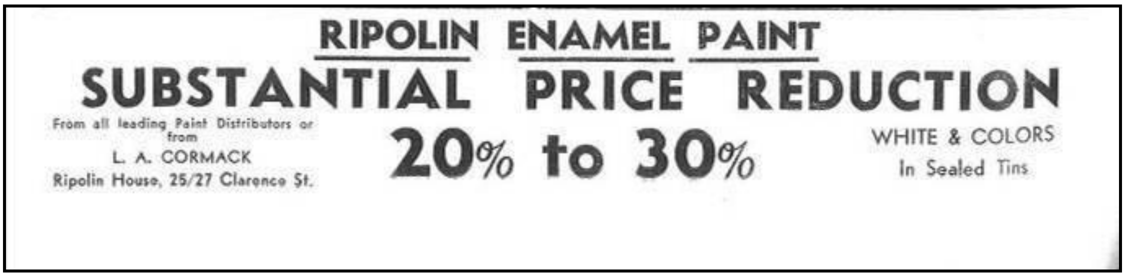


Figure 28. Decorator & painter for Australia & New Zealand, 10 March 1939, p. 186.

Nolan began work in early February 1943 with his new paint medium, writing to Sunday Reed.

> You should have been here for the unveiling of the ripolin. Perhaps it is going to take longer to paint good pictures now, it seems like it when you have to dig deeper & perhaps it will be a while before I really know the paint. But the paint itself will take all the discipline in the world. Someday I feel I know what paintings will come from it. (Nolan 2 February 1943 pp. 1-2)

This shift from Dulux to Ripolin as Nolan's principal media for painting from February 1943 is also documented in one of Sunday Reed's 1943 diaries in which the media descriptions of paintings received are noted. These are invariably Dulux from 9 December 1942 through to January 1943 but from February 1943 there is a change to Ripolin as the only medium recorded up to the end of the entries on 17 April 1943 (Reed 1943)[6].

The Ripolin paint was both inspiring and difficult for Nolan. It required a new way of working as it was slower to dry than the nitrocellulose and alkyd paints he had used previously. He had to leave paintings drying flat for days in front of a small heater, which was frustrating as he preferred to work more quickly. Of his first painting in Ripolin he said, 'Finished one & there appears to be the beginning of a glow that Ripolin can give. But I bit my teeth on lacquer & the change over is really quite considerable' (Nolan 9 February 1943, p. 2).

The idea of Nolan using Ripolin paint prior to 1943 was so strongly held by Nolan researchers that when Burke describes Reed's diary entry for the 5 of February 1943, 'painted first Ripolin canvas' (Reed 1943), she interprets its significance as a

[6] In this sudden shift to a new medium as a result of receiving the consignment of Ripolin paint, there is a critical confusion in the record of dates in Reed's diary entries. On the 8th of January 1943 she notes 'received first Ripolin Nhill dated 43 canvas 23' x 25'' (Reed 1943). This is the month before Nolan writes he had received the Ripolin and is about to start work with it (Nolan 31st January 1943). In fact Nolan was not transferred to Nhill, the subject of this painting, until the 14th of January and so this diary entry is unlikely to be correct (Reed 1943, entry 14th January). A second diary kept by Reed for 1943 offers a more rational timeline. In this diary she records telephone conversations with Nolan and the letters she received from him, Nolan's leave and transfers and some paintings as they were received. On the 2nd February she writes 'painted first Ripolin canvas' and 5th of February 'First Ripolin painting arrived' (Reed 1943).

reference to Nolan's first painting on ***canvas,*** in contrast to other paintings he had done on cardboard or Masonite; not that it was his first painting in ***Ripolin*** (Burke 2005 p. 203). In fact Nolan had painted on canvas well before this date, (for example, *Untitled (Big Dipper)* c. 1941).

This search for an exact date for Nolan's first use of Ripolin might seem pedantic, but the longstanding tendency to assign the medium description Ripolin to all of Nolan's works in gloss paint from the 1940s, overlooks his more wide-ranging and radical use of locally made alkyd and nitrocellulose paints. The overuse of the Ripolin medium description is, in part, a problem created by Nolan himself. When interviewed in 1962 he was asked by Bernard Smith 'When did you start using Ripolin then Sid, remember?' Nolan replied 'Oh yes before I went into the army, just before probably, '42. More or less the first Ripolin I had went into the army with me I think, about a year before I suppose.' Asked where he obtained his stock from he said; 'From London' (Nolan & Smith 1962).

It is very unlikely that Nolan was able to import Ripolin paint directly from London during the war, but it is this recollected version of events, rather than the evidence contained in his correspondence with Sunday Reed and her diaries, that became the dominant version of events. Why Nolan might have obscured the details regarding his take up of Ripolin in this 1962 interview is not entirely clear. It may have been a poor recollection of dates and events, or a deliberate attempt to obscure Sunday Reed's close technical assistance in the wake of their unhappy relationship break up in 1947. Additionally at the time of this interview with Bernard Smith in 1962, Nolan was seeing his paintings dating from the early 1940s for the first time since he left Melbourne in 1947.

Inscribed 'March 1943' in Nolan's own hand, *Self portrait* (collection: Art Gallery of New South Wales) dates from soon after the arrival of the Ripolin in January (Figure 29). Although it is an early example of Nolan's shift in medium to Ripolin, it retains the use of the three primary colours along with black and white that Nolan had been using in the Dulux paints. This painting is probably the work described in Sunday Reed's diary as 'Head Nhill' which she received on 22 March 1943 and describes as 'Ripolin on hessian' (Reed 1943).

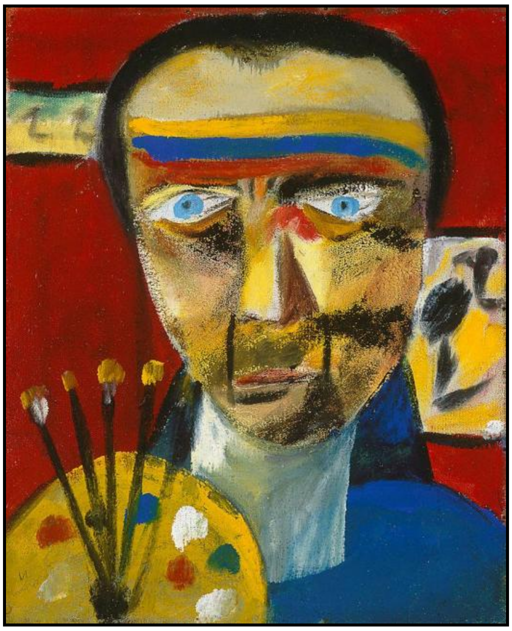


Figure 29. Sidney Nolan, *Self portrait*, 1943, ripolin enamel on canvas, 61.0 x 52.0cm. Collection: Art Gallery of New South Wales, purchased with funds provided by the Art Gallery Society of New South Wales 1997. © Trustees of the Sidney Nolan Trust

Ironically, a traditional artist's palette as depicted in this painting would have been impossible to use with the liquid Ripolin, particularly when held on a vertical plane as shown in *Self portrait*. The tendency of Ripolin to flow down surfaces is evidenced in this painting at the hair line where the black paint has dripped into the forehead, in this case softening the line between hair and skin in a surprisingly and convincing manner. Another unusual feature of the paint on this work is the apparent resistance and pooling of the black paint used as shadows applied over the lighter paint of the face, possibly after the lower paint layer had skinned and begun to dry. This is a problem caused by the surface drying of enamel paints and their inherent smoothness that resists liquids once dry. What might be considered paint defects are made into convincing assets in his early Ripolin painting *Self portrait*, but these serendipitous 'accidents' become far less common as Nolan became proficient with his new material.

Wartime supply difficulties not only affected the availability of paint for artists, but also of supports to paint on. In planning his return to solvent-based paint while in Dimboola in October 1942, Nolan wrote to Reed about supports.

> To be practical. I have hunted around here but there is no wood around to paint on, the lads have burnt any there might have been, so it is a good plan to send up whatever you can find in the way of cardboard for a start. (Nolan c. October 1942, p. 2)

Some successful scrounging of materials from the Army must have occurred as an ink stamp reading ‘Dept. War Organization of Industry’ on the handmade wooden strainer for *Self portrait* 1943, suggests that it was ‘reassigned’ from wartime use (Dredge 1999). The Department for the War Organization of Industry (WOI) assigned war production to industries while maintaining a sustainable level of civilian production (Department of War Organization of Industry 1943). It was established in October 1941 as the executive department of the Production Committee in the War Cabinet. Part of its strategy was to reduce varieties of products that existed in a free market, but were considered a drain on resources during wartime. For example, the department issued a simplification system of clothing and furniture styles. Linen was impossible to procure during the war, and cotton was one of the most regulated rations after food supplies. The WOI prohibited cuffs on trousers and ‘patch’ pockets on shirts to reduce material use. These restrictions on civilian use of cloth had an impact on artists during the period and lead to the common substitution of artists’ linen canvases with recycled boards and cloths as supports for painting.

Muslin, which Nolan had become partial to in 1943 as a textured surface stuck to a smooth board, was also extremely hard to obtain due to its assigned use as gauze dressing for wounds (Kubik 2006). Nolan, as always, was extremely resourceful and in 1943 was able to post a stock of muslin back to Sunday Reed for preparing supports for painting.

> I posted Mac’s novel today with six yards of muslin wrapped around it. Doctors certificates are required here for muslin but the man at the canvas place is anti Redman so he gave me the six yards. 7 ½ ^{d} yard. It doesn’t look very suitable but as its all I can get I took it in any case. Have to make cheese with it if it wont marouflage’
> (Nolan c. Autumn 1943, p. 1).

Boards made from pulped wood, such as Masonite, that Nolan was beginning to use along with cardboard, were difficult to find as it was assigned for use by the Australian Army to make shelters at the battle front, particularly in New Guinea. Masonite was manufactured in Australia from 1938 at a factory at Raymond Terrace, north of Sydney ('Masonite plant operating' 1938). Australian-made Masonite is easily distinguished from American and Swedish-made composition boards, by its dark colour, as the local product was manufactured from Eucalyptus hardwood, not pine as used in the USA and Europe (Algar 2000). Masonite's attraction for artists was its larger sizing and portability, particularly in the period when artists' canvases were expensive and difficult to find during the Second World War. Sunday Reed's success in finding two large sheets of Masonite in October 1942 was a cause for celebration and Nolan outlined for Reed very specific instructions for how best to cut one of the large sheets into as many useful, smaller pieces for painting without wastage (Nolan 27 October 1942).

It appears that Sunday Reed was very much hands on in not only cutting Masonite and procuring materials for Nolan during this period, but also in preparing the supports with priming layers which she would send to him on the train for painting. When Nolan found some white paint in a local hardware store in Nhill, he sent it directly to Sunday Reed to use for priming his supports.

> I got some white dulux primer which is different from the gray but it is a nessecaty [sic] to have plenty of it. I brought a tin of master painters white, liked the name probably, 90% lead & 10% [sic]. Old stock, there is no zinc now being put up. You can try it, if it is satisfactory I can get another ½ gal. Its not the same as titanium & zinc & fresh eggs I know, but we will have to allow some margin to get paint at all.
> (Nolan 4 February 1943, p. 1)

The suggestion in this letter that Nolan and Reed had previously made ground preparations with titanium and zinc white and egg is intriguing and warrants further investigation. Nolan's clear differentiation of the three white pigments then in use in commercial paints; titanium, lead and zinc, also suggests he was fully versed in the differences between these white pigments, used not only as priming layers, but also as the base for coloured paints.

A number of paintings by Nolan from this period are painted on grey priming layers such as *Dimboola* 1942 (Figure 30). There is a can of white Dulux primer that has been tinted grey in the Nolan studio contents at the National Gallery of Victoria and a can of Ripolin white paint tinted grey that all suggest their use by Nolan as priming paints.

Figure 30. Sidney Nolan, *Dimboola*, 5 December 1942, synthetic polymer on cardboard, 62 x 74.7cm. Collection: Heide Museum of Modern Art. © Trustees of the Sidney Nolan Trust

Other paintings from Nolan's Army period utilise brilliant matte white primings as the image layer that contrast with the high gloss finish of the coloured areas. This important visual contrast in surface is visible only on those paintings that retain their original unvarnished state such as *Bathers* 1943 (collection: Heide Museum of Modern Art). Ripolin paint was not only offered in a gloss, but also as a flat paint, and both types are present in the paints from the Wahroonga studio. What has previously been unacknowledged in Nolan practice is the deliberate use of both these types of Ripolin in his paintings, offering deliberate contrast between high-gloss and dense matte in his surfaces.

In addition to procuring materials, priming supports and keeping records, Sunday Reed turned her hand to making frames and arranging several exhibitions of Nolan's work in the window of Sheffield's, a general store in Heidelberg. Photographs of the second of these exhibitions in July 1944 show Sunday Reed leaning on a car near the display of Nolan's works, most of which are shown with simple light coloured frames (Figure 31). Letters to Reed from Nolan are sometimes addressed to 'Dear framemaker' and it appears that it may have been Reed's suggestion to frame Nolan's works flush with the front face of the frame. 'Frames are going to be a big point. The idea you had of putting the canvas flush with the frame sounds good' Nolan wrote to Reed in 1943 (Nolan 29 March 1943). Nolan also turned his hand to three-dimensional work, modelling a gun from a plastic compound called Nucraft™. This was exhibited in the Sheffield window, but fell apart and had to be removed.

Figure 31. 2nd Nolan exhibition at Sheffield's, Heidelberg, July 1944, Black and white photograph. Collection: National Gallery of Australia

The powerful effect of preparing supports for Nolan and receiving back paintings in luminous paint was recalled years later by John Reed in notes he made for an autobiography.

> S.[Sunday] used to prepare the canvasses [sic] & we wld.[would] send them up to him by train wrapped in hessian & they wld.[would] be retd.[returned] to us the same way, transfigured by N's [Nolan's] magic. With them wld.[would] come little sketch books filled with crayons to supplement the ptgs.[paintings]; but time was relatively short, & we had to wait a few more yrs.[years] before what was started in the W.[War] was continued & marvellously extended in the Kelly ptgs.[paintings]
> (J. Reed 1970s)

The paintings made while in the Army, limited as they were by circumstance and choice of materials, set Nolan on a technical pathway which he continued well after the war finished and other materials including artists' paints were once more available. In the midst of supply difficulties, Nolan wrote he would like some artists' tube paints, 'still a hankering after oil-color but I really feel it belongs with Rembrandt & Cezanne – or after the war' (Nolan c. October 1942 p.3). It seems that the attractions he found shortly afterwards in the cans of Ripolin paint sustained him for at least another decade.

2.7 Hiding out 1945-1947

In July 1944 Nolan absconded from the Army and went into hiding in Melbourne living both at the Reeds' house at Heidelberg, and in a warehouse in Parkville. If Nolan felt anxious about his illegal status it did not prevent him from exhibiting paintings at regular Contemporary Art exhibitions in Melbourne and Sydney. Nolan continued to paint with his now familiar Ripolin paint and photographs taken by Albert Tucker at the Parkville studio show his technique of propping up the painting slightly from the horizontal on the table (Figure 32). This method of working with paintings almost horizontal was necessitated by the liquid nature of the enamel paint which would run down the surface if worked with the painting in the traditional vertical orientation. Nolan justified his technique to Sunday Reed saying; 'all good painters work on the floor Sun' (Nolan 18 May 1943 cited in Burke 2005 p. 209)

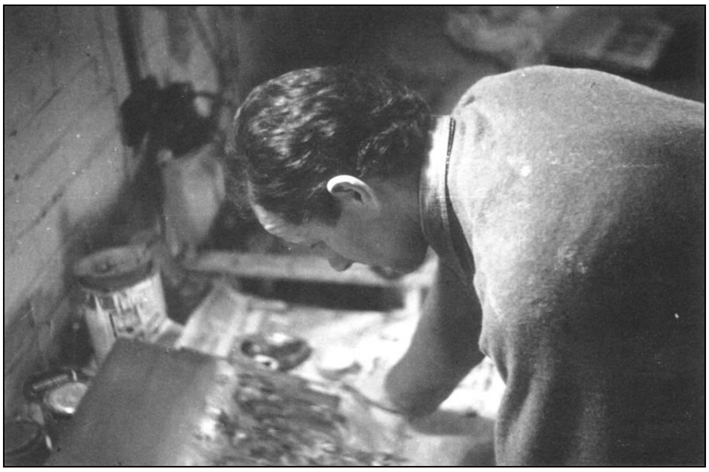


Figure 32. Albert Tucker, *Nolan looking at Dimboola in Parkville studio*, September 1944, contact print, Albert Tucker Photographic Collection, Heide Museum of Modern Art and State Library of Victoria, Melbourne, H2008.98

It would appear that the Ripolin paint settled many of Nolan's experiments with other paint media. It satisfied for some time what had been Nolan's quest for unorthodox materials, brilliant colour, high-gloss and liquid paint. When in 1946, he began to work on what was to become his iconic series of paintings on the subject of the bushranger Ned Kelly, Ripolin paint was central to the process. Several years of use had by that time cemented his experience and agility with this medium. It is easy, therefore, to presume this was his sole medium, but there are some clues to suggest he may not have been one hundred percent faithful to his closest technical ally.

Photographs of the house at Heide during this period show the outside of the house surrounded by glass jars filled with liquid (Figure 33). Janine Burke says these were bottles of linseed oil left in the sun to bleach (Burke 2004). Nolan's technical mentor, Max Doerner, is very positive about the virtues of sun-thickened linseed oil for painting. 'It gives colours an enamel-like character and permits' he says 'despite its viscidity, a great amount of technical freedom. Since it has already absorbed oxygen, it dries more quickly than ordinary linseed oil… It does not crack and is very elastic. The Old Masters knew well the great advantages of this oil, especially that it had lost all objectionable qualities before being introduced into the picture. Cennini calls it 'the best of all oils'. I could not give you anything better' (Doerner 1934 p. 105).

Figure 33. ***John Reed (behind window), Barrett Reid, Sunday Reed and Laurence Hope, Heide, December 1946. Courtesy Laurence Hope*** **(Reproduced in Janine Burke, In the Heart Garden, Sunday Reed and Heide, 2004, photos after page 136)**

Doerner's suggested technique for obtaining this thickened oil was to pour the oil into a shallow dish, allowing for the maximum exposure of the oil to the air (oxidation) as well as to the light and heat (polymerisation). It is hard to imagine how the oil in narrow necked bottles, as shown in Figure 33 would have offered enough surface area to allow the oxidation process to occur.

There is another technical guide which gives a recipe for sun drying of linseed oil that is a better fit with Nolan's use of narrow necked bottles. Ralph Mayer's *The artist's handbook of materials & techniques* was first published in 1940, and in that book he describes a method for sun-refined or sun-bleached oil. Mayer says that traditional techniques (such as those suggested by Doerner) use sun and air to oxidise, semi-polymerise and bleach the oil. However, the process of oxidation caused excessive thickening and yellowing. Instead he recommends retarding the oxidation by using a narrow-mouthed jar, while allowing for bleaching and polymerisation. He also suggests adding water to the oil in equal quantities and shaking the two together daily while leaving them exposed to the sun for a few weeks. In this way he says the water soluble mucilage and impurities are separate from the oil, and the bleaching and polymerisation 'increases its speed of drying and its levelling and protective qualities. It is therefore' he says, 'more suitable for clear varnish, or glaze and painting medium purposes' (Mayer 1970 p. 133). One can imagine that a paint additive that combined fast drying, self-levelling and good longevity would have been attractive to Nolan. It also suggests that his Ripolin paintings dating from 1946-47, including the Kelly series, may have sun-dried and thickened oil present either as an addition to the paint, or as glazing layers to which Nolan may have added his own pigments. Certainly there is evidence that while painting the Kelly series at Heide, Nolan was using oil as well as the Ripolin paint, as Barrett Reid recalled when visiting in late 1946: ‘the dining room was a studio, with tins of ripolin, bottles of oil, a scrubbed long table…’ (Barrett Reid 1967 cited in Burke 2005 p. 256).

When Nolan first started using the Ripolin paint in February 1943 he deliberately chose textured absorbent surfaces such as jute canvas, the rough side of Masonite panels and muslin glued to cardboard to imitate canvas texture for, he said; ‘the Ripolin washed in the muslin like watercolour’ (Nolan 12 January 1944). By 1946 Nolan had embraced the inherent qualities of the paint and was consistently choosing the smooth side of his Masonite supports or cardboard to give physically flat surfaces.

First class marksman 1946 (Figure 6) is typical in technique of the group of Kelly paintings. This work was the only one of the Kelly series not painted at Heide, but during Nolan’s short period minding Danila Vassilieff’s studio towards the end of 1946. It shares the deliberate and distinctive use of gloss and matte passages of paint with those other paintings. As this painting has never been varnished these critical surface variations are well preserved. The smooth side of the Masonite sheet was primed with a matte white paint used throughout the landscape as the image layer. Over this is worked the bushland in the middle ground in a matte paint, with final highlights rendered in gloss. The figure, hills and sky are all more densely worked in the gloss medium. The figure of Kelly himself is rendered in high gloss, opaque black paint with some wrinkling in the paint layer evident. The edges of this figure are sharply delineated and sit separate from the paint layers of the landscape as if the black paint was applied after the rest of the painting had dried. The features of the black paint on this work are different to those observed on Nolan’s *Self portrait* 1943, with no sign of paint resistance and pooling when applied over dry paint below, or blending and dripping when used into the wet paint layers (Figure 29).

2.8 Queensland and Sydney 1947-1953

On July 8 1947, Nolan, having completed the Kelly pictures, left Heide and began a trip to Queensland which was to take him to Sydney and a new life forged away from the Reeds. Some of his stock of Ripolin paint continued the journey with him. 'My 30lbs of Ripolin looks me in the eye every morning' Nolan said in writing back to Albert Tucker from Brisbane, 'soon have to start making it lighter' (Nolan 16 July 1947 cited in McCaughey 2006)

Nolan's travels in Queensland in 1947 included several weeks living on Fraser Island, and it is this experience and the story of the shipwreck survivor Eliza Fraser, which became the subject for a group of pictures he exhibited at Brisbane in 1948. A review of the exhibition by Elizabeth Webb was critical of Nolan's use of Masonite as a painting support. 'Mr Nolan's blatant extremism and what appears to be deliberate maltreatment of so much useful and hard-to-come-by building material (all his 'works' are on masonite).' (Webb 18 Feb 1948 cited in Clark 1987 p. 91). Nolan took this criticism badly, saying that he had in fact retrieved much of the Masonite from an abandoned building on Fraser Island. The painting *Fraser Island* 1947 (collection: Art Gallery of New South Wales) supports Nolan's version of reuse of Masonite, as a line of pre-existing nail holes is evident down the left and across the bottom edge (Figure 34).

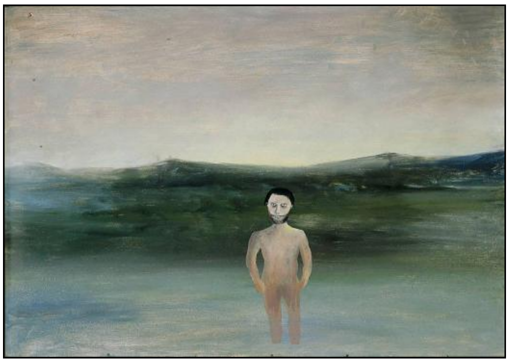


Figure 34. Sidney Nolan, *Fraser Island* 1947, Ripolin enamel on hardboard, 76 x 104cm. Collection: Art Gallery of New South Wales. Purchased with funds provided by the Art Gallery Society of New South Wales 2001. © Trustees of the Sidney Nolan Trust

In 1948 Nolan settled in Sydney and shortly after moved in with, and married Cynthia Reed, Sunday Reed's sister-in-law. Cynthia Reed and her daughter Jinx were living in

Wahroonga, a suburb on the northern side of Sydney Harbour. Nolan, Cynthia and Jinx, whom Nolan formally adopted, travelled extensively through Central, Northern and Western Australia in the years they lived in Sydney. Nolan had a number of successful exhibitions in Sydney deriving their subjects from these travels. In 1948 an amnesty for Army deserters was declared and Nolan received a dishonourable discharge.

2.9 The Wahroonga studio

In 1952, as building materials were still in short supply, Nolan began building a studio at the Wahroonga house from a deconstructed building he and Cynthia had purchased. Nolan worked at his home at Wahroonga Sydney from 1949 and studio (after it was reconstructed in 1952) until his departure for Britain in October 1953 (Pearce 2007). But the combination of a trip to Europe in 1952, the success of his Sydney exhibitions, and the support for his work given by a visit from the prominent art critic, Kenneth Clark, combined to draw Nolan and his family into making a permanent move to London. The house at Wahroonga was retained and the contents of the studio remained as a time capsule of Nolan's working materials until the house was sold by Jinx Nolan in 2006. Prior to the sale of the house, Jinx Nolan donated the contents of the studio to the Art Gallery of New South Wales, with a smaller selection going to the National Gallery of Victoria (Figure 5). Nolan never having returned to use the studio, the contents are a time capsule of his painting materials from the early 1950s. There are 120 items comprising cans of paint, thinners, oils, varnishes, driers, receipts, Masonite panels, inks, a colour chart and various jars and bottles of unlabelled material, in addition to a leather case with adapted screw-top metal canteens containing mixtures of paint.

The timing of Nolan's move to the UK and the closing of the Wahroonga studio in 1953 is a significant date marker for Nolan's use of materials as it predates his use of polyvinyl acetate (PVA) binders for paints and the development of synthetic emulsion paints based on vinyls and acrylics that became widely used by Nolan and other artists in the late 1950s. The period of Nolan's painting practice in Australia from 1938 to

1953 also represents an era of change for the commercial paint industry as new synthetic resins and pigments were rapidly developed.

While the cans from the Ripolin paint company comprise the greater part of the studio contents, with thirty-five cans of paint, a can of thinners for gloss paint and a filler paste, there are also a number of other types of commercial, household paints. There are no artists' quality paint, but several bottles of picture varnish and three small bottles of Talens® stand oil. Whether Nolan took some painting material from the studio with him on his departure in 1953, such as artists' paint which would have been small and easy to carry and expensive to replace, or whether he was entirely committed to the use of commercial and household paint during the period of the Wahroonga studio, is not known.

Evidence of Nolan's preparations for his move in 1953 and his anticipation of the need to find London suppliers for his favourite materials is found in a pencil inscription on the back of a chart for Surtint™ (SID 44209)[7]. The inscription in Nolan's hand reads; 'Ring Hatrick for English firm' suggesting Nolan was researching the English supply of some of his preferred commercial materials (Figure 35).

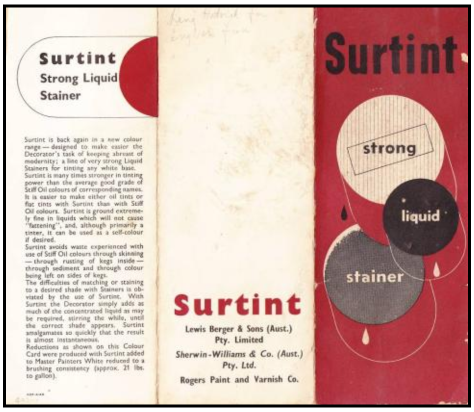


Figure 35. Colour chart for Surtint stainers. Collection: Sidney Nolan Wahroonga studio contents. Artists' Materials Archive, Art Gallery of New South Wales, SID 44209. Photo: Felicity Jenkins and Art Gallery of New South Wales

[7] The materials from the Nolan studio are individually catalogued with a system identification number (SID). The list of the studio contents with the SID numbers are given in Appendix ii.

The Wahroonga studio was closed after Nolan’s departure in 1953, but at least one can of paint from a later time has been merged into the material. This is a can of British Paints® undercoat, the contents of which are described in millilitres dating it to the period after the introduction of metric volumes and measures in Australia in 1971. It is possible that the studio continued to be used by Jinx Nolan to store materials used to paint the house, and this particular can became integrated into the studio material. The presence of this can does raise questions about the integrity of the time capsule; however, all the other materials as catalogued are in imperial units. Analysis and examination of the materials in relation to Nolan’s practice will assert this connection more thoroughly.

There is also evidence that some previously owned material was brought by Nolan to Wahroonga when he moved there in 1949. Two items from the Wahroonga studio have strong associations with the period of Nolan’s life prior to his arrival in Sydney in 1947 (Figure 36). The label on a bottle of mosquito repellent (SID 44169) is labelled ‘RETURN BOTTLE D↑D AUSTRALIA’ indicating it was manufactured for the Australian Department for Defence and was either issued to Nolan or ‘requisitioned’ by him while he was serving in the Australian Army from 1942 to 1944. The shape of the jar and label is consistent with the dimethyl phthalate (code name ‘Mary’) pioneered and produced by W. Hermon Slade & Co in Sydney from 1943, as a preventive treatment for malaria and issued to troops departing for service in South-East Asia and New Guinea (Todd 1998b p. 43-44). A small glass bottle containing pink powder with an adhered cut out picture of flowers has been identified by Heide Museum of Modern Art Curator, Kendrah Morgan, as extremely typical of Sunday Reed’s handiwork and was probably a gift from Reed to Nolan during the time of their relationship 1939 to 1947 [personal communication]. Analysis of the pink powder-like contents with FTIR gave a positive result for magnesium carbonate. As talc is magnesium silicate, the contents are unlikely to have been used as a talcum powder, but possibly as substitute toothpaste during the war.

Figure 36. Bottle of mosquito repellent and bottle of pink powder with paper. Collection: Sidney Nolan Wahroonga studio contents. Artists' Materials Archive, Art Gallery of New South Wales, SID 44169 and 44190. Photo: Felicity Jenkins and Art Gallery of New South Wales

Solvents and thinners are another large group of materials in the Nolan archive. Some of these are labelled; mineral turpentine, methylated spirits, gum turpentine, distilled turpentine. Others are unlabelled and are of various colours including green and red (Figure 37). Nolan was himself interested in the difference between the petroleum-based mineral turpentine, as compared to gum turpentine obtained from trees. ‘You will also have to let me know the actual difference between pure turps, that is pine tree, and the substitute which is apparently is mineral’ (Nolan 4th February 1943, p. 1).

Figure 37. Group of solvent bottles. Collection: Sidney Nolan Wahroonga studio contents. Artists' Materials Archive, Art Gallery of New South Wales. Photo: Felicity Jenkins and Art Gallery of New South Wales

These studio materials suggest that although Ripolin paint, which forms the bulk of the studio material, was of primary importance, other types of commercial paint products still held great interest for Nolan in the 1950s. Among the finished paint products is a single can of black Dulux paint (Figure 1), suggesting Nolan may have had an on-going interest in this type of alkyd even after he obtained the Ripolin, (at least in this one colour). Three cans of Kem-Tone paint manufactured by Berger & Sons are also present although two of the larger cans have been adapted after the contents were used, possibly for use as stoves (Figure 38). The labels on the cans of Kem-Tone noted that they are ‘the oil paint that mixes with water’, one of the earliest emulsion paints used for interior house-painting. It may have been that the Kem-Tone in the studio was used as wall paint for the studio and not on Nolan’s art works, although a matte white paint that dried fast would no doubt have been attractive to Nolan as a priming material. The presence of a can of Reely’s bitumen paint (SID 43389), probably for use on the house or studio, is worth noting although it is unlikely that Nolan used it on his paintings.

Figure 38. Cans of Kemtone. Collection: Sidney Nolan Wahroonga studio contents. Artists' Materials Archive, Art Gallery of New South Wales. SID 43391, 43637, 44181. Photo: Felicity Jenkins and Art Gallery of New South Wales

Evidence of Nolan’s experiments with making his own paints and additives is also present in the studio materials. In addition to the collection of tiny glass bottles with clear material there is also a group of Vegemite® jars, with splashes of paint on the outside of the jars suggesting mixtures of colours (Figure 39).

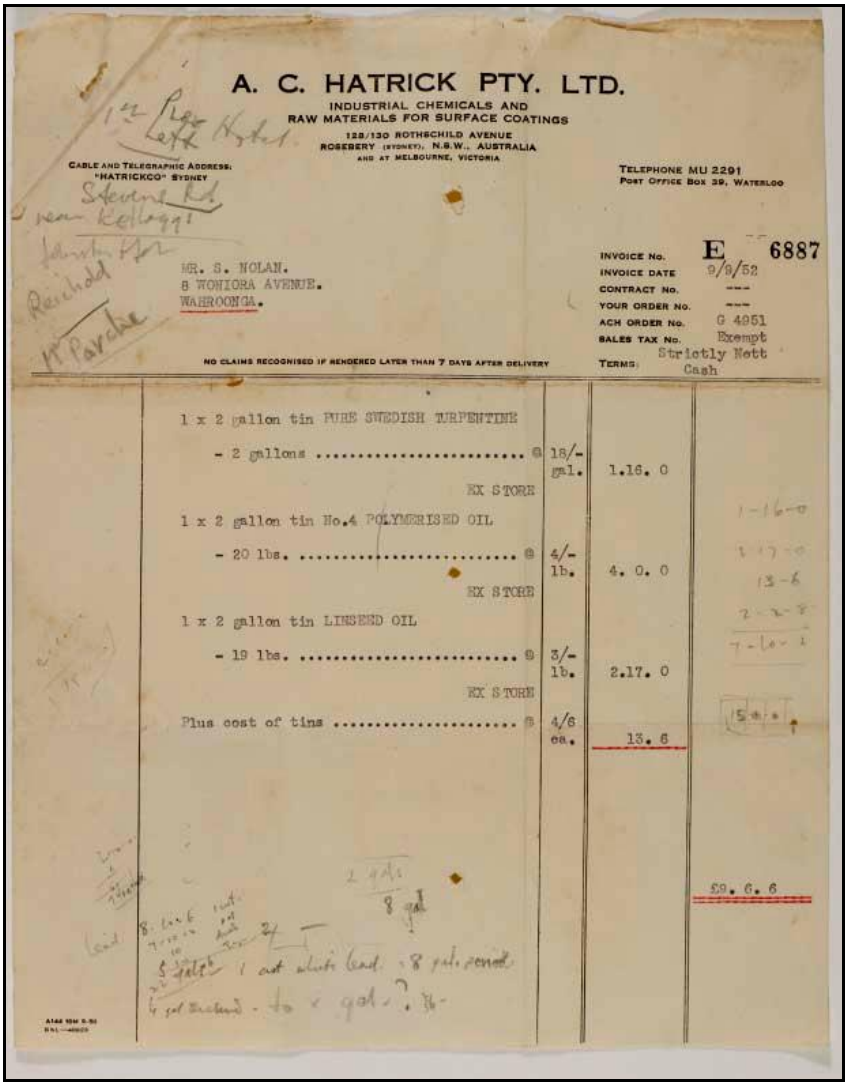
Figure 39. Various mixtures in Vegemite jars. Collection: Sidney Nolan Wahroonga studio contents. Artists' Materials Archive, Art Gallery of New South Wales, SID 44178. Photo: Felicity Jenkins and Art Gallery of New South Wales

Further suggestion of Nolan's experimentation is an invoice dating from September 1952 which indicates that Nolan purchased Swedish turpentine, polymerised oil and linseed oil from A.C. Hatrick (SID 44213) (Figure 40). While linseed oil is typical for an artist working with oil based media, the specificity of gum turpentine and polymerised oil is less usual. The invoice from A.C. Hatrick reveals other evidence of Nolan's technical engagement with his painting materials; at the upper left in Nolan's hand are handwritten directions to the Reichhold plant in Botany, 'Stevens Rd, near Kelloggs'[8] and the name 'Mr Parche' ('A.C. Hatrick Pty Ltd invoice for Mr. S. Nolan' 1952).

A.C. Hatrick was the director of the Reichhold manufacturing plant in Sydney and sales distributor of their products from his own company, A.C. Hatrick Pty Ltd. Mr Parche was the chief chemist at Reichhold (Todd 1998b). Reichhold was the leading paint ingredient manufacturer in Australia in the 1940s to 1980s. While many of the large paint makers such as B.A.L.M. and Taubmans manufactured paint components themselves, smaller companies were dependant upon Reichhold to provide them with paint resins and pigments and the technical knowledge to formulate synthetic paints. As Reichhold did not directly market any finished paint products, they were not generally known to the public. Nolan's visit to the plant in 1952, indicated by his scribbles on the invoice, suggest he actively sought out this technical knowledge and

[8] Now called Nuplex, the company is still at Stephens road and is the main producer of alkyd resins for the paint trade in Australia.

was probably in search of specific paint ingredients or information that might not normally be available to the public.


A. C. HATRICK PTY. LTD.

INDUSTRIAL CHEMICALS AND
RAW MATERIALS FOR SURFACE COATINGS
128/130 ROTHSCHILD AVENUE
ROSEBERY (SYDNEY), N.S.W., AUSTRALIA
AND AT MELBOURNE, VICTORIA

CABLE AND TELEGRAPHIC ADDRESS: "HATRICKCO" SYDNEY

TELEPHONE MU 2291
POST OFFICE BOX 39, WATERLOO

MR. S. NOLAN.
8 WONIORA AVENUE.
WAHROONGA.

INVOICE No. E 6887
INVOICE DATE 9/9/52
CONTRACT No. ---
YOUR ORDER No. ---
ACH ORDER No. G 4951
SALES TAX No. Exempt
TERMS: Strictly Nett Cash

NO CLAIMS RECOGNISED IF RENDERED LATER THAN 7 DAYS AFTER DELIVERY

1 x 2 gallon tin PURE SWEDISH TURPENTINE			
- 2 gallons .... @	18/- gal.	1.16. 0	
EX STORE			
1 x 2 gallon tin No.4 POLYMERISED OIL			
- 20 lbs. .... @	4/- lb.	4. 0. 0	
EX STORE			
1 x 2 gallon tin LINSEED OIL			
- 19 lbs. .... @	3/- lb.	2.17. 0	
EX STORE			
Plus cost of tins .... @	4/6 ea.	13. 6	
			£9. 6. 6

Figure 40. Invoice for goods received from A.C. Hatrick. Collection: Sidney Nolan Wahroonga studio contents. Artists' Materials Archive, Art Gallery of New South Wales, SID 44213. Photo: Felicity Jenkins and Art Gallery of New South Wales

Another set of notes in Nolan's hand at the bottom of the A.C. Hatrick invoice appears to describe a recipe for a typical lead white in oil paint. The measurements in gallons are: '8.10.6 lead/7.10.0 oil/ 0.10.0 drier/5.10.0 turps' giving a huge total of almost 24 gallons of finished paint. It is difficult to imagine that Nolan might have been mixing his own paint in these quantities. It is possible, however, that he experimented with making proportionally smaller amounts. Some of these self-made products might be in the studio contents, such as a jar of mixed paint, which judging from its considerable weight is lead based (SID 44173) (Figure 41). The presence of these types of handmade paints by Nolan that use typical commercial paint materials and recipes adds to the challenge of analytically distinguishing commercial ready-made paints from Nolan's own mixtures.

An added difficulty is raised by a recent study by Carlyle (2001). She demonstrated that commonly described features of house paint such as self levelling, gloss surfaces and liquid application can all be created by increasing additions of turpentine, copal resin and linseed oil to standard artist's paint. The large number of bottles of oils, solvents and varnishes in Nolan's studio contents from Wahroonga and many unlabelled 'mixtures', suggests that Nolan, like many artists, was in the habit of modifying the properties of his paint as he worked. Distinguishing these artists' modifications from paint makers' formulations increases the difficulties in the correct identification of commercial ready-made paint on Nolan's paintings.

Figure 41. Glass jar of solids. Collection: Sidney Nolan Wahroonga studio contents. Artists' Materials Archive, Art Gallery of New South Wales, SID 44173. Photo: Felicity Jenkins and Art Gallery of New South Wales

A bottle from the Wahroonga studio has a handwritten label that describes the contents as cobalt naphthenate in turps (Figure 42). Cobalt naphthenate was typically used in oil enamel paints as a catalyst for the fast formation of a touch dry skin, called a surface drier. Used in too high a quantity or added by the painter without control, it could cause paint film wrinkling. Typically, driers are used in proportions of 0.15-0.05% (Atherton 1969). For this reason they were not generally available, and it may have been this product that Nolan was seeking directly from Reichhold in 1952. If used at a concentration of about 3.5%, as described in the recipe on the A.C. Hatrick receipt, the paint would be overdosed with drier and perhaps this has resulted in the poor appearance of the paint in the jar in Figure 41.

Figure 42. Bottle with label reading cobalt naphthenate in turps. Collection: Sidney Nolan Wahroonga studio contents. Artists' Materials Archive, Art Gallery of New South Wales. SID 44165. Photo: Felicity Jenkins and Art Gallery of New South Wales

Another product from the studio which has clear associations with A.C. Hatrick, are the three tins of Euston™ white lead in oil paint (Figure 43). This was a product developed by A.C. Hatrick under licence, in which lead white pigment was produced by a precipitation process. This was an alternative to the traditional Dutch stack process in which lead metal was exposed to acidic vapour until it transformed into lead white, the technique used by the other major Australian lead white producers. Euston lead white was promoted as a fine pigment with better purity than stack-made lead white.

Figure 43. Euston White lead in oil. Collection: Sidney Nolan Wahroonga studio contents. Artists' Materials Archive, Art Gallery of New South Wales, SID 43385. Photo: Felicity Jenkins and Art Gallery of New South Wales

Other pigment material from the studio includes a bottle of yellow ochre dry pigment labelled in Nolan’s hand as Fox (Figure 44). Fox Bros. was a large stationery and artists’ materials supplier in Sydney in the 1950s. FTIR analysis suggests is a natural yellow ochre as it has aluminium silicate and possibly quartz as additions to the iron oxide.

Figure 44. Jar of yellow ochre labelled Fox. Collection: Sidney Nolan Wahroonga studio contents. Artists' Materials Archive, Art Gallery of New South Wales, SID 44184. Photo: Felicity Jenkins and Art Gallery of New South Wales

Several paintings by Nolan dating from his trips to central Australia in the late 1940s, such as *Burke and Wills expedition, ‘Gray sick’* 1949 (collection: Art Gallery of New

South Wales) have medium descriptions that include ochre, suggesting Nolan may have been adding ochre pigment to oil for painting (Figure 45).

Figure 45. Sidney Nolan, 1949, *Burke and Wills expedition, 'Gray sick'*, synthetic polymer paint and oil-based red ochre on hardboard, Art Gallery of New South Wales. Gift of Edron Pty Ltd 1995 through the auspices of Alistair McAlpine. © Trustees of the Sidney Nolan Trust

A colour chart for Berger Surtint stainers and a can of Berger lead chromate stainer are also among the studio material (Figure 46). These stainers were concentrated, highly pigmented, oil-based paints which could be added to a white paint for colour. The handwritten ticks beside the colours, burnt sienna, pale chrome, mid green, burnt umber, ochre, deep chrome and red oxide, suggest these colours were of particular interest to Nolan.

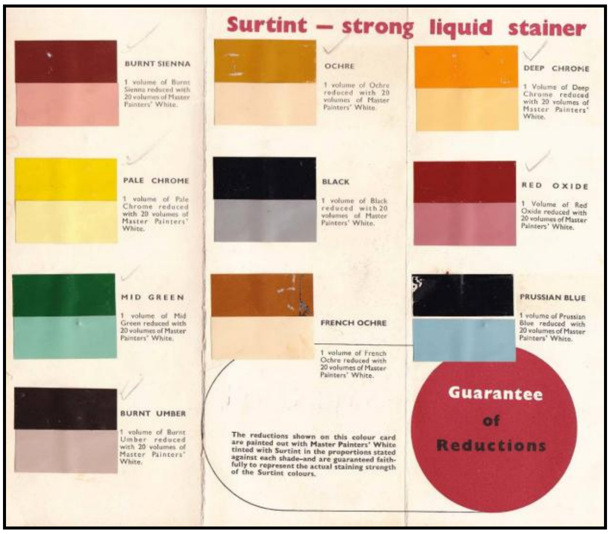


Figure 46. Surtint colourchart inside. Collection: Sidney Nolan Wahroonga studio contents. Artists' Materials Archive, Art Gallery of New South Wales. Photo: Felicity Jenkins and Art Gallery of New South Wales

2.10 Conclusion

In this chapter the study of Nolan's paint biography raises critical questions in relation to Nolan's paint mediums prior to 1953. It suggests that despite paintings from 1939 being catalogued as Ripolin, he may not have actually used it until 1943. If this is the case, then what was he using on those works beginning in 1939 in which high gloss is evident? Were these paints Dulux or Dynamel or some other type of early gloss paint? Can we distinguish Ripolin paint on Nolan's paintings from these other types of products? Was the Australian made Dulux an alkyd resin paint as it was formulated in the USA? What was Dynamel? What other types of materials might have been used in commercial paints of the period? Are there any identifying analytical tags for commercial paints that might distinguish them from artists' paints? What might Nolan's experiments with oil and other additions to his paint mediums be?

The next chapter explores the rich history of paint-making in Australia from the 1920s to the 1950s. It is a guide to local production and provides context for Nolan's use of these commercial materials. Many of the materials from the Wahroonga studio introduced in this chapter 2 are described more fully and given context for their production by the industrial paint-making history provided in Chapter 3.

Chapter 3. A history of Australian paint technology 1920s-1950s

The Paint Manufacturer's Lament

If you formulate varnish and paint
You have excellent cause for complaint
When you think you are choosing
What you will be using
The Government tells you 'You ain't!'

If there's Chinawood oil in your stuff,
To get it is terribly tough.
Dehydrated castor
They tell you is faster,
But still there is never enough.

When you pick out your resins with care,
Priorities get in your hair.
Your set-up they 'bollix'
By cutting phenolics
And leaving you up in the air.

Of course there is nothing to do
But try formulations anew.
You cannot use vinyl —
That order is final —
You will have to get some other 'goo.'

If lacquers you're trying to make.
You'll find it is all a mistake,
Solvents and cotton
Must all be forgotten,
Each number you buy is a 'fake.'

Of all the pigments we lack
No human could ever keep track.
The colours are many
And you choose any —
So long as you're sticking to black.

The Army and Navy 'tis true,
Want plenty of coatings from you.
But specifications
Perform such gyrations
You never know what you can do.

There's only one comforting note —
We're all in the very same boat,
So make up your lacquer
Of cheese and tobaccer
And don't let it all get your goat.

Dudley Clapp, New England Paint and Varnish Club, America (cited in Boland 1944-45, pp. 12-3)

3.1 Introduction

The previous chapters demonstrated that research on the history of commercial paint making in Australia has the potential to unlock new analytical pathways for the identification of these materials on paintings. An outline of the dates at which certain types of binders, pigments and additives were first available in Australia gives opportunities for dating the earliest possible use of these materials on Australian paintings. Changes in formulation or manufacture also have the potential to provide useful dating information. Research regarding the development of brands of paint, particularly those in the Wahroonga studio or described by Nolan in his letters to Sunday Reed, also assist with dating and the identification of analytical tags. In addition, the history of the paint-making industry in Australia provides a rich context for understanding Nolan's use of these materials. What emerges in this chapter is an increased understanding of the complexity of paint used for painting houses, furniture and commercial signage, their rapidly changing technologies, and the significant affect of raw material shortages on formulations.

Household paints are usually either gloss solvent-based paints with low pigment concentration that dry to smooth, level surfaces, or interior wall paints with high pigment volume giving matte surfaces and stippled textures. Both types of paint had use for artists. Flat, interior wall paint was attractive for its cheap price and was often used (and still is) to prepare canvases or solid boards with priming layers for painting. Unlike a traditional artists' priming of lead white pigment in linseed oil, which can take weeks to dry, interior wall paints dry quickly allowing the artist to begin painting soon after application. Wall paint is generally matte and the slightly textured surface allows the paint used on top to be absorbed, offering (hopefully) good adhesion.

3.2 Matte interior paints

Emulsion wall paint based on vinyl or acrylic was not developed until the late 1940s, but prior to this there were a number of other matte paint types. Distemper (glue) paint was common, but as it continued to be water soluble after drying it was difficult to maintain, and exacerbated the potential for mould growth and pest attack. These paints were however cheap and easily to apply by the home decorator and were therefore popular. At least two brands of distemper paint were made in Australia, Kalsomine™ by Wesco, and Calcimo™ by Muralo (Figure 47). Early in the twentieth century Muralo was imported from the USA. A licence to manufacture Calcimo locally was purchased by B.A.L.M. in the 1930s. These paints continued to be manufactured up to the late 1950s at which time synthetic emulsion paint became a more durable alternative.

Figure 47. Packet of Wesco Kalsomine and Muralo powdered distemper paint. Collection: Artists' Materials Archive, Art Gallery of New South Wales. Photo: Paula Dredge

Casein paint based on milk protein was a significant improvement on distemper. Casein paint was sold as either a powder or paste to which the painter would add water prior to use. The great advantage of casein lay in its natural emulsion-like characteristic which allowed it to be applied with water, but when dry would be insoluble.

The artist Frank Hinder (1906-1992) took an interest in casein paint as a potential priming material for his egg tempera paintings. A set of boards painted by Hinder in the 1940s and given to the conservation department at the Art Gallery of New South Wales in the 1970s, demonstrate the extent of his experiments with casein paint. It would appear from the inscriptions on the boards that his concerns related to the growth of mould on his paintings primed with tradional egg tempera ground (McCarthy 2004).

Oil-based paints formulated to be matte in appearance were also used for interior walls. These were more expensive that distemper or casein paints and appear to have been less available in Australia than perhaps in Europe. The British Australian Lead Manufacturers (B.A.L.M.), made an oil enamel paint line from the 1930s to 1950s called Pure Prepared Paint (Figure 48). The paint as described on the colour chart was made from ‘genuine stack-made white lead and zinc oxide, and only the strongest colours necessary to produce the standard shades, these pigments being thoroughly dispersed in a liquid medium consisting of genuine treated linseed oils, liquid driers and turpentine’ (B.A.L.M. c. 1930s). Pure Prepared Paint was however glossy and only one matte colour, white, is offered on the chart in Figure 48.

Figure 48. B.A.L.M. Pure Prepared Paint chart, c. 1930s. Collection: Caroline Simpson Library and Research Collection, Historic Houses Trust of New South Wales. TC 681.1 BALM

A number of emulsion paints which used natural oils with surfactants were developed to improve the application and wearing properties of distemper and casein paints. A can of Majora Mill white™ dating from the 1920s manufactured by a Sydney paint-maker, Major Brothers, may be one of the earliest (Figure 49). Instructions printed on the back of the can instruct that for inside painting, water and ‘petrifying liquid’ (mineral spirits) should be added to the paste in the can. For outside work linseed oil and water could be added, making a more glossy, water shedding paint. Although a miscible paint to which both oil and water could be added, it is not clear if this paint was an oil-in-water emulsion paint, or casein paint with an emulsified oil, varnish or resin addition.

Figure 49. Majora Mill White circa 1920s manufactured by Major Bros. Sydney. Collection: the author

Kem-Tone was a true oil-in-water emulsion paint (Figure 38). Manufactured in Australia from 1942 by Berger & Sons it had been developed in the USA by Sherwin Williams. It was made from animal glue and oil, emulsified with special paint mills and a number of surfactants[9] (Lewis Berger & Sons Ltd 1942). According to Stuart Croll (2006) Kem-Tone as made in the USA from 1941, used casein, corn protein, rosin and linseed oil and was pigmented with titanium dioxide, chalk, clay and mica (aluminium silicate). Although supplied ready-mixed in the tin, it was of a thick paste consistency that required thinning with water before painting. Kem-Tone was a popular paint product in Australia as it could easily be applied by the home decorator. The first paint roller, called a Roller-Koater™, was developed for use with Kem-Tone (Standeven 2011).

Kem-Tone production in Australia was halted during the Second World War and recommenced in 1950 ('Back again. Better than ever. Kem-Tone' 1950). After the Second World War a variation of the standard Kem-Tone called super-grade Kem-Tone was also manufactured in which styrene-butadiene, was added to improve

[9] Surfactants are detergent-type additives that allow oily material to be suspended in water thus making an emulsion. When dry, the water is no longer present and the paint, that is principally oil, becomes water resistant.

durability. ‘It contains Styrene’ the colour chart reads, ‘the wonder ingredient that wraps the surface it covers in a plastic wear-resistant film’ (Lewis Berger & Sons Ltd 1958-1960). This was one of the earliest uses for vinyl in a commercial paint.

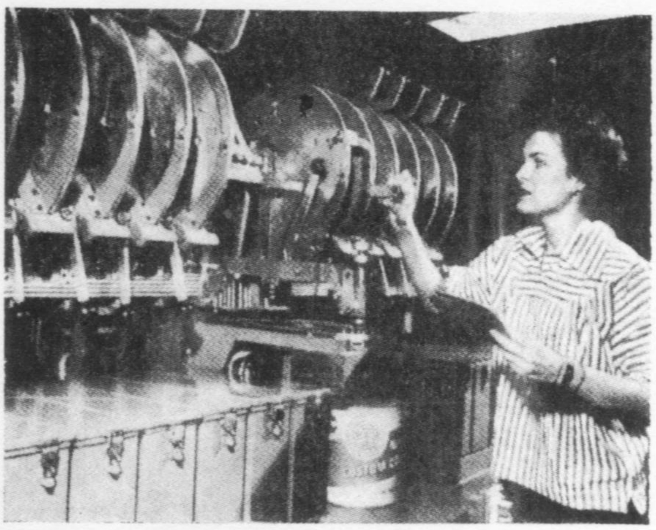
Several cans of standard, (without styrene), Kem-Tone are included among the Sidney Nolan studio contents. Their labels proclaim, ‘The oil paint that mixes with water’ thus promoting its durability as an oil paint, but its ease of application with water. It is not clear if Nolan used Kem-Tone for painting his studio walls or as a priming layer for his paintings. Some adaption to several of the empty cans by Nolan is evident with perforations of the bases suggesting their re-use as stoves.

The formulation of ready-made flat, interior paint in the period prior to the development of synthetic emulsions was extremely complex with the development of many variations in binder (Standeven 2011). The difficulties in the analytical identification of matte types of paint are compounded by the small proportion of binder compared to pigment, making the binder difficult to detect in dry paint films. There is an added difficulty, in that artists were more comfortable with making their own priming paint than they were in making paint for image layers. Nolan for example refers to his own preparation of priming layers using titanium dioxide, zinc oxide and eggs (Nolan 4 February 1943). The identification of egg, animal and milk protein that might be found in priming layers deriving from either handmade paints or from complex commercial emulsions is difficult, and not possible with standard instrumentation.

Gloss paint, in comparison with matte paint, offers greater possibility for analytical identification of binders, as the pigment-to-vehicle ratio is reversed. A high proportion of binder is typically used to assist with the formation of high gloss paint finishes. There are three principal types of binders used in gloss paints during the period of the 1920s to 1950s and they are; oil, alkyd and nitrocellulose. While other types such as phenolic resin (phenol-formaldehyde) and gloss oils (limed rosin) were also available they probably had limited use for artists. Phenolics for example produced a hard and brittle paint, that was principally used for industrial, baked finishes. They were however,, sometimes used in quick drying four-hour enamels for decorative painting and it is possible that they could be found associated with artist use in this form (Standeven 2011).

3.3 Oil-based enamel paints

Oil and natural resin-based (oleo-resinous) enamels were the first ready-mixed paints in tins pre-coloured in prescribed tints. The use of tinting machines which could colour a can of base white to any tint desired by the consumer was a development only available from the 1950s (Figure 50). Therefore the colour range offered by the manufacturer was a critical limiting factor of the use of these paints by artists. Additionally, many manufacturers specifically warned against mixing colours from different cans, even within the same range of paints, as each had been individually formulated. Compared with some imported brands, Australian enamel paints were available in a limited colour range, 36 tints in the Pure Prepared Paint™ by B.A.L.M. for example, compared to 71 offered by the imported Ripolin range on the chart dating from the 1920s (Ripolin Ltd. c.1923).



A girl attendant operating a "Robot" paint-mixing machine.

Figure 50. Paint bar where colours are mixed, *The Decorator & Painter for Australia & New Zealand* 15 November 1953, p. 22

There were a large number of Australian paint makers in the 1920s making oleoresinous enamel paints, in addition to significant numbers of imported products. The diverse and large range of paints available in Sydney in the 1920s can be seen in a view of C. E. Crane & Sons, a popular Sydney decorating store (Figure 51).

A VIEW OF PAINT DEPARTMENT.

Figure 51. C.E. Crane & Sons Limited. *The Decorator & Painter for Australia & New Zealand*, 1 April 1929 p. 200

Up to the 1920s enamel paints were made with a high proportion of drying oil and often with the addition of a natural resin to give a glossy finish. The principal oil used prior to the Second World War was linseed oil, although tung oil imported from China (unavailable during the war) was also popular. The oil was usually pre-thickened by boiling (heat-bodied), producing a paint that was non-dripping and needed fewer solids in the form of pigments (Standeven 2011). In the twentieth century, the use of strong tinting pigments, many derived from coal-tar products, meant that less pigment was required to give rich colour. The high proportion of thick oil could be used to impart gloss while maintaining body however, a high oil content had a negative effect on the speed of drying. This was a disadvantage with oil-based enamels for painters concerned with recoating and the avoidance of dirt pickup. Catalysts (called driers) were therefore commonly added to the oil to speed drying.

As well as imparting gloss and hardness, the addition of a natural resin speeded the formation of a touch dry surface as the resin hardened by evaporation of the solvent. This was a difficult compromise however, as natural resins yellowed and became brittle with exposure to light and weathering particularly when used in exterior paints. Spirit-soluble resins such as dammar could be used, but a hard insoluble fossil resin called copal was the most highly regarded. Copal was not soluble like dammar and had to be melted and poured into hot oil in order to be incorporated into the liquid paint medium. Copal resin is high in acidity and not suitable for use with some pigments and so a modification was developed called esterfied copal that made neutral media.

Rosin (colophony) the tree resin from conifers, often a by-product of the distillation of gum turpentine, was a cheap resin additive with poor reputation when used in linseed oil based paints. Used in tung oil or modified by esterfication it was more stable. The most stable rosin derivatives were the esterfied rosins called ester gums. Limed rosin prepared by reacting rosin with calcium hydroxide (hydrated lime) formed calcium rosinate, could be added to linseed oil and thinned with turpentine to make cheap enamels called ‘gloss oils’ (Barry 1969). These were only suitable for indoors work due to their poor durability.

Gloss oils may be the binder of the popular Dynamel paint manufacturered by Taubmans from 1931 (Todd 1998a). Dynamel was marketed as fast-drying enamel and was stated to be suitable for interior painting only. A colour chart, tentatively dated by the printer’s code to 1940, clearly distinguishes it from enamel. Dynamel is ‘better than enamel’ it says (Figure 52). ‘Dries twice as fast — twice as hard’ (Figure 53). Nolan’s fall-back suggestion to Sunday Reed in 1942 if she did not find any Dulux, was Dynamel.

> Dynamel is the next best. I don’t know what they call their brightest red, yellow & blue but it is the same as the three very small tins you bought before. You also got the big Dynamel so will know which colors.
> (Nolan 27 October 1942 p. 3)

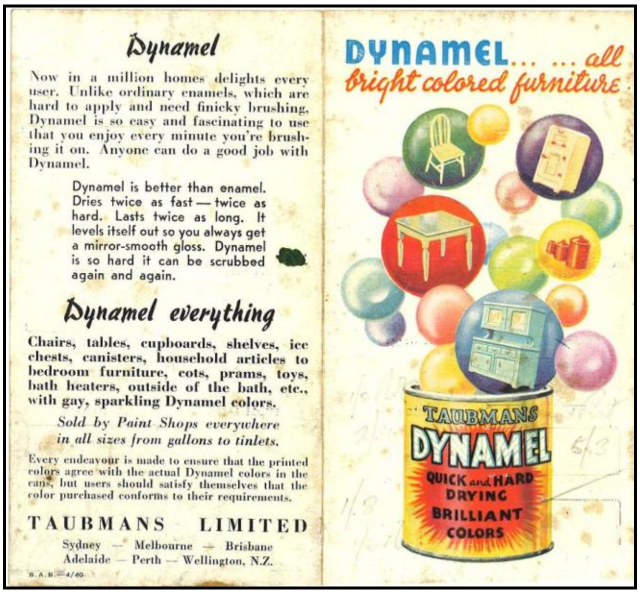


Figure 52. Dynamel colour chart, c. 1940. Collection: Caroline Simpson Library and Research Centre, Historic Houses Trust of NSW, TC 698.1/TAU/3

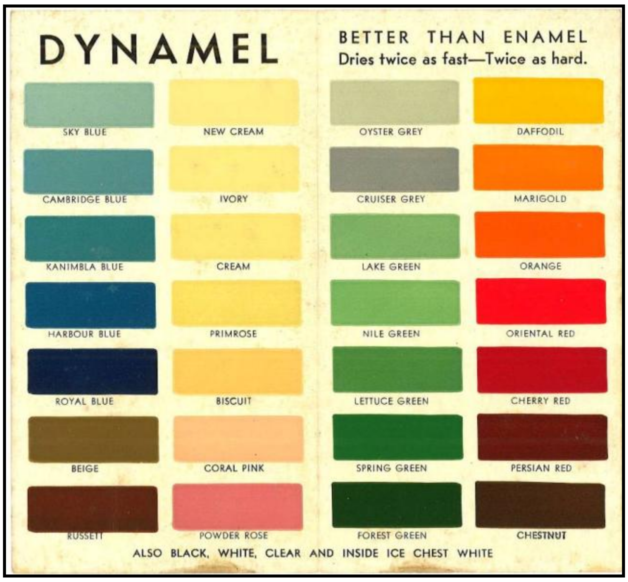


Figure 53. Dynamel colour chart (inside), c. 1940. Collection: Caroline Simpson Library and Research Centre, Historic Houses Trust of NSW, TC698.1/TAU/3

It was however the Ripolin paint that gave Nolan new possibilities in colour choice. Although available in Australia's close neighbour, Indonesia, as early as the ninteenth century as advertised in a Dutch language newspaper ('Ripolin is een aangemaakte' 1900), Ripolin does not appear in Australian newspaper advertisements until just prior to the 1920s. It must, however, have been available in Sydney as early as 1914 as the building of the new Nepean Hospital solicited a letter from the Australian distributor of Ripolin paints, Lindsay McCormick, in which he forwarded a test on the germicidal properties of Ripolin paint ('Our hospital' 1914).

Available initially only in white, and promoted as a paint for cars, the arrival of the full colour range in 1921 attracted great interest ('Crane's the paint specialists have a full range of colours and a unique stock of Ripolin the motorists enamel' 1921). Ripolin paint imported into Australia in the 1920s was made in Holland and subject to high import tariffs, making it expensive in comparison to locally manufactured products.

A Ripolin colour chart with 71 colour swatches dating from the 1920s is written in English but stamped ‘Made in Holland’ on the front cover (Figure 54 and 55). The chart offers the English system for naming the colours which differs slightly with the use of letters for some colours from the French and Dutch systems as documented by Gautier et al. (2009). The chart gives detailed instructions for painting a car with Ripolin and states that ‘Ripolin can be used for painting on stone, plaster, woodwork, garden gates, greenhouses, yachts, steamers, motor cars, baths, radiators etc.’ (Ripolin Ltd. c. 1923).

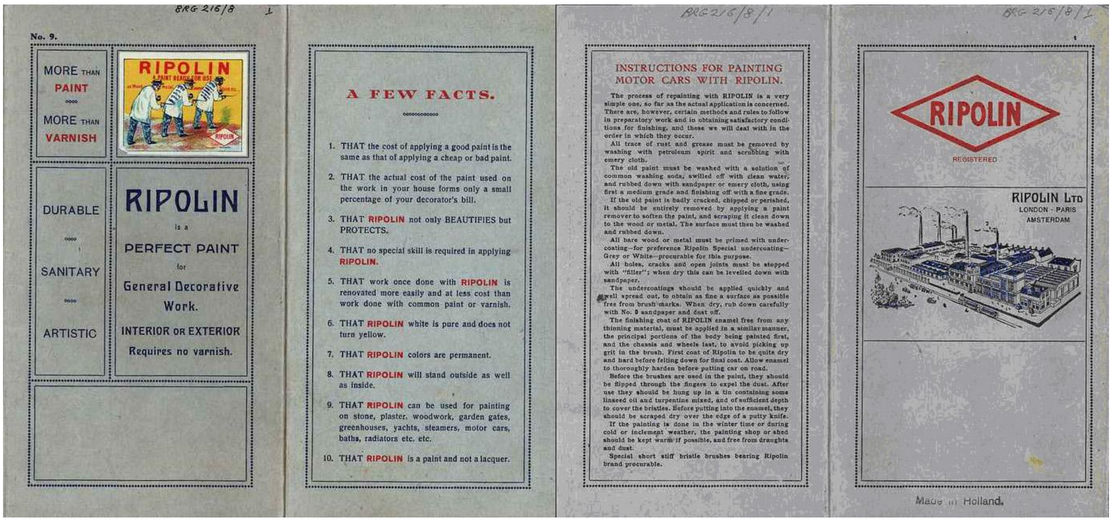


Figure 54. Ripolin Ltd. Paint colour chart, (outside), c. 1923. Collection: Walter Buxton Bruce Collection, State Library of South Australia BRG 216/8/1

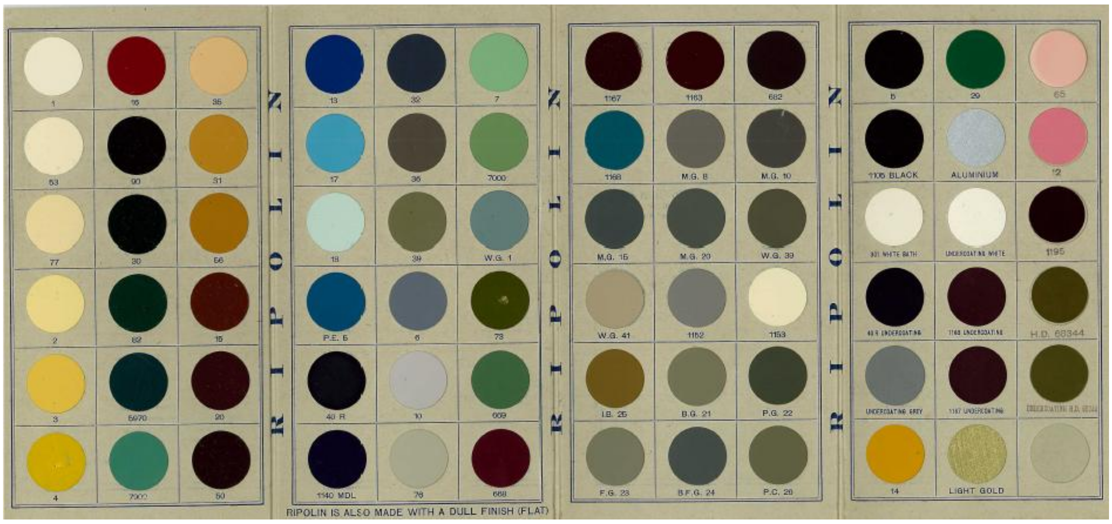


Figure 55. Ripolin Ltd. Paint colour chart (inside), c. 1923. Collection: Walter Buxton Bruce Collection, State Library of South Australia. BRG 216/8/1

The potential of Ripolin to be used for different types of painting appears to have been one of its great appeals and is the idea behind the company's iconic logo featuring the three men painting each other's backs. 'a paint ready for use' it reads, 'on wood plaster metal stone etc' (Figure 54). The Ripolin logo became one of the great advertising successes of the twentieth century, appealing enough, for example, to be used as a decorative poster in a rice merchant's office in Indonesia (Figure 56).

Figure 56. Poster for Ripolin paint in the office of Mr. Gho Lay Kiong at the Sam Joe Kionsi rice mill, Indonesia, *Oedaya* March 1927, p. 39

The attraction of Ripolin enamel for artists like Nolan interested in glossy liquid paint is apparent when comparing the range of colours available on the English colour chart (Figure 55) with similar colour charts of Australian-made oil enamel paints (Figures 48 and 53). The intensity of the colours from the Ripolin range must also have been attractive to Nolan. No longer confined to three primaries as outlined in letters to Sunday Reed, Ripolin paint offered brilliancy and also, importantly, a number of colours with transparent effects not usually considered a desirable characteristic in household enamels.

The Ripolin paint that Nolan used was made in London. The Ripolin Ltd. Company established a branch in England in 1898, initially importing and selling the paint manufactured at its Dutch factory ('Ripolin celebrates its 80th anniversary' 1978). In 1932 a factory making Ripolin was opened at Southall, London (Ripolin Ltd. 1931-32). Considerable pressure was placed on Ripolin Ltd. to establish a relationship with an existing British manufacturer, however direct ownership of the English Ripolin branch was retained by the parent Dutch company. The Managing Director was J. Colaço-Osorio, a relative of the financier involved in the formation of the French Ripolin company in 1897 (Raeburn 2011, p. 123). The close relationship between the Dutch and English branches and their desire to retain proprietorship over Ripolin is also demonstrated by an application made by the British Ripolin company to bring a paint chemist over from the Dutch factory: ‘As our goods are made by a secret process, it is essential for us to employ this man’ (Ripolin Ltd. 1931-32). The British arm of the company remained under the management of the Colaço-Osorio family until 1977 ('The boss bows out' 1977). By 1980 the UK Ripolin company maintained a network of over 150 retail outlets in addition to the factory production ('Grand opening in Greenford' *Ealing Gazette* 21 March 1980, pp. 14-5). The company broke from the parent European company with a management buy-out in 1981 and the Southall factory was sold and closed ('Firm makes a splash and brush with bankruptcy' 1981).

3.4 The development of alkyd paints

The difficulties of formulating natural oil and resin paints across a large colour range, particularly in the darker colours, is demonstrated by a close examination of the Pure Prepared Paint colour swatches in the chart shown in Figure 48 and in detail below (Figure 57). According to notes on the chart the paint swatches were made from the paint itself and the darker green and brown colours exhibit signs of deterioration. A later chart for Pure Prepared Paint dating from sometime after 1939 has a new description in which it notes: ‘Revolutionary synthetic resins are incorporated in the permanent greens and dark shades which ensures results not hitherto possible’ (B.A.L.M. after 1939). The dark green and brown tints on this later chart are in excellent condition and the ‘revolutionary’ synthetic which made this possible was probably an oil-modified polyester resin called alkyd. Developed as a paint resin in the late 1920s and used in commercial paints from the beginning of the 1930s, it had an enormous effect on the paint making industry, particularly in Australia’s extreme climatic conditions, where its better performance and durability was appreciated.

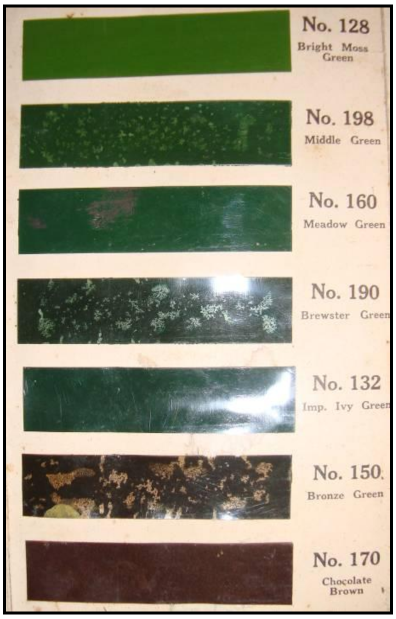


Figure 57. Detail of B.A.L.M. Pure Prepared Paint chart, c. 1930. Collection: Caroline Simpson Library and Research Collection, Historic Houses Trust of New South Wales, TC681.1 BALM

In 1928, as the licensed Australian manufacturer of other DuPont products, B.A.L.M. was in an advantageous position to negotiate a similar arrangement for the new alkyd-based paint Dulux, developed by DuPont. For this technology a tough deal was negotiated in which B.A.L.M. sold 40% of its shares to DuPont and Imperial Chemical Industries (I.C.I.). B.A.L.M. began production of Dulux at its factory Cabarita in Sydney in 1929, initially as a finish for Holden Body Parts (Todd 1998a). As the recession began to hit Australia and car sales dipped, the diversification of the product into a paint line called the ‘Dulux 388 brushing line’ was launched in 1931

('DULUX launch' 1931). This alkyd paint gained rapid popularity in Australia as it was considered more durable than oil-based enamels and it dried in several hours giving a high-gloss level surface. It was the ability of alkyd based paints to retain a degree of flexibility and gloss even after considerable weathering that was its advantage over traditional oil and natural resin-based enamels (Leach 1937). The colour range prior to the Second World War was, however, identical to the B.A.L.M. oil-based Pure Prepared Paint, with just 36 colour tints.

Outside the dominance of B.A.L.M. Dulux, there was another paint manufacturer that played a critical role in the development of the alkyd paint industry in Australia from the 1930s. This was Archibald Hatrick. Originally a natural resin importer, Hatrick developed a relationship with an Austrian/American company called Beck-Koller & Co. and began importing their resins in 1934 ('A.C. Hatrick Limited' 1934). These included a phenol-aldehyde type called Beckacite™, an alkyd type called Beckosol® and a substitute for copal made from rosin called Synthecopal™.

Beck-Koller had developed a successful form of phenolic resins for paint that was used on Ford Motor cars in the 1920s in the USA. The company was owned by two brothers, Helmuth and Otto Reichhold who ran the business from the USA and Austria. In 1937 Otto Reichhold was killed in the crash of the Hindenburg airship while on his way to visit his brother Helmuth. Soon afterwards Helmuth Reichhold separated from the original Austrian business and the American company renamed itself Reichhold Chemical Inc. In that same year, a representative of the company, Dr Krumbhaar, came to Australia and gave a lecture in Sydney on synthetic paint resins (Figure 58).

Figure 58. Snap taken in Sydney. Mr J. Bishop, Dr. Krumbhaar, Mr A.C. Hatrick *The Decorator & Painter for Australia & New Zealand* 10 June 1937

Shortly after Dr Krumbhaar's visit a partnership was initiated with Archibald Hatrick to open a manufacturing plant for synthetic paint resins in Sydney. Production at Reichhold Chemicals Inc. Australia Pty. Ltd. began in 1940 (Figure 59) ('Reichhold Chemicals Inc. (Aust.) Pty. Ltd. A new Australian industry' 1940). Australia, it seemed, was an eager consumer of the new synthetic paints.

> Australia has taken up synthetics as quickly as America, and quicker than England. I think you have even taken them up faster than America. In Australia, you have a sunny climate. There are about 300 days in the year when the sun shines brightly. The sun's light is very severe on paint materials and, for that reason, synthetic paints are proving popular in Australia. The use of synthetics in a paint may increase its life 100% in a climate like this. The paint trade and the public in this country appear to realise this for our sales of synthetics in Australia in 1936 was four times as great as in 1935.
> ('Dr. Krumbhaar's visit. First impressions of Australia' 1937)

Figure 59. Reichhold. A name identified with synthetic resins, *The Decorator & Painter for Australia & New Zealand* 12 March 1940 p. 10.

Reichhold Chemicals Australia did not market finished paint products directly to consumers, but provided the synthetic resins, pigments, driers and technical expertise to local paint manufacturers in order to develop their own lines of synthetic paint. This enabled the large number of paint-makers to keep current with overseas developments and compete effectively with the larger companies which had direct licence arrangements with US and UK chemical companies. The role of A.C. Hatrick in importing alkyd paint resin from 1934 and developing the Reichhold Chemicals manufacturing plant, broke the B.A.L.M./DuPont monopoly in Australia. From 1934 alkyd resins might therefore be found in any paint made by an Australian paint-maker.

Other sources for early alkyd resin in Australian-made paint came from partnerships with overseas companies. Taubmans for example began importing a German-made alkyd resin called alkydal from the early 1930s (Todd 1990 p. 120). Alkydal® was manufactured by I.G. Farbenindustries (I.G. Farben), a consortium of German chemical companies. After Walter Taubman visited Britain, (Pinchin Johnson), Germany (I.G. Farben) and the USA (Beck Koller & Co.) on a fact finding mission in

1937 Taubmans developed their own alkyd resins (Todd 1990 p. 123). A plant in St Peter’s, Sydney was modified to manufacture alkyd resin. The alkyd factory quickly gained the local nickname ‘dead-house’, due to the strong smells which emanated from it (Todd 1990).

During the Second World War Dulux and other alkyd paints became extremely hard to obtain in Australia as they were considered essential for war issue armaments and vehicles. From 1942 manufacturers were prohibited from making any synthetic paints for civilian use, although there was no restriction on the sale of existing stock ('Prohibition and restrictions on paints and brushes. Effect on paint trade' 1942). An additional pressure on the supply of alkyds during the war was the discovery that dimethyl phthalate, a component of alkyd resin, was an effective mosquito repellent and large amounts were soon diverted from alkyd manufacture to use by the Australian Army in South East Asia. (Boland 1944-45). After the Second World War there was a period of continuing shortage of alkyd paints for the public until 1948. The difficulties this caused consumers were acknowledged by B.A.L.M. in a series of advertisements in 1947 (Figure 60).

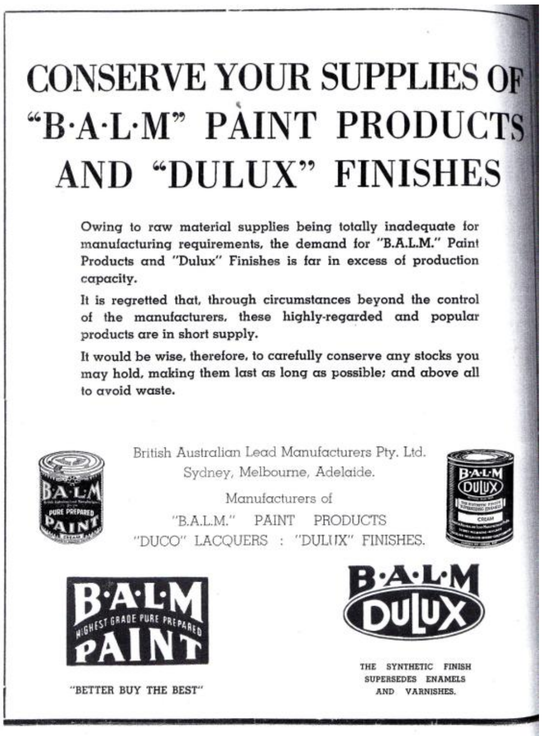


Figure 60. Conserve your supplies, *Decorator & Painter for Australia & New Zealand*, February 1947, p.24

With the relaunch of Dulux post-war came an extended range of colours, utilizing many of the newer synthetic pigments. A colour chart dating after the relaunch of the Dulux range in 1948 has a range of 53 colours, 17 more than the 36 offered prior to the war (B.A.L.M. undated). Although alkyd paint quickly became the dominate oil-based gloss finish in Australia, it was not used in artists' paint until Winsor & Newton launched the Griffin line in 1976 (Winsor & Newton 2003-2011). Therefore, the presence of alkyd binders on paintings prior to this date indicates the use of a commercial paint product.

3.5 Other locally produced paint binders

Before alkyd resin began to dominate the Australian gloss paint market in the 1930s, there was another resin that was used to make fast drying gloss paint. This was nitrocellulose. Nitrocellulose is called a semi-synthetic as it is derived from natural cellulose fibre that undergoes synthesis with nitrate. Nitrocellulose paint was termed a lacquer due to its drying and film formation by solvent evaporation, not by polymerisation as for oil-based paints.

DuPont marketed the first nitrocellulose lacquer paint, Duco, in the USA in 1923 (Standeven 2011). Available shortly afterwards in Australia for import, Duco was manufactured from October 1928 at the B.A.L.M. factory in Sydney (Todd 1998). Other Australian paint manufacturers quickly began to produce their own pigmented nitrocellulose paints. The strongest competitor to Duco was Opex, manufactured by Berger Australia through licensing arrangements with Sherwin-Williams (USA). Berger began to make Opex for the Ford Motor Company of Australia and it was used on their new Model A motorcar in 1928 (Todd 1998). Nitrocellulose lacquers were very popular paints in Australia. So popular in fact that the term 'duco' came to mean any type of high gloss brightly coloured paint applied to cars. This continued in common parlance well after nitrocellulose had been uniformly superseded by alkyds for this use.

Duco was applied to cars and advertising signage by spray-gun, and its quick-drying feature was a great advantage over oil-based paint. The fast setting of the paint by solvent loss made it difficult to apply in an even coat when brushed and to build up layers, as it readily redissolved when recoated. It required, therefore, the addition of plasticisers such as alkyds, ester gums or non-drying oils, and slower evaporating solvents like amyl acetate, when reformulated into a brushing paint for furnishings and house trim.

The Taubmans paint company, whose clients were painters and decorators interested in brushing lacquer rather than spray or dipping lacquer, invested heavily in developing local brushing nitrocellulose paint from 1926 (Todd 1990 p. 61). They used plasticisers such as dibutyl phthalate or dimethyl phthalate (the starting compound used in alkyds), and dispersed the pigments in castor oil which was compatible with the lacquer. Taubmans also used linseed and tung oil, treated to make them non-drying, as additions to the nitrocellulose (Todd 1990 p. 62). These complex formulations included additions of resins for adhesion, such as dammar and esterfied rosin. Taubmans' first nitrocellulose lacquer product line was called Fascinac. Fascinac came in a number of brushing variations including a recolouring finish for leather shoes and bags (Todd 1990 p. 63). It was produced in a range of bright colours including silver and gold.

Another synthetic material used in paint in the 1930s to 1940s was phenol formaldehyde, commonly called phenolic. This was a hard, water-resistant resin. It was generally considered by paint manufacturers to be too yellow and brittle for use in light coloured paints. Phenol formaldehyde was insoluble in oil until it was either heated and run into hot oil or fused with natural rosin. The heated phenolic was particularly dark, but the rosin-fused types were much lighter. Reichhold Chemicals promoted its modified phenolic resin Beckacite 1112, for white enamels and pale varnishes particularly in the kitchen '...for tough, gleaming white enamels' ('You'll do better with No. 1112 Beckacite' 1949). Standeven (2011 p. 67) writes that Reichhold's predecessor, Beck-Koller, pioneered a manufacturing process that yielded a more light-fast phenolic paint resin, and this was probably the basis of the Beckacite No. 1112 formulation. During the Second World War phenolic resins were unavailable for use in domestic paint production. By the time they were re-introduced in 1949, they had probably been superseded by the more stable alkyd (Figure 61).

Figure 61. Again available in quantity Super-Beckacite, *The Decorator & painter for Australia & New Zealand* April 15, 1949, p. 11.

Phenol formaldehyde is not generally included in texts regarding artist use of commercial materials. It appears, however, that it was often incorporated in quick-drying enamels in the 1930s and may be present more often than has been considered.

> These rosin-modified Bakelite resins have been marketed for some years under various trade names. The use of such resins in the varnish industry today is very widespread, and it may be said that the greater proportion of outside varnishes manufactured at the present time contain these materials as their resin constituent
> (Leach 1937, p. 321)

There are few known examples of artists deliberately using phenolic as a paint binder, although, Hans van Meegeren used it in the 1930s when making a fake painting in order to replicate the hardness of a 300 year old oil paint film (The Courtauld Institute of Art 2011).

3.6 Oils: linseed, candlenut, tung, castor, soya bean

Linseed oil was the most common drying oil used in Australian paints. Several factories in Sydney produced large quantities of linseed oil from seed sourced from India and Argentina. This ready source of cheap seeds ensured that very little linseed was grown in Australia. After the Second World War, this lack of local production became a problem for the Australia paint industry. The ‘linseed oil crisis’ was not caused by an increased need for oil, but for the fibrous cake formed after removal of the oil and considered to be good feed for livestock. India and Argentina found local needs taking precedence over exports especially during the unsettled period of Independence in India. The extent to which the Australian paint trade was dependent upon the import of linseed is highlighted by a public meeting held in Melbourne and Sydney in March 1947, at which attendees urged the Government to take steps to negotiate directly with the Indian Government to obtain linseed ('Queensland restrictions' 1947)

The effect of the linseed oil shortage was also felt directly by artists’ in the period, including Joy Hester.

> It is impossible to buy tube color with the exception of earth colors and they are scarce. Powdered color is worse for they only sell poster colors but one can mix them with oil if one can get it! Linseed oil is the catch. Got about ½ gall. by luck the other day but it is not enough to mix up powdered color.
> Hester June 1947 (cited Burke 1995 p. 77)

Substantial efforts were directed towards growing linseed in Australia as a result of the shortage; the first local trials had begun in 1942. It was realised that linseed grew well in the same districts as wheat and utilised the same machinery for sowing and harvesting, so it was promoted as a rotational crop with wheat (Heazlette 1950). Trial crops were not successful until a rust-resistant variety was developed in Australia called Walsh. This was first sown commercially in 1945. Harvests continued to be poor due to attack from the bollworm (heliothis caterpillar). It was not until the development of aeronautical crop dusting with the pesticide DDT in 1947, that sufficient linseed was successfully harvested in Australia to begin full-scale production in 1948 ('Spraying linseed crops from the air' 1950). When India and Argentina began processing linseed and exporting the extracted oil in 1949 local linseed production became less critical.

During this linseed oil drought a Sydney oil manufacturer Harold Meggitt, began extracting the oil from candlenuts (Figure 62). The candlenut tree (*Aleurites moluccana),* related to the tung oil tree (*Aleurites fordii)* produced a fast drying, hard oil. It grew in the Atherton Tablelands of Queensland and in many Pacific countries. According to Harold Meggitt, 'thousands of gallons of candle nut oil were delivered to the Paint Manufacturers over and above their linseed oil quota' in the period from 1946 to 1949 (Meggitt 2000). It may have even been exported from Australia to the USA for use in paint (Press 1946). Candlenut oil is interestingly described by Max Doerner (1934) in his *Materials of the artist and their use in paintings with notes on the techniques of the old masters*. 'When cold-pressed,' Doerner says, 'it [candlenut oil] dries quickly and is viscous and light' (op. cit. p.113).

Figure 62. Harold Meggitt Ltd advertisement for candle nut oil, *The Decorator & Painter for Australia & New Zealand* 15 October 1948, pp. 8-9.

Tung oil[10] sourced principally from China and the USA, became increasing popular from the 1930s, initially in fast drying enamel formulations. Tung oil made harder films with better gloss retention and water resistance than linseed but it was severely curtailed during the Second World War ('Replacing tung oil' 1941). Attempts to establish tung oil plantations in Australia in the 1930s were a failure due to incompatible climate and growing conditions (Roche 2008). Tung oil required heating prior to use as a paint binder, but this had to be carefully controlled as over cooking caused the oil to gel. Rosin was often used during the heating of tung oil to reduce the tendency to gel (Leach 1937). Another problem with the use of tung oil was its inclination to wrinkle on drying. It was therefore usually mixed with linseed oil when prepared as an enamel medium, the suggested ratios being three parts linseed to one of tung (Greaves 1969 p. 155)

Other types of oils became common in paint during the 1930s to 1950s, particularly semi-drying oils which could be used with alkyd formulations due to their inherent drying characteristics. Soya beans, safflower and dehydrated castor were the most usual and locally grown stocks in Australia and became increasingly successful through the 1940s. Dehydrated castor oil was a satisfactory substitute for linseed oil during the linseed oil shortage. In fact dehydrated castor oil became an industry standard because although a poorer drier than linseed oil, it was a lighter colour. Dehydrated castor oil was commonly used in alkyd paints that had better drying characteristics than standard drying oil. It was also compatible with nitrocellulose resin and became a commonly used plasticiser in those paints ('Kellogg Spencer Research Laboratories, USA' 1950). An article published in 1940 names four proprietary dehydrated castor oils available for use in paints in the USA under the trade names Isoline™, Dehydrol™, Synthenol™ and Castolene™ (Killeffer 1940 p. 1467). It is not clear when dehydrated castor oil became available in Australia, although Reichhold/Hatrick were advertising the availability of Dehydrol in 1949 ('A.C. Hatrick the source of supply for —' 1949).

[10] Also called China nut oil

3.7 Resins: copal, rosin and rubber

Natural resins derived from trees are classified into several groups according to their solubility. Spirit varnishes including dammar and mastic were used as picture varnishes, but were considered less stable in paint formulations. The most highly valued resins for paint were the hard insoluble copals. These include; Manila, Congo, kauri and Brazilian (Mantell 1950). Kauri resin was extremely popular in enamel formulations in the 1920s. It was hard and light coloured and required relatively low temperatures to melt. This was a fossilised resin located where it had fallen to the ground and buried in the soil in forests of stands of kauri (*Agathis australis)* on the North Island of New Zealand. According to Mantel (1950), there were still Kauri copals being dug from the ground in 1950, although the loss of kauri forests was having an impact. Kauri copal was extremely difficult to extract from the boggy ground but its attraction for use as a hard but workable resin imparting gloss to paint was invaluable. 'It has been stated that even as the English varnish maker made the reputation of kauri, so kauri made the reputation of the English varnish maker' (Mantell 1950 p. 237)

Archibald Hatrick, the founder of A.C. Hatrick in Sydney, grew up in Wanganui in New Zealand and when he began his business in Sydney in 1916, the import of kauri gum for the paint trade was one of his main product lines (Kolm 1988). By the 1930s, this resin had become hard to obtain and Congo copal, a hard resin from West Africa, was the most commonly used copal. African copal required higher temperatures to melt than kauri and this took some adjustment for paint-makers. However, after overcoming initial difficulties they quickly made it the industry standard. It was often modified to prevent the formation of soaps with pigments, due to its acidity. This could be achieved by esterfying with fatty acid glycerides or other polyhydric alcohols to form copal esters.

African copal was the hardest and most insoluble of the copal resins. Congo copal could be tapped from the tree directly, but mostly it was collected as fossilised resin in the lower parts of rivers systems, where it had been deposited after rains. Generally collected by women and children, they would tap the mud with metal-tipped lances while wading, listening for the sound and feel of a hard lump of resin hidden in the mud (Mantell 1950 p. 222). Other types of copal were collected in West Africa and also in Madagascar. Another, less common type of copal was Jotobá resin from Brazil. This was resin from trees of the Hymenaea genus which has a number of species in Brazil. Mantell describes these copals as the softest of all the copals and therefore of least value (Mantell 1950).

The process of adding copal to the oil was dangerous as it involved heating flammable materials to high temperatures. In the 1930s several techniques for modifying the copal resin for enamels and varnishes were developed. The Powerhouse Museum in Sydney has three samples of Congo copal given to it in 1939 by Beck Koller & Company. They are natural copal (Beck Koller & Company 1937b), esterfied copal (Beck Koller & Company 1937a), and fused copal (Beck Koller & Company 1937c). Reichhold Australia also produced a phenolated copal from at least 1940 which was a Congo copal modified with phenol formaldehyde to make it harder and more water resistant (Figure 63).

Figure 63. Advertisement for Beckopol phenolated copal, *The Decorator & Painter for Australia & New Zealand* 12 July 1940, p. 17.

Aside from the copals there are three other resin groups Mantell describes: *Dammar*, spirit soluble soft resins from Batavia (Indonesia) and Singapore; *East Indies resins*, semi-fossil resins both solvent and oil soluble such as Batu, Rasak from Singapore and Hiroe from Macassar (Sulawesi, Indonesia); and *Miscellaneous* which includes xanthorrea, elemi, mastic and sandarac, all spirit soluble. The trade in natural resins collected in many different parts of the world was exploitative and dependent upon Colonial expansion and development. During the Second World War many of these resin producing countries were no longer viable sources for raw materials and by the time political life and trade had resettled, the paint industry had moved onto the use of synthetic resins and the natural resins were no longer desired.

Natural rubber or latex was experimented with in the 1940s and 50s as an additive to paint. As a natural emulsion, it was considered possible as a 'plasticiser' for brittle paints such as distemper or casein paints. Problems with durability however were noted. Added to oil-based paints it assisted with self-levelling and rain resistance, but it was effective in extremely small proportions of 0.5% of oil added (Whiteside 1951).

Oil-free emulsion paints were also proposed as an alternative to oil-based paints during the period of the post-war linseed oil crisis, as an effective substitute for matte interior wall paints. These emulsions were made from chlorinated rubber in a naptha solvent dispersed in water with emulsifying agents. 'These paints had excellent water, acid and alkali-resistance; chlorinated rubber paint were good anti-corrosive primers and had been used on submarines during the war' but they were difficult to brush and had to be spray applied ('Everyday paint problems' 1948). A chlorinated rubber called Parlon™ was marketed by A.C. Hatrick from 1948 as a useful additive to concrete and chemical resistant paints due to its high alkali and abrasion resistance and as a quick drying alternative to tung oil ('Parlon chlorinated rubber' 1948). Flatex™ a rubberized exterior flat paint manufactured by the Olympic Paint Co. in Sydney was advertised in 1953, but otherwise there are few advertised examples of products incorporating this product ('Flatex rubberised exterior flat paint' 1953). The use of the term latex (natural rubber) became somewhat confused with the development of synthetic emulsion paints based on polyvinyl acetate (PVA) and styrene butadiene which became increasingly popular in this same period.

3.8 Driers: resinates and napthenates

Commercial paints routinely included driers since the nineteenth century. The need for house paint to dry quickly to avoid dirt pick up and to enable recoating is unlike the requirements of artists as they usually prefer to work on a painting over a period of time. The higher proportion of oil in commercial paints compared to artists' paints also made them inherently slower to dry without the assistance of drying agents.

Natural resins and lead and manganese oxides were early driers for house paints. Commonly, these metallic compounds were added to heat-bodied oils during processing. The use of treated oils could reduce the drying time of the paint from three or four days to a few hours. Alternatively, metallic oxides including lead, cobalt and manganese could be pre-heated with oil or rosin to form linoleate (from oil) or resinate (from rosin) driers. Linoleate and resinates could be diluted with turpentine and added in liquid form to the paint, but these driers deteriorated with storage. The use of metallic naphthenates as driers was a significant improvement over previous driers in this respect. In particular, cobalt naphthenate was used in paints from the 1930s as a surface drier to assist with the quick formation of a touch-day skin. It could only be added in small proportions, however, (typically 0.15-0.05%) or it would result in paint film wrinkling (Atherton 1969). The addition of other driers, called through driers, based on calcium, lead and manganese, helped to offset this effect.

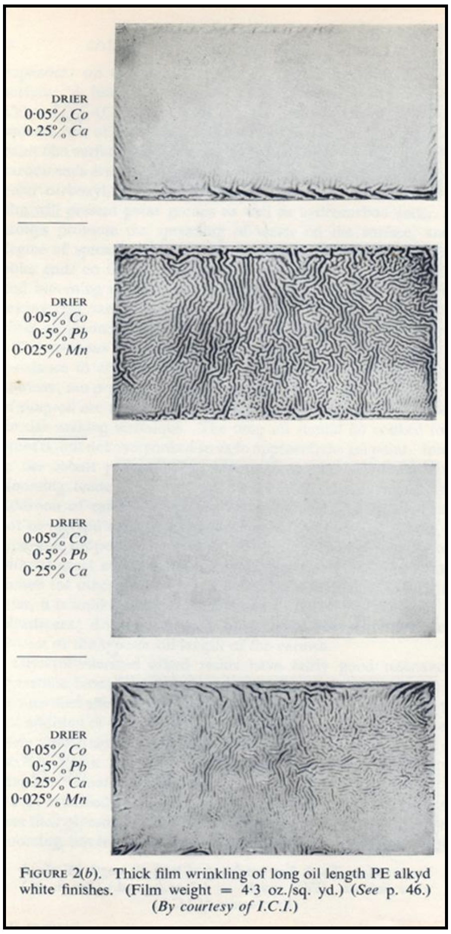


Figure 64. Effect of drier formulation on paint film wrinkling. Illustrated in; Atherton, *Driers in Paint Technology Manuals: Solvents, oils, resins and driers*, 2nd ed. 1969. between p.48-49.

The critical formulation of driers is well illustrated by a series of images in Figure 64 above. It demonstrates that paint wrinkling is exacerbated by the incorrect combination of driers. It is possible that driers were also added directly to the paint by artists, and a bottle of cobalt naphthenate is found in the Nolan Wahroonga studio contents. Added in uncontrolled quantities it would be likely to cause paint film wrinkling. In fact the tendency of some house painters to add additional driers to ready mixed paints is cited as a cause of rapid deterioration of those paint finishes ('Zinc shortage blamed for failure of ready mixed paints' 1950).

3.9 Solvents

Solvents are a critical ingredient in paint formulation. Their presence is often overlooked in discussions on paints as they evaporate on exposure to air and are not present in dried paint films. Solvents do contribute importantly to paint film formation. In particular, the reduction of the oil content and its substitution with turpentine maintained brushing ability while imparting matte surfaces. In addition to the essential suitability of the solvent to dissolve the paint binder, solvents impart characteristics to the paint dependent upon evaporation rate and viscosity.

Typically, solvents used for oil and alkyd-based paints were gum turpentine derived from varieties of softwood trees in the USA and Europe. Venice turpentine was more specifically the turpentine product of the European larch. Mineral turpentine, also called white spirit, was alternatively a petroleum product distilled at temperatures between 148 to 185 ºC ('Mineral turpentine' 1926). Both natural and petroleum turpentine contain a mixture of hydrocarbons in which drying oils are soluble. The substitution of the cheaper petroleum turpentine for hard the to obtain natural gum turpentine in the 1920s was accompanied by a great deal of suspicion in the painting trade. Concerns were expressed for the tendency of mineral turpentine to create pin-holes in paint films and poorer compatibility with previously unpainted wood ('Value of turpentine' 1930). Considerable education of the paint and decorating trade was undertaken throughout the 1920s by solvent suppliers to demonstrate the suitability of mineral turpentine for all purposes for which gum turpentine was used. Nolan himself appeared to struggle with this shift towards mineral turpentine.

> You will also have to let me know the actual difference between pure
> turps, that is pine tree, and the substitute which is apparently is mineral.
> Apart from 1 gal which I might be able to get from the Nhill stores &
> the ½ gal. I already have there is no more to be got here
> (Nolan 4 February 1943)

The lack of turpentine was in fact one of the most difficult wartime shortages for the paint industry in Australia. The Commonwealth Paint Orders from 1942 completely prohibited the use of turpentine in domestic paint production and allowed as a substitute only a limited amount of kerosene that had poor solubility with oil (Australian Government 1942).

3.10 Coloured pigments

The most commonly used pigments in house paint were selected for their strength of colour and cheapness. Traditional inorganic pigments were extensively used such as lead chromate, ochres, umbers, lead white and zinc oxide. The more expensive metallic (inorganic) pigments such as cobalt blue and cadmium yellow and red, were rarely used. A selection of some of the common inorganic coloured pigments used in commercial paint of the period is given in Table 3.1.

Table 3.1 Common inorganic coloured pigments used in commercial paint

Inorganic coloured pigments	Chemical name	Chemical formula
Chrome yellow	Lead chromate (lead sulphate)	$PbCrO_4$
Chrome orange/red	Basic lead chromate	$PbCrO_4$
Yellow ochre natural	Hydrated iron oxide + silicates, sulphates	$Fe_2O_3{\cdot}H_2O$
Yellow ochre synthetic	Hydrated iron oxide	$Fe_2O_3{\cdot}H_2O$
Umber	Iron oxide/manganese oxide/manganese hydroxide	$Fe_2O_3/MnO_2/Mn(OH)_2$
Red oxide	Iron oxide	Fe_2O_3
Molybdate red	Molybdated lead chromate	$25PbCrO_4.4PbMoO_4.PbSO_4$
Prussian blue	Iron ferrocyanide	$Fe_4[Fe(CN)_6]_3$
French ultramarine	Polysulfide of sodium, alumino-silicate	$Na_{8-10}Al_6Si_6O_{24}S_{2-4})$
Chrome red	Basic lead chromate	$PbCrO_4$
Brunswick green	Iron ferrocyanine/lead chromate	$PbCrO_4$/ $Fe_4[Fe(CN)_6]_3$
Bone black	Calcium phosphate	$Ca_3(PO_4)_2$

Prussian blue, (iron ferrocyanide) a powerful tinter, was common both in blue and in green commercial paint where it was precipitated onto lead chromate yellow (Boan 1924). The Prussian blue/lead chromate green combination was often referred to as Brunswick green. It sometimes suffered from streaking where the Prussian blue separated out from the lead chromate. Efforts after the Second World War to stabilise these greens by the use of non-acicular (non-needle-like) lead chromate and finer particles seem to eliminate these problems (Brickwood 1950).

The artist Albert Tucker was particular impressed by the strength of colour of Prussian blue. In an interview about his early influences in 1994 Tucker spoke of his uncle living in a tent in his back yard.

> There were a lot of his rather pathetic drawings and things around and then I inherited his paint box. And I remember a tube of Prussian blue that I got out there and got all over the place. I remember I was enormously impressed by the incredible power of the blue. That really, really affected me.
> (Tucker 1994)

French ultramarine was also used, but was not as strong a tinter as Prussian blue. Both of these blue pigments became unstable in different environments, French ultramarine was susceptible to acid conditions and Prussian blue to alkaline, such as when used on plaster substrates. Copper phthalocyanine blue (PB15) was first advertised in an Australian paint journal in 1936 as a strong tinter in both acidic and alkaline based paints and environments ('Monastral fast blue, claims for new product' 1936). Marketed by I.C.I. as Monastral blue™, it was initially expensive and probably did not supersede the dominance of Prussian blue until after the Second World War. A synthetic indigo, known as Heliotrope™, (tetra-bromoindirubin) originally patented by Chemische Industrie Basel (CIBA) (Martin 1926 p. 55) was preferred in camouflage paints as Prussian blue was highly absorptive to infrared radiation and was easily distinguished by use of infrared aerial examination (Mellor 1954).

Yellows were most often chromes; commonly lead chromate, mixed or co-precipitated with lead sulphate. Lead chromate formed in alkaline solution (basic lead chromate) produced a crystal called phoenicochroite, that gave orange and red tones (Otero et al. 2012). Zinc chromate was found to be an effective anti-corrosion pigment and its use was tightly controlled during the war for use on planes and boats

Yellow and red oxides were also used in house paint and although there are many sources for natural oxides in Australia, these were generally considered poor in colour. Spanish oxides were the industry standard and these were imported in large quantities. Yellow and red oxides were also synthetically prepared for stronger colour. The manufactured oxides are without the presence of silicates that are often found with naturally sourced ochre. However, even colours labelled yellow oxide were more often based on lead chromate for strength of colour and brightness of hue.

One of the few, new inorganic pigments discovered in the twentieth century, molybdate red, is first described in Australia in 1937 ('New mineral pigment' 1937). It was made with lead chromate and lead sulphate co-precipitated with lead molybdite, giving bright red tetragonal crystals. The extent to which it may have been used in locally made paint is not clear.

Hundreds of new synthetic pigments manufactured from coal-tar products were developed during the first half of the twentieth century and were used in commercial paint for their strength of hue. These gave intense, brilliant colours but they varied greatly in permanence. The coal-tar colours were given different brand names for the same compound manufactured by different companies A useful guide to the various brand names is given in Taylor and Marks (1966 p. 285-298) and a listing of just a few of the most popular colours are given in Table 3.2 below, although books published on the subject at different dates give variation of naming. It is very difficult to unravel this complex terminology of related chemical compounds. To assist with clarity and analytical identification, it is usual practice to use the Colour Index Number when describing coal-tar colours. Terms such as Hansa® and Monolite™ are brand names for a large group of colours produced by a particular manufacturer, and are not specific to the compound. Hansa yellow is a particularly difficult name as it became a brand-name generic for the compound monoazo arylamide, but has many different colour index numbers including PY1, PY2 and PY3; all different in hue and chemistry.

Table 3.2 A small selection of organic colours and manufacturers

Colour index name	Compound (chemical formula)	Some common brand names (manufacturer)[11]
Pigment Red 1 (PR1)	Para red *(p*-nitroaniline β-naphthol)	Carnelio para red (Berger & Sons) Para red (Reeves & Sons) Monolite fast red (ICI) Recolite Para red (Reichhold)
Pigment Red 2 (PR2)	Arylamide red (β-oxy-naphthoic arylamide)	Not known
Pigment Red 3 (PR3)	Toluidine red (o-nitro-p-toluene-azo-β-napthol)	Carnelio helio red (Berger & Sons) Fastona red B (J.W. & T.A. Smith) Graphtol red 4RL (Sandoz) Irgalite fast red P4R (Geigy) Monolite fast scarlet (ICI) Recolite fast red RBL (Reichhold)
Pigment Red 4 (PR4)	Chlorinated para red (*p*-chloro-o-nitroaniline-β-napthol	Hansa red (Reeves & Sons) Carnelio red R (Berger & Sons) Fastona red R (J.W. & T.A. Smith) Graphtol red RL (Sandoz) Irgalite fast red PR (Geigy) Monolite fast red G (ICI) Recolite fast red R (Reichhold)
Pigment Red 83 (PR83)	Synthetic alizarin (1,2-dihydroxyanthraquinone)	Alizarin crimson Alizarin lake Madder synthetic
Pigment Orange 5 (PO5)	Dinitroaniline red or orange (2,4-dinitroaniline β-naphthol)	Hansa red GG Irgalite fast red 2GL (Geigy) Monolite fast orange G (ICI) Recolite orange G (Reichhold)
Pigment Yellow (PY 1)	Arylamide yellow (2-nitro *p*-toluidine-acetoacetanilide)	Hansa yellow G (Reeves & Sons) Helio yellow (Berger & Sons) Monolite yellow G (ICI) Recolite fast yellow G (Reichhold) Cadmium yellow hue (Winsor & Newton)
Pigment Yellow 2 (PY2)	Aylamide yellow GR (mono azo arylamide)	Not known
Pigment Yellow 3 (PY3)	Arylamide yellow (4-chloro-2-nitroaniline-*o*-chloroacetanilide)	Hansa yellow 10G Helio yellow pale (Berger & Sons) Monolite yellow (ICI) Winsor lemon (Winsor & Newton)
Pigment Blue (PB 15)	Phthalocyanine blue (copper phthalocyanine)	Monastral blue (ICI) Cromophtal blue (Ciba) Irgalite fast brilliant blue (Giegy) Heliogen blue (Berger & Sons) Winsor blue (Winsor & Newton)
(Color index number not known)	Synthetic indigo, (tetra-bromoindirubin)	Heliotrope (Ciba)
Pigment Black 1 (PBk 1)	Aniline black (benzenamine)	Monolite fast black (ICI) Diamond black Black lake
Pigment Black 6 (PBk 6)	Carbon black	Carbon black Vine black Lamp black

[11] Naming (cited in Martin 1926, Taylor & Marks 1966 & Myers 2010)

Despite Britain's initial lead in the development of these types of colours in the nineteenth century, it was German chemists that began to excel at their production in the twentieth century. After Germany's defeat in World War One, patents for many coal-tar colours were extinguished under the Treaty of Versailles in exchange for the agreement not to dismantle the German chemical factories (Jeffereys 2008, pp. 81-85). The brilliant toluidine red originally patented in 1905 by Badische Anilin & Soda Fabrik (B.A.S.F.) was one of the colours that became broadly available after the First World War (Gettens & Stout 1966 p. 162).

The German chemical factories resumed production and development in the area of coal-tar chemistry between the wars and quickly regained their position as the leader in the development of new synthetic colours. In 1924 under the stewardship of Otto Bayer, a consortium of companies formed merging BASF, Bayer, Hoechst, and Agfa and others into I.G. Farbenindustrie Aktiengesellschaft (I.G. Farben). This large German consortium became notorious in the aftermath of the war when it became apparent that it had been involved with slave labour and selections for death at its synthetic rubber factory, Bunawerks built at Auschwitz, Poland (Jeffereys 2008). I.G. Farben was broken apart into its original subsidiaries after a war crimes trial at Nuremberg of the I.G. Farben executives.

There was an effort from the Allies to uncover the German secrets to colour-making after the war. Australians were initially kept out of the 'scientific missions' to post-war Germany, but in 1946 and again in 1947 Hermon Slade, an Australian chemist and developer of paint resins, was sent to Germany as an agent for the Australian Scientific and Technical Mission (Todd 2007, pp. 34-35). The technical rewards from these trips are uncertain, but in 1950 Australian paint makers were invited to view microfilms of German industry related to paint-making prepared by The Australian Scientific and Technical Missions at the Division of Industrial Development ('Microfilms of German industry' 1950). Acknowledgement of the German expertise in colour-making is also suggested by Joy Hester's comments to Sunday Reed in 1947 regarding Dulux and the development of the post-war colour range led by a German chemist.

> Guy's pottery [Guy Boyd (1923-88) working in Sydney at Neutral Bay from1946] is in lovely superb yellows (looks like cadmium) and marone [sic] and all colors in fact which Arthur [Boyd] cannot get as they are made over here [Sydney] by Dulux and they have a german [sic] ex-internee and color specialist working for them and it can only be obtained in small quantities and it's expensive and rare. Guy has to pick it up personally. I'm going to find out how they're going (for Nolan) if I can, if [the] new Dulux colors post war can be obtained for 'outsiders' yet. Apparently you have to be in the know to get it.
> (Hester 1947 cited in Burke 1995)

Arthur Boyd was a keen user of many of the new coal-tar colours. He started making his own oil paint using a small addition of beeswax in 1940. Writing in 1983 he said that he used I.C.I. coal-tar colours on a painting *The Mockers* 1945 (collection Art Gallery of New South Wales). These he said '...were fairly new at the time. They had good covering power.' (Boyd 1983). In another letter dating from the 1980s Boyd elaborated and said the coal-tar colours he obtained from I.C.I. were monastral blue (copper phthalocyanine) and monolite yellow. Boyd says that he chose only those colours only with the best lightfastness.

Nolan too was interested in the strong tinting power of coal-tar colours which he referred to generically as aniline colours. He wrote of incorporating them into white paint for use as coloured paint layers.

> If you are going to get a bit of a hoard together darling it would be good to see Deans about more aniline dye. They had some before which came from England. Ask if they have the three colors, red, blue & yellow again soluble in spirit. And also three soluble in water, although the spirit ones are really all that is necessary. And black. But as strong as they have got, they probably call them chrome yellow, crimson or scarlet & prussian blue. An ounce of the dye goes a long way, amongst other things it works well in Nucraft, so it is a good investment in spite of being, so they tell, very fugitive
> (Nolan 27 October 1942)

Nolan's reference to aniline colours is not specific enough to be able to identify the exact pigments he may have added to his paints. Chrome yellow and Prussian blue which he mentions in the context of aniline colours, were not in fact coal-tar colours but metallic pigments, although Nolan may have been referring to coal-tar colours in the hue of those inorganic pigments.

Strong tinting pigments including both inorganic and organic colours enabled paint manufacturers to add liquid stainers from the 1930s to base white paint to obtain the desired strength of colour. Lewis Berger & Sons (Aust) Ltd. launched the first liquid stainer, called Surtint, for general use on the Australian market in 1931 (Figure 65). Sidney Nolan, who had an interest in the use of dyes and tinters for paint to create strong colours, had both a colour chart and a can of Surtint among his studio materials.

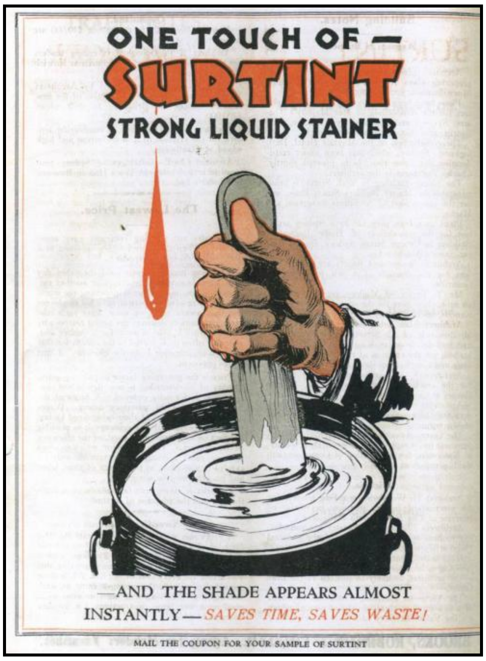


Figure 65. One touch of Surtint, *The Decorator & Painter for Australia & New Zealand*. 1 August 1931, p. ix.

The major component of most house paint is, however, not the coloured material but the body white. The use of powerful tinting pigments in the twentieth century gave prominence to the white pigment used to bulk up the paint and give it body and covering power.

3.11 Lead white debate, zinc and titanium

Traditionally, lead white (basic lead carbonate) was the white pigment used as a base for house paint, as it was for artists' paint. The large Australian paint manufacturer B.A.L.M. was in fact formed from a combination of Broken Hill mining companies and British lead corroders companies, demonstrating the central place of this white pigment in the paint trade of Australia. The galena (intimate combination of silver, lead and zinc) lode at Broken Hill was one of the world's most productive sources of lead and zinc for paint in the twentieth century. B.A.L.M., Berger and Champion Druce were all producers of lead white in Australia in the 1930s using the stack process. These large Australian paint companies were therefore intimately connected with the production of lead white. From 1937 a series of advertisements were published and co-authored by BALM, Champion Druce and Lewis Berger promoting the use of lead in paint (Figure 66).

Figure 66. There's no substitute for white lead, *The Decorator & Painter for Australia & New Zealand*, 10 February 1937, p. 201

Issues related to the toxicity of lead white in house paint were recognised as early as the late 19th century and by the 1920s it was of great concern in many countries including Australia. The White Lead (Painting) Convention convened by the International Labour Organisation in Geneva 1921, advocated the abolition of basic lead carbonate and lead sulphate in internal house paint. In Australia, and particularly in Queensland, where the combination of extreme weathering and proliferation of weatherboard houses appeared to cause increased problems the debate concerning the use of lead in house paint was fraught and protracted ('Lead paints in Queensland. Inquiry by Federal Government' 1930: 'Whitelead paints in Queensland. Debate in House of Representatives' 1930: 'Absence of lead poisoning cases' 1950: 'Attack on lead' 1951). Through the 1920s there were a number of State and Federal inquiries on the subject. The Queensland government passed legislation in 1923 with a partial prohibition on use of lead paint, but the legislation was suspended pending a Federal Commission. In 1930 this commission was appointed and its 1932 report found there were no proven examples of lead poisoning from lead-based house paint ('Queensland and white lead paints' 1939). The debate between detractors and advocates of lead white in paint continued throughout the 1940s and 1950s, but lead white continued to be the most common white pigment in locally manufactured commercial paint during this period.

During the Second World War, lead white was most commonly found in the form of Master Painters White which was 90% lead and 10% zinc (Figure 67). Combining a small amount of zinc oxide with lead white was standard practice in the 1920s.

Figure 67. Sherwin-Williams Master painters' white *The Decorator & Painter for Australia & New Zealand.* 12 June 1941, p. 41.

> The manufacturer of mixed paint almost invariably blends zinc white and white lead together in order to produce the ideal mixture. White lead used alone rapidly develops what is known as 'chalking', or powdering away of the surface, while zinc oxide, on the other hand, dries to a very hard film, which is somewhat brittle and liable to crack. The ideal mixture, therefore, combines these two white pigments, and the durability of such a paint is vastly superior to that of paints made with either pigment alone
> (Boan 1924 p. 95).

A.C. Hatrick, in anticipation of the continuing use of lead white in paint, took a bold step in 1946 in purchasing the licence to manufacture and distribute a precipitated white lead product from the Euston Lead Company in Pennsylvania, USA The plant in Footscray, Melbourne, opened in 1949 and the product was promoted as a fine pigment, more easily incorporated into linseed oil ('For more profitable painting. Euston white lead now freely available' 1950). Several cans of Euston white lead in oil were found in the Sidney Nolan studio contents, probably dating from Nolan's visit to the A.C. Hatrick/Reichhold plant in 1952. A.C. Hatrick's enterprise in the direction of white lead production for Australia was poorly timed, as titanium white had become the dominant white pigment used in house paint from the early 1950s. Euston’s Lead White factory was wound up in 1956 and sold to the linseed oil producer, Meggitts Ltd. A.C. Hatrick’s remaining lead production shifted to the Botany site where it was used as a stabiliser in the production of polyvinyl acetate (PVA), the new plastic product of the late 1950s (Todd 1998b).

In contrast to Australia, many European countries had banned the use of lead white and sulphate in paint and switched to pure zinc oxide paints after the 1921 Lead White Convention. Exported Australian zinc metal became a major source for white pigment in European paint.

> There’s a far-famed paint called Velure,
> Made of zinc from Aussie, and pure;
> For inside and out and work to endure,
> There’s nothing on earth like Velure.
> ('Velure' *The Decorator & Painter for Australia & New Zealand* 1 September 1926, p. 354)

Australian production of zinc oxide pigment was limited to a few manufacturers. Mascot Zinc Smelting Works was a producer of zinc oxide and zinc oxide-based oil paints in 30 tints from 1917 ('The Mascot Smelting Works' 1925). Mascot zinc white was promoted as a non-poisonous white pigment from at least 1924 (Figure 68). The zinc oxide produced at Mascot was of the ‘indirect’ process, often called the French process, where zinc metal or ore was combusted to form zinc oxide. This produced a fine, agglomerated (spherical groupings) particle of good purity.

Mascot Smelting Works Exhibit of Zinc Paints.

Figure 68. Mascot Zinc Smelting Works exhibit, *The Decorator & Painter for Australia & New Zealand* 1 June 1924, p. 248

After the Second World War there was a critical shortage of zinc for paint as it was required for steel and galvanising, and the Australian Government sought foreign dollars from export of metals. This was keenly felt in Queensland where limits on the use of lead white had continued to be enforced due to issues of lead poisoning ('Queensland limit on painting' 1949).

The combination of zinc ions from zinc white pigment, and the fatty acids in the oil medium, readily combine both in the can and after drying, to form zinc soaps. This could be advantageous to manufacturers as the zinc soaps thickened the paint and maintained the pigments in suspension, thus increasing the shelf life of ready-mixed paints. Zinc soaps were considered such useful stabilisers that both zinc stearate and zinc palmitate were sometimes added to paint (Atherton 1969, p. 55). Zinc soaps whether formed in-situ or added deliberately, were often cited as causing problems with regard to paint film stability. Dawn Rogala (2011) reviewed the paint manufacturing literature on this subject, and it is extensive. One of the most expansive sources for research into zinc oxide paints and soap formation was Australia. This was probably due to the higher temperature, humidity and light environments that house paint was exposed to in Australia, which caused these problems to emerge more frequently.

One of the critical problems with zinc oxide and soap formation in artists' painting is their ability, in some instances, to aggregate into spheres. The aggregates may move within a paint film and over time break through the surface of the painting. In a number of instances this causes physical disruption and breakage of the paint film on artworks painted with zinc oxide oil paint. It is still not understood what mechanisms cause zinc soaps to aggregate and move within paint films. Gillian Osmond reviewed the conservation literature and outlined a large number of possible causes which include: exposure to water and humidity, high light levels, pH within the paint film, presence of metallic ion catalysts from other pigments, other paint additives and oil type (Osmond 2012). The possible instability of zinc oxide in oil paint is a critical issue in regard to artists' use of paint such as Ripolin, which is a zinc oxide in oil paint. In addition, while European paints such as Ripolin were based extensively on zinc oxide, Australian-made lead white paint as demonstrated in this study, also often contained a proportion of zinc oxide with the potential to produce zinc soaps, possibly even more that pure zinc oxide paint due to the presence of other metallic ions.

Another white pigment, titanium dioxide, initially in use in the 1920s, did not supersede zinc oxide and lead white in commercial paint until after the Second World War. The earliest description of titanium white in the Australian paint industry journal was in January 1925 ('Titanium dioxide from bauxite' 1925), but the English paint company, Hubbuck, wrote that it had been importing titanium-based paints into Australia from 1922 ('Hubbuck's white zinc paint' 1930). An imported patented white pigment called Tanox was advertised from 1929 as a 'non-poisonous titanium-zinc white' ('Tanox white in oil' 1929). In the 1920s a combination of titanium dioxide and zinc oxide was considered to give benefits both of tinting strength and hardness.

At least one Australian paint manufacturer was an advocate for non-poisonous titanium dioxide and zinc oxide pigment in the period prior to the Second World War. Taubmans began importing titanium dioxide in 1925 and used it as the base white pigment with zinc oxide in a number of products including Taubmans Zinc White in Oil, No. 3. Undercoat and Trade Service White (Figure 69) (Todd 1990, p. 50). With foresight, Walter Taubman had stocked up on raw materials prior to the Second World War, including a large amount of titanium dioxide, after visiting Germany in 1937 (Todd 1990, p. 129).

Figure 69. Taubmans Trade Service White, *The Decorator & Painter for Australia & New Zealand* 1 December 1928, p. xv.

Prior to the Second World War, titanium dioxide was based on the anatase form of the pigment and two main processes were generally used. One licensed by the Société de Produits Chimiques des Terres Rares, was called the Blumenfeld process and it produced an almost pure anatase titanium dioxide. The other was mixed with barium sulphate and was licensed by British Titan, the National Lead Company, USA and I.G. Farben, Germany (Laver 1997).

The first factory to commence production of titanium dioxide in Australia was opened in Melbourne in 1932 using ilmenite deposits from King Island, ('Titanium pigment' 1932) but it appeared to have problems producing a viable product. Under licence from British Titan, another factory, Australian Titan Products Ltd, opened at Heybridge, near Burnie in Tasmania in January 1949, manufacturing sulphate-process rutile titanium (Figure 70). It was not until this time that titanium white began to be used extensively in Australian house paint ('Titanium production will vitally affect paint industry' 1949). The ilmenite was obtained from India, and cheap power in Tasmania helped to make the processing economical, while sulphuric acid needed to form the titanium salt was manufactured in Risdon, Tasmania ('Modern plant installed in Australia's new titanium factory' 1949). Rutile titanium dioxide manufactured at the Tasmanian plant created pigment particles that were extremely tiny and suited therefore, to gloss enamel and spray applied paints that did not clog the apertures of the equipment.

Figure 70. *Titan paint pigment factory*, Cooee, undated, BandW photograph, 8' x 10'. Collection: State Library of Tasmania

All three white pigments; lead white, zinc oxide and titanium dioxide have properties in house-paint that were rigorously debated in the trade journals regarding benefits and deficiencies. Lead white is a dense warm white, but has a tendency to darken on exposure to polluted atmosphere (sulphur) and to chalk and powder. Zinc oxide was a bright white with fine particle size, but had less covering power. Its tendency to form soaps when mixed with oil and resin could cause flaking and paint film failure. Paints made with pure zinc oxide were considered too hard and inflexible. Titanium dioxide was a dense extremely fine pigment but had issues with chalking, particularly in the anatase form. The anatase titanium dioxide was commonly mixed with zinc oxide to produce more stable paint films. Rutile titanium dioxide, available after the Second World War, was an excellent product that quickly superseded the use of zinc oxide and lead white in commercial paint production in Australia. By 1952 sixty percent of the titanium dioxide used in Australian paint was manufactured at the Titan plant in Tasmania and was of the rutile form ('Future for white lead' 1952).

There is little opportunity to attribute the presence of titanium dioxide identified on a work by an artist to the use of a commercial paint, as titanium dioxide was also used in artists' paint as early as 1925 in France, and sometime between 1928 and 1934 in the Winsor & Newton artists' oil paint range (Laver 1997, p. 303). The presence of the rutile form may assist however in dating paint, as the rutile form only became available after the Second World War.

A number of other white, filler pigments without strong covering power, but useful for other effects, are also found in house paint of this period. These include barium sulphate, often used as naturally sourced barytes. In the 1920s, a deposit of barytes in South Australia was considered to be the whitest natural barium sulphate in the world (Boan 1924). Barium sulphate was useful in paints of stronger deeper colour as it provided bulk without causing too much lightening of colour.

Lithopone, an intimate combination of barium sulphate and zinc sulphide with some zinc oxide, when added to paint was usually confined to interior paints as it was not considered light stable. A lithopone factory opened at Homebush Bay, N.S.W. by Electrolytic Zinc Co. of Australasia Ltd. in 1929 ('Manufacture of lithopone in Australia' 1929). It appears that Australian-made lithopone was not highly regarded as in 1939 A.C. Hatrick imported a large quantity of lithopone manufactured by Union Chimique Belge Société Anonyme. This activity attracted the attention of Customs and the matter was referred to investigators under the Trading with the Enemy Act 1939 (Customs and Excise Office 1940). It appeared, however, that the cargo was from Belgium and dated prior to that country's occupation by Germany in May 1940, so there was no case to pursue and the matter was dropped. In 1932 Union Chimique Belge SA had refined a technique for washing calcined lithopone with phosphoric acid to reduce the zinc oxide content and make it more light stable and it was probably this light stable product that Hatrick was importing in 1940 (Guillissen & Union Chimique Belge Société Anonyme 1932). Lithopone gave excellent covering power particularly in flat wall paints. Its presence when used in a mixed paint with zinc oxide and barium sulphate presents difficulties for analysis as identification of the elements zinc, sulphur and barium cannot distinguish between lithopone and a mixture of zinc oxide and barium sulphate.

Table 3.3 Common white pigments and fillers

White pigments and fillers	Common names	Chemical formula
Basic lead carbonate	Lead white	$PbCO_3$
Zinc oxide	Zinc white	ZnO
Titanium dioxide (anatase)	Titanium white	TiO_2
Titanium dioxide (rutile)	Titanium white	TiO_2
Barium sulphate	Barytes	$BaSO_4$
Calcium carbonate	Chalk	$CaCO_3$
Zinc sulphide/Barium sulphate	Lithopone	$ZnS/\ BaSO_4$
Aluminium silicate	Kaolin/China clay	$Al_2Si_2O_5(OH)_4$
Magnesium silicate	Talc	$Mg_3Si_4O_{10}(OH)_2$
Lead sulphate	Fast white	$PbSO_4$
Calcium sulphate (dihydrate)	Gypsum/terra alba	$Ca\ SO_42(H_20)$
Antimony trioxide	Antimony white	Sb_2O_3
Magnesium carbonate	Magnesite	$MgCO_3$

Other pigments such as, antimony trioxide, aluminium silicate, calcium carbonate, lead sulphate and magnesium silicate, are all mentioned in the literature of the period as possible additions to the primary body white and their presence may suggest use of a house-paint, although it is not yet clear how extensively these whites and fillers were added to artist's paints from the same period. A listing of common white pigments and fillers is given in Table 3.3 above. Antimony trioxide was recommended for use along with titanium dioxide in early alkyd formulations due to the pigments compatibility with acidic mediums (Technical Service Department of I.C.I. ANZ 1941).

3.12 Analytical considerations

The positive identification of the commercial paints on artworks is difficult. Assumptions about their use based solely on observation are not sufficient. Instrumental analysis is required to begin to unpack these complex paint systems. Even with analysis there are continuing difficulties in the distinction of artists' oil paints from oil-based house paints and artists' own manipulation of their paints.

Oleoresinous enamel paints are perhaps the most difficult to distinguish analytically from artists' oil paints. Oil type is extremely difficult to ascertain, and so the presence of tung oil (or perhaps even candlenut oil) which may indicate a commercial paint, is unlikely to be detected over linseed oil by common methodologies. As lead white, zinc oxide and titanium dioxide are all used in artists' paints, these also offer little assistance.

The presence of coloured pigments common to commercial paints and the absence of the expensive artists' colours may be indicative of house paint. Likewise, fillers and additions to the primary body white, such as kaolin and barytes may suggest a house paint formulation. A definitive positive identification for commercial paint is only possible however when alkyd, nitrocellulose or phenolic binders are found to be present, as these were not used as artists' paints during this period.

3.13 Summary

The research in this chapter on the historical development of the house paint industry in Australia in the first half of the twentieth century has demonstrated its rapid adoption of new technologies. This was achieved by the formation of partnerships and licensing arrangements with the overseas chemical and paint companies developing these new materials. The early insertion of Reichhold Chemical Industries into Australia also enabled local production and availability of many of these new materials to smaller paint companies, ensuring their continued viability in a competitive environment.

Experiments with emulsion paints using glues and oils and surfactants were also common in this period. Paint formulations in the 1940s were challenged by wartime restrictions as many raw materials were no longer available and supplies of paint were reserved for war use. The Australian paint industry, despite these difficulties, was able to continue to manufacture some paint for domestic use with locally sourced materials (Figure 71).

Figure 71. Sherwin-Williams solves wartime problem, *The Decorator & Painter for Australia & New Zealand* 17 January 1942, p. 15.

The end of the Second World War also brought a period of supply difficulty with many sources for raw materials no longer available due to political realignments. Again, paint manufacturers quickly adapted and successfully supplied paint for local use and building programs. This post war period also saw the development of a number of new pigments and resins for the paint trade, some of which became standard in artists' paint but were first developed for use in house paint. In addition to supplying raw minerals for local pigment manufacture, Australia was a major supplier of many of the minerals for pigments used by paint manufacturers throughout the world, particularly zinc oxide and titanium dioxide.

Perhaps the most significant shift in paint making that evolved through the first half of the twentieth century was the move away from raw materials derived from natural sources towards materials synthesized from coal and petroleum. This included both pigments which increasingly were made from coal-tar, and resins developed from nitrates, polyester and phenol. This shift away from natural materials gave greater control over the sourcing of materials and quality control, both of which had been significant limiting factors in paint making in commercial quantities.

The variety of materials in commercial paints makes the job of analysing and identifying these types of paints on works by artists of the period a challenging one. This study of the Australian house paint industry outlines some important developments that can be useful in the interpretation of analytical results. It is the paint that Nolan left in his studio in Wahroonga Sydney studied in detail in the following chapter that offers the opportunity to study a reference set in order to test the most suitable analytical systems. It also enables the comparison of this study of the paint industry against some historic case studies of actual paints.

Chapter 4. Examination and analysis of Sidney Nolan's Wahroonga studio material

> *And now it is raining as if it would never stop drumming on the tin roof of the studio and I have finished what might be called a mystic painting on the masonite, with a figure sitting on a shell that makes me think of Botticelli, in spite of the figure however it is probably a sea painting if you can paint the sea like porcelain, things happen in it almost of their own accord. Ripolin is like quick silver I can [see] us cooking it over a fire or leaving it out under the rosemary all night to see what secrets can be found in it.*
> (Nolan 16 November 1943)

4.1 Introduction

The previous chapter examined the manufacture of commercial ready-made paints in Australia in the first half of the twentieth century. It uncovered the complex and intricate history of paint components made from natural sources, which gradually became superseded by the development of synthetic alternatives. Many of the labelled materials in Nolan's Wahroonga studio are part of this rich history of technical development. Chapter 4 looks at these materials as subjects for analytical investigation.

The collection of paint materials from Sidney Nolan's Wahroonga studio offers an opportunity to create a set of analytical standards for comparison with the analysis of samples from paintings. The quantity of material available from the studio materials is considerable in comparison with material that can be obtained as samples from paintings. Paint-outs of materials still inside tins can also be undertaken that may lead to ageing studies and solubility and cleaning experiments.

This chapter offers a detailed study of the English-made Ripolin material as the primary paint used by Nolan from at least 1943 until 1953, to answer questions regarding its formulation and ability for analytical identification. Questions to be addressed in this chapter are, was the Ripolin paint used by Nolan and manufactured in England, oil-based enamel? If so, can we identify the types of oil and the possible presence of resin in these paints? What are the pigments used in the Ripolin cans? Do they correspond with the same colours on the French chart studies by Gautier, Bezur, Muir, Casadio and Fiedler (2009)? Do the binders and pigments in the paints provide any potential for further dating of the Ripolin cans? Can the analytical spectra gathered on samples from the cans using FTIR and pXRF be used to 'fingerprint' Ripolin and identify it on Nolan's paintings? Do any of the paints present issues with ageing and deterioration?

Nolan's other ready-made paint of choice Dulux, is the subject for a second analytical study of reference material. The can of B.A.L.M. Dulux in Nolan's Wahroonga studio is useful for providing analytical information of typical alkyd based paints from the period as used by Nolan. Due to the presence of only one Dulux from Nolan's studio, other alkyd-based Dulux material of the period was sought to provide a larger group of comparative standards. These were sourced from The Powerhouse Museums collection of 1934 alkyd resins from called Paralac, which were used in the formulation of B.A.L.M. Dulux paints (B.A.L.M. 1934). A second group of Dulux 388 brushing-line paint in cans were borrowed for this study from Dion's Bus Company, Wollongong, from their stores of products used from the 1930s to 1960s in the maintenance of their buses. This part of the study is an attempt to identify differences between Dulux manufactured prior to the Second World War compared to that manufactured after Dulux production was resumed in 1947. According to the research on Nolan's practice in Chapter 2, Nolan may have been using Dulux paint in the period 1939 to January 1943 and also after the war as suggested by the can of Dulux in his Wahroonga studio. Historical studies on the production of Dulux in Australia outlined in Chapter 3, suggest there was a break in production between these two periods, corresponding with changes in formulation. This study attempts to locate distinguishing analytical features which may be used to identify Dulux paint and potentially date the presence of such paint to either pre-war or post-war production. This is of interest as a tool for both attribution and dating. Nolan's wartime use of alkyd paints is earlier than any other recorded use by any artist and may provide unique information on these early alkyd paints.

Some of the specific questions regarding formulation are examined, such as whether pentaerythritol-based (PE) alkyds, which were first used after the Second World War, can be distinguished with FTIR from those based on glycerol as suggested by Cappitelli (2003). How soon after the war was PE used in Australian made Dulux alkyd formulations? What is the earliest example of a PE alkyd that can be identified? What were the pigments used in the Dulux 388-brushing line range and how did they change post-war, when the new expanded colour range was launched. Can Dulux be distinguished from other alkyd-based paints that Nolan may have used?

Finally a brief analytical study is offered on other material from the studio that may be found on Nolan's paintings. Many of the items from the studio tell a story of wartime production when chemical and paint industries in Australia switched from domestic need to suppling troops, particularly in South East Asia. The Nolan studio products also enable the development of standard analytical spectra from labelled cans and bottles for comparative studies of materials found on paintings. An on-line library of these spectra was developed as a research outcome on the *20th century in paint* web-site as a tool for future studies on Nolan's paintings and also for studies of other artists use of similar materials (http://www.20thcpaint.org/). It is hoped that this spectral library will form part of an Australian spectral resource for analytical conservation research of twentieth century paint.

4.2 Analytical systems

Several bench top analytical systems were chosen as first step processes. They were; Fourier Transform Infrared (FTIR) and portable X-ray Fluorescence (pXRF). These were combined with Polarising Microscopy (PM) and incident light microscopy and Ultraviolet Fluorescence (UV) microscopy examination of cross-sections embedded in polyester or epoxy resin. These techniques are the most common analytical techniques available in conservation laboratories, providing both organic and inorganic analysis of many pigments and binders found in artworks.

Several more detailed analytical techniques were undertaken on a selection of materials. Raman spectroscopy was used to examine the pigments in several titanium-based paints from the Wahroonga studio by the Centre for Microscopy and Microanalysis at the University of Queensland. Scanning Electron Microscopy (SEM) with Energy Dispersive X-ray Spectroscopy (EDS) was undertaken on samples at the Microstructural Analysis Unit at the University of Technology, Sydney. Meth-Prep Pyrolysis Gas-Chromotography, Mass Spectroscopy (Meth-Prep GC/MS) was undertaken on ten Ripolin paint samples and derivitised Pyrolysis Gas Chromatography, Mass Spectroscopy (TMAH-PY GC/MS) on five alkyd samples at the Getty Conservation Institute. A number of Ripolin paint samples were also studied using the Infrared Beam-line at the Australian Synchrotron to obtain more detailed information regarding the formation of zinc soaps. The protocols used for the different systems are described in detail in Appendix iv.

All instrument systems used during this study required the use of specialised operating software and, usually, additional analytical software to interpret the data. Considerable time was spent in developing these skills and knowledge for the instruments. The FTIR in particular required extensive development of experience in optimising spectral quality and interpreting complex multi-component samples. Several libraries on the FTIR at the Art Gallery of New South Wales were essential to identify many spectral features, in particular the Coatings Technology Library (Nicolet Instrument Corp. 1991-1994) and HR Aldrich Dyes, Indicators, Nitro and Azo Compounds (Thermo Scientific 1999-2001, 2004, 2008). During the course of this research, membership of the Infrared Users Group (IRUG) was sought and obtained. Membership of this group gave licensed access to the IRUG spectral library of cultural material samples (IRUG 2007). In addition to spectral libraries, reference texts which describe likely materials to be found in twentieth century paints and the identification of their FTIR spectra are essential guides in this work. Learner (2005) in *Analysis of Modern Art* describes in detail the distinctive features of the FTIR spectra of many twentieth century paint pigments and media. The FTIR spectral peak assignments, taken from a number of different sources, of some common commercial paint components are given in Table 4.1. Van der Weerd, van Loon and Boon in their study *FTIR studies of the effects of pigments on the ageing of oil* (2005) make the critical point however, that the interaction between oil and pigments in a typical paint is not always passive. Other, third party components may form during the drying and ageing process that may be detected in FTIR spectra and add to the complexity of the interpretation of the results. The most relevant of these interactions for this study is that between zinc oxide and the fatty acids in oil. These two components readily form zinc carboxylate species, including zinc stearate/palmitate and zinc oleate/linoleate seen in the FTIR absorption region between 1500 and 1600 cm^{-1}.

Table 4.1 Paint components and FTIR spectral peak and metallic ion assignments

Compound (common name/s)	Identifying FTIR peaks cm^{-1} (references)[12]	Elements detectable with pXRF
Linseed oil unpigmented	1738, 1710, 1458, 1414, 1374, 1242, 1167, 1099, 980, 725[i]	None
Alkyd	2932, 2958-60, 1733, 1601-5, 1583, 1454-64, 1270, 1139, 1071-3, 744[ii]	None
Nitrocellulose	1656, 1281, 1060, 846[ii]	None
Prussian blue	2087, 607, 499[ii]	Fe, K
Copper phthalocyanine	1508, 1464, 1419, 1377, 1334, 1286, 1165, 1120, 1090, 1068, 901, 754, 731, 723, 573[vii]	Cu
French ultramarine	1001, 714, 680[i]	Al, Si, K
Lead chromate (chrome yellow)	853, 831, 820[iv]	Pb, Cr
Lead sulphate tribasic	1527, 1396, 1134, 1095, 1033, 602[iv]	Pb, S
Lead sulphate mono basic	1080, 602[iv]	Pb, S
Basic lead carbonate (lead white)	3539, 1408, 776, 681[i]	Pb
Calcium carbonate (chalk)	2513, 1794, 1424, 876, 713[iii]	Ca
Barium sulphate (barytes)	1195, 1120, 1075, 640, 611[ii] 1180, 1119, 1088, 980, 632, 609[vi]	Ba, S
Antimony oxide	1620 (broad), 740 [vi]	Sb
Titanium dioxide (titanium white)	630-650 (broad) inception approx 850[vi]	Ti
Calcium sulphate dihydrate (gypsum)	3556, 3402, 1619, 1173, 1142, 675, 602[iv]	Ca, S
Zinc oxide (zinc white)	400-550 (broad) inception approximately 600[xi]	Zn
Metallic carboxylate moieties	1500-1600 (broad)	Zn, Cu, Pb, Ca…
Zinc stearate/palmitate	1540, 1465, 1398, 745, 723[v]	Zn
Zinc oleate/linoleate	1548, 1526, 1467, 1455, 746, 722[v]	Zn
Toluidine red	1618, 1526, 1498, 1468, 1448, 1402, 1377, 1342, 1302, 1255, 1190, 1130, 849, 754, 509[vii]	None
Alizarin	1662, 1631, 1587, 1456, 1350, 1331, 1296, 1198, 1047, 1032, 1012, 847, 827, 748, 713, 660, 579 [viii]	None
Aluminium silicate dihydrate (kaolin/china clay)	3697, 3671, 3654, 3621, 1118, 1034, 1016, 917[ii]	Al, Si
Magnesium silicate (talc)	3676, 1018, 669[vi]	Mg, Si
Carbon black (lamp black, vine black)	none	None
Bone black (ivory black)	2015, 1043, 604, 563[viii]	Ca, P

12 **i (van der Weerd, van Loon & Boon 2005), ii (Learner 2005)p.89 iii Ferreira, Boon & Stampanoni 2011, iv (Otero et. al 2012), v (Robinet & Corbeil 2003), vi (Nicolet 1991-1994), vii (Thermo Fisher 1999-2001, 2004, 2008), viii (IRUG 2007), xi (McMillan et. al 2013)**

4.3 Ripolin study

The Nolan Wahroonga studio Ripolin in cans is mostly of two types of finish, a flat range of colours in eleven different tints and a gloss range in seven tints. An additional can of white, open and dried out, has no indication on the label of gloss level and is referred to in this study as 'old white'. Most of the gloss cans are described on their labels as 'Quality BLT'. This is a term used on the English labelled gloss Ripolin cans from at least 1927 as it appears in a drawing of a Ripolin can in an Australian newspaper advertisement at that date (Figure 72)

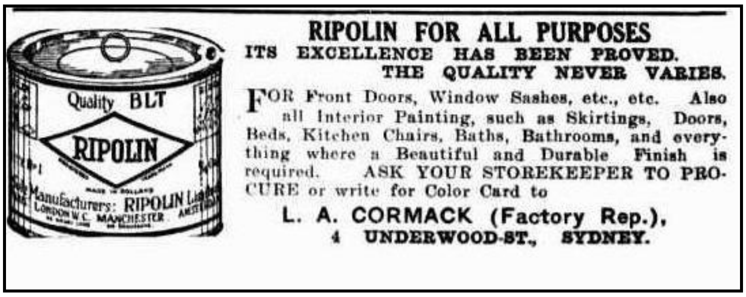


Figure 72. Advertisement for Ripolin paint Singleton Argus, 7 May 1927. p. 3

The meaning of the term 'Quality BLT' is elusive. BLT may be an abbreviation of the French term *brillant* used to describe a gloss finish. For example, a French Ripolin colour chart includes the note that Ripolin '*se fait en mat ou brillant*' [is made in matte or gloss] (Le Ripolin c.1908-1924), but the use of an abbreviated French term on British labelled cans is uncertain (Figure 73).

Figure 73. Interior of Ripolin brochure dated circa 1908-1924. Collection: Art Institute of Chicago (image courtesy Art Institute of Chicago)

Some colour tints in the Wahroonga studio contents are duplicated, making up a total of 20 different types from a total of 35 cans in the Art Gallery of New South Wales group and 12 in the National Gallery of Victoria. Just one can in the National Gallery of Victoria group is not represented in the Sydney collection and that is a mid-range blue called 'Special to shade No. 1135/ N.A.G. blue'. This can does not form part of the analytical study group.

While both the BLT white 1 and flat white 501 are in large cans of ¼ gallon and ½ gallon, all tinted cans except for the slightly small cans of gloss red 16 (½ pint), are in 1 pint cans. There is additionally a can of 'thinners for gloss Ripolin' (SID 43390) and a can of paste filler (SID 43388) also made by the Ripolin company. A leather case with army-style metal panniers, modified with attachments brazed off and cardboard spacers, has been adapted as a carry system for the liquid paint (SID 44139). Finally, the group of Ripolin material is completed by two unlabelled rectangular cans of additional mixtures with paint drips suggesting they contain bright yellow and white gloss paint (SID 44141 & 44142) (Figure 74).

Figure 74. Ripolin Ltd. material from contents of Sidney Nolan's Wahroonga (Sydney) studio. Collection: Artists' Materials Archive, Conservation Department, Art Gallery of New South Wales. Gift of Jinx Nolan 2006. Photo: Felicity Jenkins and Art Gallery of New South Wales

While the paint in the leather carry satchel has dried through exposure to air and some of the Ripolin cans have been used, most retain their proprietary fastener and triple seal mechanism and have never been opened. Gentle movement prior to opening suggested that most of these sealed cans were still liquid. The elaborate seal system intact on most of the cans included a coloured string and metal seal across an outer metal ring in addition to an inner painted lid showing the colour of the paint in the can (Figure 75)

Figure 75. Ripolin BLT white no. 1 (SID 43220). Photo: Felicity Jenkins and Art Gallery of New South Wales

The colour numbering system used on the Nolan studio cans relates to the colour codes on the British Ripolin Ltd. chart from the State Library of South Australia (Figure 55) and varies somewhat from the codes documented on the French Ripolin charts (Gautier et al. 2009). Unlike the exclusive use of numbers for the French colours, British Ripolin uses a combination of numbers and letters for some colours. The flat paints from Nolan's studio are also given a number 5 at the beginning of their numerical code to differentiate them from the same colours offered in the gloss range. While the British colour chart does not give names to the tints offered, the Wahroonga studio cans specify both colour code and name enabling some correspondence to be established between the English-made colours with French colours as documented by Gautier, Benzur, Muir, Casadio and Fiedler (2009). These pairings are given in Table 4.2.

Table 4.2. English Ripolin cans from Nolan studio compared to French Ripolin colours

English made Ripolin from Nolan studio	**French Ripolin colour (Gautier & Casadio 2011)**
White 1	*Blanc de neige 1*
BLT white 1	*Blanc de neige 1*
BLT ochre 3056	*Ocre jaune 56*
Red 16	*Rouge de Chine 16*
BLT blue deep 40RD	*Bleu de Prusse 40*
BLT blue PE5	*None*
BLT ultramarine 13	*Bleu outremer 13*
Black 1105	*Noir d'ivoire 5*
Flat white 501	*Blanc de neige 1*
Flat canary 504	*Jaune clair 4*
Flat lemon 514	*Jaune foncè 14*
Flat red 516	*Rouge de Chine 16*
Flat maroon lake to shade 1167	*Violet mauve 67*
Flat pink very light 565	*Rose pâle 65*
Flat blue deep 540RD	*Bleu de Prusse 40*
Flat black 505	*Noir d'ivoire 5*
Flat olive green 573	*Vert romain moyen 73*
Flat peacock green 582	*Vert irlandais foncé 82*
Flat green dark yellowish 590	*Vert wagon 90*

Three cans from the Wahroonga studio differ from the others in the group. The black 1105 is similar in appearance to the other gloss cans, but is without the BLT notation. The English chart has two black swatches, one 1105 and the other 5, and so the use of this number in the eleven hundreds for a black must have been an alternative to the standard black 5. Similarly the can of flat maroon lake to shade 1167 is given a number in the 1100s, but this number notation is also found on the English chart. Strangely the number given on the can of ochre 3056 does not match the ochre on the English chart where it is given 56, as for the French chart. Researchers at the Art Institute of Chicago suggested that these additional numbers at the beginning of series may indicate changes in the type of binding media. In correspondence with this author, they suggested the following number systems, however none of these number series matches those of the aberrant numbers on cans from Nolan's studio.

Ripolin Express: numbers between 1000 – 1100,

Ripolin Express, serie Synthetique: numbers in 2000,

Glacis Ripolin: numbers in 1400.

Ripolac: numbers between 100-120,

Ripolin 500: numbers in 500 (later, numbers in 3500)

Ripolin 500 mat: numbers in 6500

[Gautier personal correspondence 2010]

Two smaller cans of red 16 appear to be gloss paint but have different labels to the BLT paints. The side of the two cans of red show the gold medal awarded to Ripolin in the 1895 Exposition d'Amsterdam and notes two further gold medals awarded in 1900 at the Exposition Universelle de Paris (Figure 76). As Ripolin continued to win medals at various international exhibitions through 1904 to 1911, as documented by Gautier (2010b), one might suggest that these two cans date from between 1900 and 1904. However the third side of the same cans of paint clearly indicates that the paint was 'made in England' and gives the location of the Southall factory (Figure 77), which could not have occurred before the English factory was completed in 1932 (Ripolin Ltd. 1931-32). It is not clear why this particular colour from the Wahroonga Ripolin cans is unlike the other colours.

Figure 76. Ripolin red 16 (SID 43213). Photo: Felicity Jenkins and Art Gallery of New South Wales

Figure 77. Ripolin red 16 (SID 43213). Photo: Felicity Jenkins and Art Gallery of New South Wales

Finally, there are two cans of Ripolin white 1 (Figure 78), one in the Art Gallery of New South Wales group and one in the National Gallery of Victoria, which may be of an older type than the others in the collection although, once again, the identification of the Southall factory on the label dates them to post 1932. Both of these older white cans have been used and the residue contents are dry in the bottom. The can in the National Gallery of Victoria has been tinted grey, probably by the artist for use as priming (Figure 190). These two whites do not indicate on the can whether they are gloss or matte formulations, but use of the number 1 suggests they are from the gloss range.

Figure 78. Ripolin white (old can) (SID 44138). Photo: Felicity Jenkins and Art Gallery of New South Wales

The date of the Ripolin cans from Nolan’s studio is, unfortunately, not indicated by the labels on the cans. The date boundaries confirmed prior to analysis of the contents were post-1932 when the Southall factory was in operation and pre-1953 when Nolan left Australia and closed the Wahroonga studio.

4.3.1 Observations on painting out Ripolin

The condition of the Ripolin paints after over sixty years in the can is variable between colours. Two of the flat colours have gelled in the can, red 516 and lemon 514, and could not be reformed to make coherent paint films. Maroon lake to shade 1167, although still liquid in the can, also did not form a well bound paint film and was extremely friable when dry. All other colours were able to be remixed and painted out giving cohesive paint films. The retention of solvent liquids in most cans demonstrate the effectiveness of the can lid sealing system, as no volume appears to have been lost from any of the sealed cans over time. The gloss Ripolin paints with thick oily liquids were slow to dry, taking between three to ten days to lose surface tackiness The flat range contained a large proportion of solvent and the paint films became touch dry within an hour as the diluents evaporated (Figure 79).

Figure 79. Ripolin flat white 501 (SID 43212) lifting solids from thin solvent liquids at top. Photo: Paula Dredge

While the gloss red 16 and flat red 516 Ripolin paint lids showed evidence of darkening and blackening where they had been exposed to light (Figure 80), the other pigments exhibited little sign of deterioration.

Figure 80. Lifting of outer lid on can of Ripolin red 16 (SID 43213) showing darkening of the paint on the lid where exposed to light. Photo: Paula Dredge

Those gloss colours without white solids such as blue deep 40RD, black 1105 and red 16 are well dispersed with virtually no pigment settlement. Those containing zinc white had settled with a still pliable lump of solids in the lower part of the can, with the liquids sitting above (Figure 81).

Figure 81. Ripolin gloss white 1 (SID 43201) lifting solids from oily liquids at top. Photo: Paula Dredge

The high quality of these paints was revealed by the process of painting out each colour (Figure 82 & Figure 83). The paint was decanted from the can and the solids and liquids re-mixed in a rough proportion to the original with a spatula on a clean ceramic tile. Systems to produce paint films of equal thickness by using drawdown tools typical for paint sampling were, after testing, considered too problematic due to the extremely liquid nature of the paint and variable flow of each colour. Attempts to contain the gloss colours within a sharply defined edge by the use of tape demonstrated the extremely liquid nature of this paint as most colours bled under the tape. In any case, the inherent self-levelling characteristic of the paints produced films of relatively consistent thickness on the glass slides. In those colours in which the solids had settled in the can, additional samples of the separated liquids were also decanted onto glass slides.

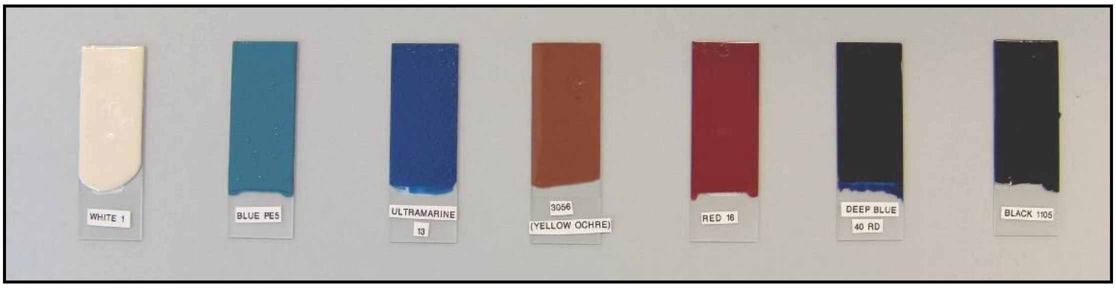


Figure 82. Ripolin gloss colour paint-outs L-R: white 1, blue PE5, ultramarine 13, ochre 3056, red 16, blue deep 40RD, black 1105. Photo: Paula Dredge

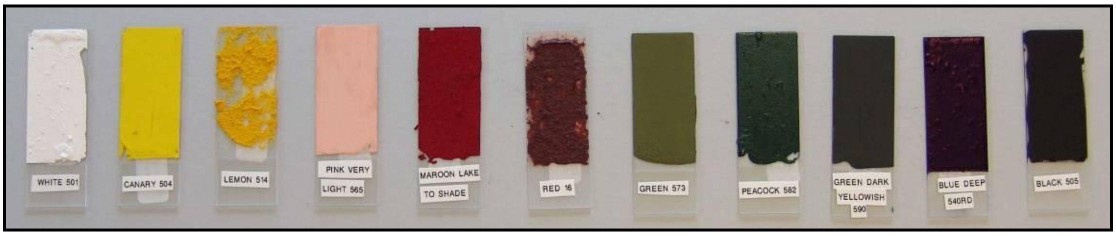


Figure 83. Ripolin flat colours paint-outs L-R: white 501, canary 504, lemon 514, pink very light 565, maroon lake to shade 1167, red 516, olive green 573, peacock green 582, green dark yellowish 590, blue deep 540RD, black 505. Photo: Paula Dredge

In most cases the gloss paints flowed onto the glass slide forming perfect, smooth, mirror-like surfaces. The red 16 (Figure 84), yellow ochre 3056, deep blue 40RD and black 1105 were particularly smooth and high gloss. The BLT white 1 retained some poorly re-integrated lumps of solids, but likewise formed a smooth high-gloss skin.

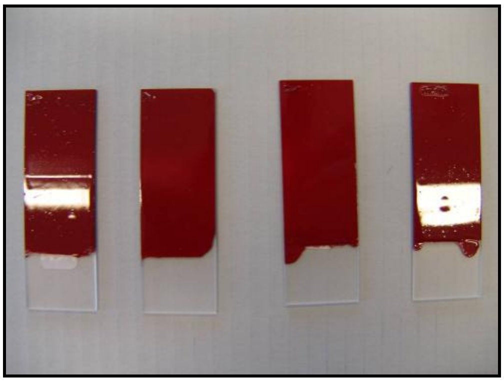


Figure 84. Paint-outs of Ripolin gloss red 16 (SID 43213). Photo: Paula Dredge

Tinting strength of all the colours was incredibly high. In the case of the BLT blue deep 40RD, the paint-outs were so saturated with pigment that the dried films were iridescent (Figure 85). The same was true of the flat blue deep 540RD.

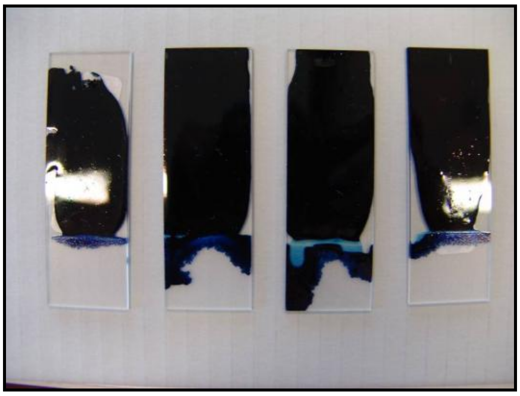


Figure 85. Paint-outs of Ripolin gloss blue deep 40RD (SID 43209). Photo: Paula Dredge

Only one set of the Ripolin paint-outs showed any tendency for the paint film to wrinkle and this was the black 1105 (Figure 86). The surface skin of these paint-outs began to form wrinkles within several days. Within two weeks, after the paint appeared to be fully hardened, the wrinkling stabilised and did not develop further. Comparisons between photographs of these samples demonstrated there was no further wrinkling over the following 18 months. If black 1105 Ripolin paint was used by Nolan, he would have certainly been able to observe the tendency to wrinkle as it dried in the first few weeks.

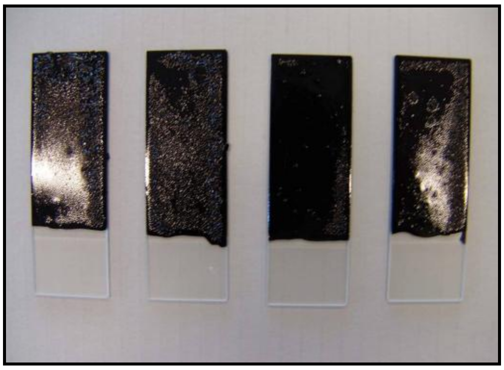


Figure 86. Ripolin gloss black 1105 after two weeks air drying (SID 43195). Photo: Paula Dredge

Although none of the other gloss colours showed signs of wrinkling, another paint feature became apparent on a number of the paint-outs. In some samples small, hard aggregates were visibly distributed within the zinc oxide solids in the can, creating seed-like lumps in the paint-outs. These were visibly present in the paint-out of the BLT PE5 colour, but most dramatically in the BLT ultramarine 13 (Figure 87).

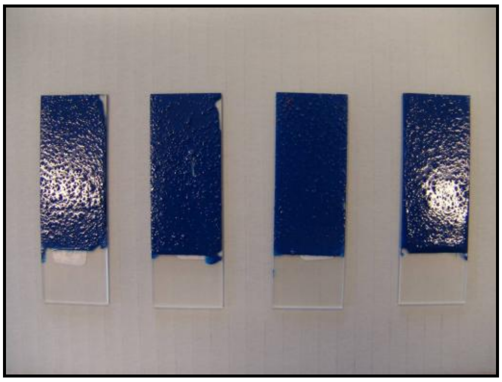


Figure 87. Ripolin gloss ultramarine 13 (SID 43230) paint-out after drying 6 weeks. Photo: Paula Dredge

Flat pink very light 565 was found to have a brittle, waxy layer sitting at the interface between the solids and the liquids when the solids were lifted from the can (Figure 88). Aggregated lumps and waxy solids are suggestive of the presence of metallic carboxylates, (soaps) which have either formed in the cans of paint, or are present as deliberate additives. These types of paint features were identified for further analytical study as they may have an impact on the stability of the dried paint film.

Figure 88. Lifting solids from can of flat Ripolin pink very light 565 (SID 43224) showing brittle waxy material. Photo: Paula Dredge

4.3.2 Pigment analysis

Pigments from the paint-outs of eighteen different colours of Ripolin paint in cans and contents from one of the open and dried out older white cans, were identified using portable X-Ray Fluorescence spectroscopy (pXRF), Fourier Transform Infra-Red spectroscopy (FTIR), and microscopy at the Art Gallery of New South Wales. Scanning Electron Microscopy with Energy Dispersive Spectroscopy (SEM-EDS) was undertaken on samples at the Microstructural Analysis Unit at the University of Technology, Sydney, and Raman microscopy was undertaken at the Centre for Microscopy and Microanalysis, University of Queensland. The accumulation of these results are shown in Table 4.3 .

Table 4.3. Pigments identified in Wahroonga studio Ripolin cans

Ripolin colour	Pigments identified (trace pigments)
Old white	Zinc oxide, barium sulphate, titanium dioxide, calcium carbonate, aluminium silicate, iron oxide
BLT white 1	Zinc oxide (barium sulphate, lead chromate, iron oxide)
BLT ochre 3056	Zinc oxide, iron oxide, lead chromate, titanium dioxide
Red 16	Barium sulphate, toluidine red (PR3)
BLT blue deep 40RD	Prussian blue, (lead chromate, barium sulphate)
BLT blue PE5	Zinc oxide, Prussian blue, (lead chromate)
BLT ultramarine 13	Zinc oxide, copper phthalocyanine, barium sulphate, (lead chromate)
Black 1105	Carbon black
Flat white 501	Zinc oxide, barium sulphate, titanium dioxide, kaolin & talc, lead chromate, iron oxide.
Flat canary 504	Lead chromate/ lead sulphate, kaolin & talc
Flat lemon 514	Lead chromate, kaolin & talc
Flat red 516	Barium sulphate, touidine red (PR3), kaolin & talc

Flat maroon lake to shade 1167	Alizarin, calcium carbonate
Flat pink very light 565	Zinc oxide, barium sulphate, titanium dioxide, chrome yellow, chrome red (phoenicochroite), carbon black, kaolin & talc
Flat blue deep 540RD	Prussian blue, kaolin & talc
Flat black 505	Bone black, kaolin & talc
Flat olive green 573	Zinc oxide, lead chromate, kaolin & talc, carbon black
Flat peacock green 582	Zinc oxide, Prussian blue, lead chromate, (kaolin & talc)
Flat green dark yellowish 590	Zinc oxide, Prussian blue, lead chromate, kaolin & talc

The white paints, BLT 1 and flat 501 and the older can were all found to contain zinc oxide pigment. Whereas the BLT white 1 was almost exclusively zinc white, the other two white Ripolin paints had a more complex mixture of pigments. FTIR spectrum of the BLT white 1 gave typical absorbance peaks for oil (1743, 1464, 1377, 1240, 1167, 1100, 968, 723cm^{-1}), zinc oxide (broad peak with inception at approximately 600cm^{-1}) and carboxylates (broad peak 1500-1600cm^{-1}) formed as a result of the interaction between the zinc oxide pigment and the oil (Figure 89). The flat white 501 gave additional peaks related to the presence of titanium dioxide (broad peak with inception at approximately 850cm^{-1}) and barium sulphate (1188, 1117, 1078, 983cm^{-1}). Aluminium silicate was also identified in this paint although not seen in the sample spectrum in figure 89. The older white can contained all of the pigments identified in the flat white 501 with the addition of calcium carbonate.

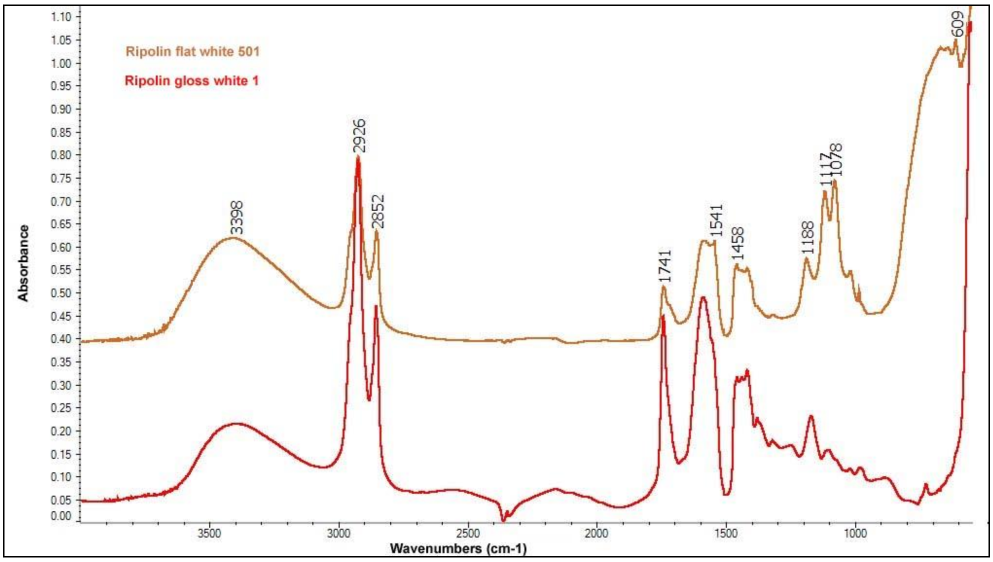


Figure 89. FTIR of solids from Ripolin gloss white 1 and flat white 501. Image: Paula Dredge

The differences between the BLT white 1 and the flat white 501 are effectively imaged in samples from dried paint-outs placed in Scanning Electron Microscope (SEM) examined with backscattered imagery (Figure 90 and Figure 91). The white 1 shows a fairly consistent morphology of pure zinc oxide paint. The flat white 501 backscattered image shows the various metallic ions as different densities on the grey scale, lead being the brightest white (heaviest mass), then barium and zinc, and the pale grey in 501 at the centre right being an aggregate of titanium dioxide. Long shards appearing as dark voids within the white 501 backscattered image are the exceptionally low mass elements of aluminium, magnesium and silica present as talc and kaolin in the flat paint range. Both paints under backscattered imagery also suggest the formation of metallic carboxylate soaps by the presence of spherical low mass forms.

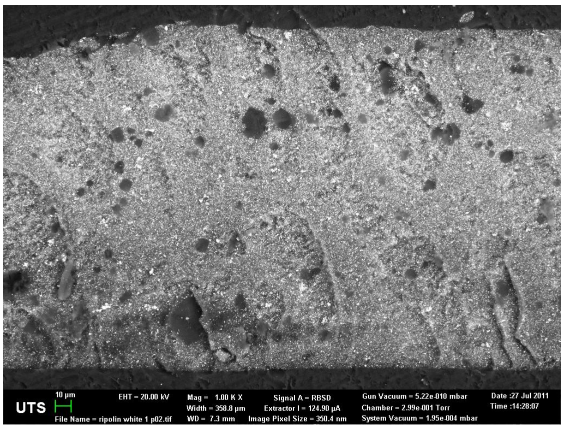


Figure 90. Ripolin white 1 Scanning Electron Microscopy in backscattered mode. Photo: Richard Whurer

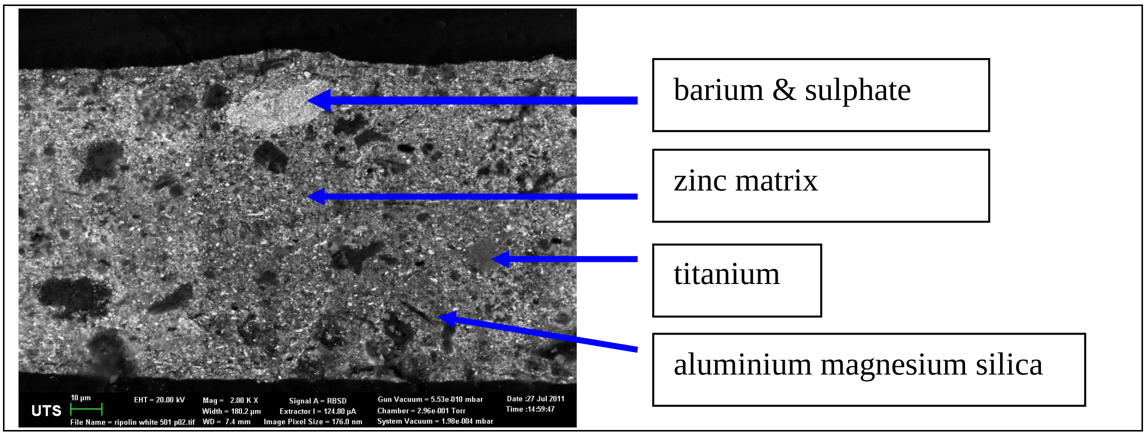


Figure 91. Ripolin flat white 501 in Scanning Electron Microscope in backscattered mode with metallic ions detected. Photo: Richard Whurer

The use of titanium white in a number of the Ripolin paints is of interest as the identification of the form of titanium dioxide present, anatase or rutile, may provide critical dating information for the paint cans from the Nolan studio. Gautier, Benzur, Muir, Casadio and Fiedler (2009) suggests the broad definition of pre-Second World War for anatase and post-War for rutile, and this is mostly in agreement with Laver (1997). Laver describes early rutile pigment development in the USA from 1940, and in tests in England from 1938, but not available until 1945. So while the presence of rutile titanium in the Ripolin paints would give secure dating to the Nolan Ripolin paints as post-1945, the presence of anatase would provide less certainty, as in France a good quality anatase titanium dioxide was produced from 1923 and was still in production in 1997 (Laver 1997 pp. 305).

The titanium dioxide particles in the Ripolin white 501 are extremely fine, measuring less than 0.25 microns (Figure 92). SEM-EDS analysis of the titanium agglomerate gave counts for titanium, zinc, silica and aluminium (Figure 93). As these elements are also present generally in the paint matrix, it is not possible to assign their presence specifically to the titanium dioxide aggregate that might assist to identify them as modifications of the pigment.

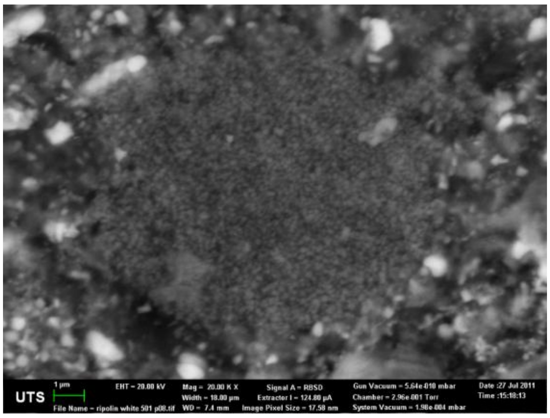


Figure 92. SEM Backscattered image of titanium dioxide aggregate in Ripolin flat white 501. Photo: Richard Whurer

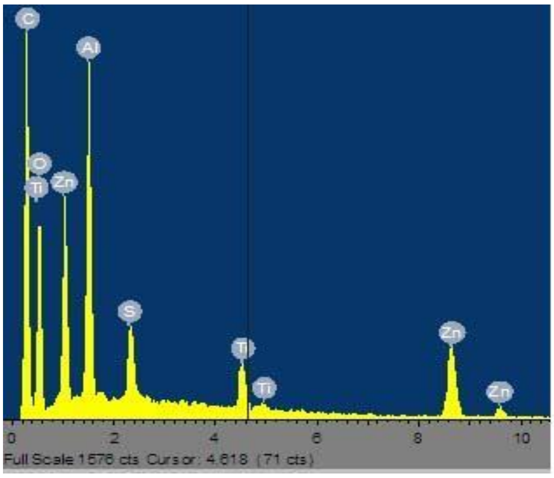


Figure 93. Energy dispersive x-ray spectroscopy of titanium agglomerate in Ripolin flat white 501 sample. Image: Richard Whurer

A paint-out of the Ripolin flat pink very light 565 which has a high proportion of titanium dioxide, compared to the other titanium containing Ripolin paints from the Wahroonga studio, was analysed with Raman spectroscopy at the Centre for Microscopy and Microanalysis at the University of Queensland. Comparison of the resulting spectrum with Raman library standards of both rutile and anatase titanium dioxides gave a positive result for anatase (Figure 94). The use of the anatase form of titanium dioxide in the can of pink very light 565 Ripolin does not exclude therefore the possibility that production of Nolan's Ripolin from the Wahroonga studio pre-dates the Second World War. Unfortunately neither is it able to provide any further narrowing of the date range 1932-1953.

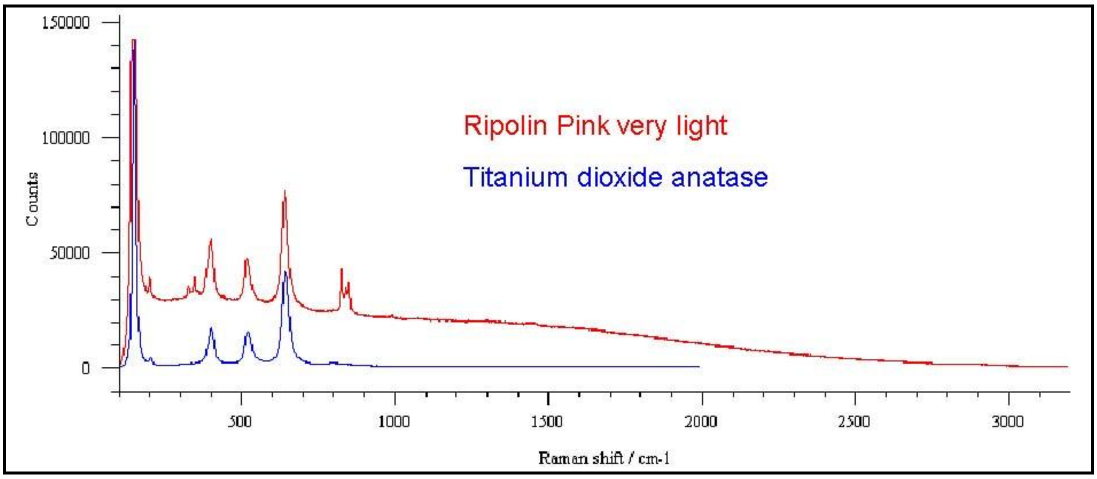


Figure 94. Raman spectrum of Ripolin Pink very light 565 against library reference for titanium dioxide anatase. Image: Dr Ying Yu & Gillian Osmond

The Raman examination of the Ripolin pink very light 565 also demonstrated the presence of another pigment that had not been identified with FTIR or PXRF. The bands visible in the Raman spectrum of the sample around 320-380cm^{-1} and the peak doublet at 837 and 847cm^{-1} are assigned to the red/orange type of lead chromate, phoenicochroite ($PbCrO_5$). A recent project in which four Winsor & Newton lead chromate recipes were recreated, found that the same form of lead chromate although present as a mineral in nature, could be manufactured synthetically. Phoenicochroite formed in those instances in which the precipitation solution was maintained at a high pH with sodium hydroxide (Otero et al. 2012). The synthesised red/orange chromate was called basic lead chromate or chrome orange (or chrome red depending upon the depth of colour). Examination of the Ripolin pink very light 565 in an embedded cross-section in reflected light shows both yellow and red forms of lead chromate are present (Figure 95).

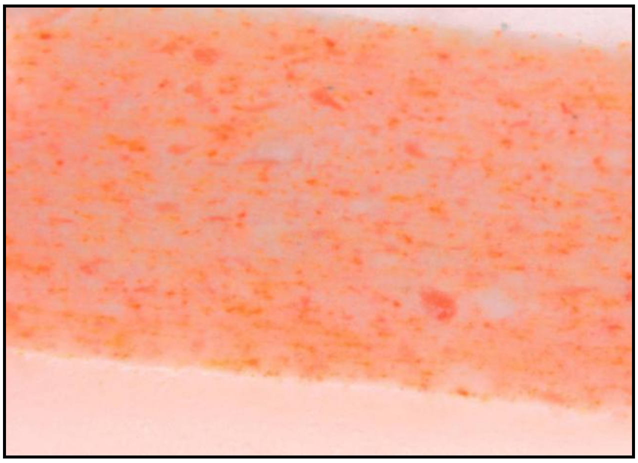


Figure 95. Incident light of embedded cross-section of Ripolin pink very light 565. Photo: Paula Dredge

Prussian blue is the principal blue used in a number of the Nolan Ripolin colours, both with zinc oxide as a pale blue PE5 and without zinc oxide or any other identified body white, as a deep transparent blue 40RD and flat 540RD. Prussian blue is readily identified using FTIR as it exhibits a strong peak at 2080-2095cm^{-1} due to the C=N stretch (Figure 96). The broad peak in the BLT blue PE5 paint from 1500-1600cm^{-1} and lesser peaks at approximately 1470cm^{-1} and 1420cm^{-1} are present in this colour and not in the deep blue 40RD and are a feature of those Ripolin paints containing zinc oxide that have developed zinc carboxylate features. Without the assistance of white pigments that provide metallic ions, deep blue 40RD must have needed considerable assistance to enable drying. This might be achieved either by the assistance of driers or addition of a hard resin. The transparency and richness of this colour would have been extraordinarily appealing to Nolan.

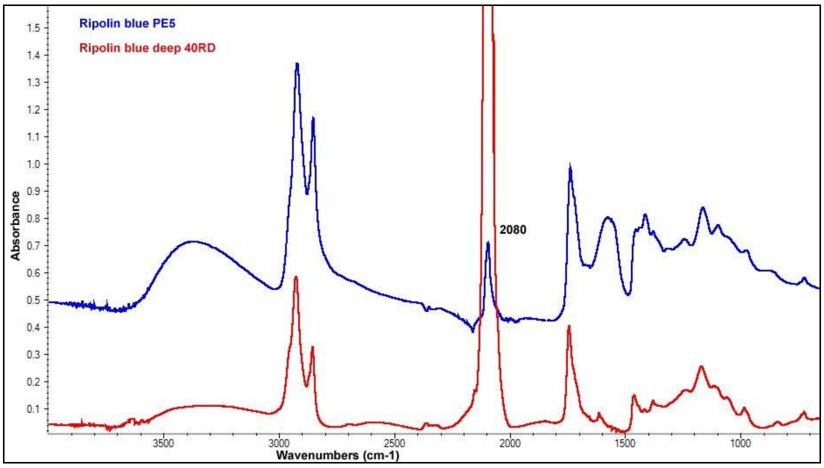


Figure 96. FTIR of gloss Ripolin paints from cans; blue PE5 and deep blue 40RD. Image: Paula Dredge

The BLT ultramarine 13 is pigmented with copper phthalocyanine (PB15), zinc oxide and barium sulphate. This was identified by the FTIR spectral match with multiple peaks against a FTIR library standard of copper (II) phthalocyanine (Figure 97) and supported by a significant copper peak in pXRF. There was no ultramarine pigment identified in this Ripolin colour when examined by X-Ray Diffraction at the Centre for Microscopy and Microanalysis at the University of Queensland. The identification of copper phthalocyanine in the Ripolin BLT ultramarine 13 assigns a new date to the

Ripolin paint from the Wahroonga studio as post-1935 when this pigment first came into use (Gettens & Stout 1966).

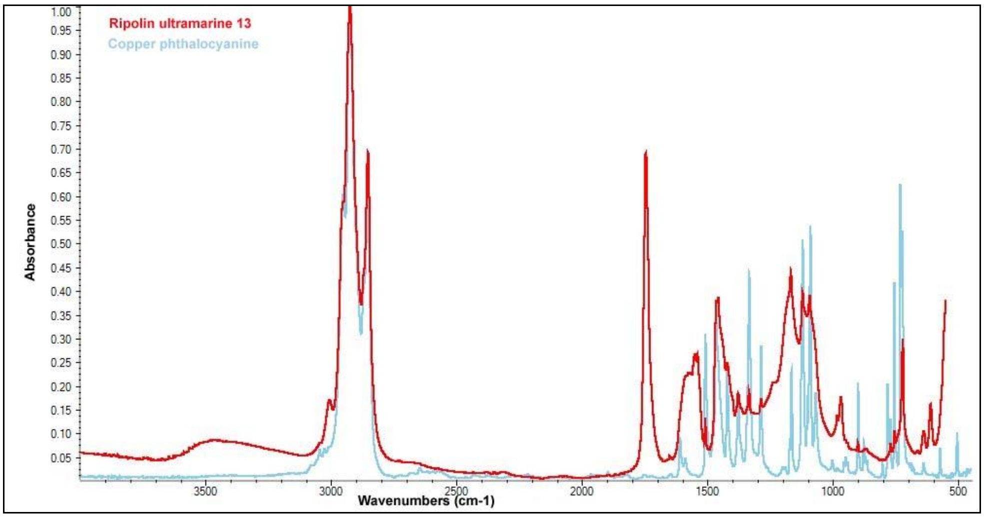


Figure 97. FTIR spectra of Ripolin gloss ultramarine 13 and library sample of copper (II) phthalocyanine (© Thermo Fisher Scientific Inc. 1999-2001, 2004). Image: Paula Dredge

The flat green paints peacock 582, and green dark yellowish 590 are variations of the combination of Prussian blue and lead chromate with zinc oxide as for the French chart study on similar colours, although they are without the barium sulphate found in small amounts in similarly numbered French colours on colour charts dating after 1930s (Gautier et al. 2009). An additional difference with the green colours is that, unlike the French *vert wagon 73*, the Wahroonga studio olive green 573 is darkened with carbon black and has no Prussian blue.

The flat lemon yellow 514 and flat canary 504 are predominately lead chromate pigment. The canary 504 has additional FTIR peaks at 490 and 660cm^{-1} and although masked by the absorption peaks related to the presence of aluminium silicate, the presence of an additional broad peak at 1100cm^{-1} suggests that the lead chromate pigment is modified by the presence of lead sulphate. Very little zinc is detected in these two yellow colours using pXRF and they have minimal carboxylate peaks in FTIR, suggesting zinc oxide as a body colour is not present in these two paints, although the lemon yellow has some titanium dioxide.

The other yellow, ochre 3056 has a large proportion of zinc oxide and titanium dioxide with iron oxide and lead chromate. Comparison of the pXRF results on all three yellow colours from the can, taken at low mass mode (15kV 15µA, no filter and vacuum), support the FTIR findings and are shown in Figure 98. Although no adjustment has been made in this comparison for the different thicknesses of samples, proportional comparison of elements within each colour provide useful information. All three colours show peaks for the elements cobalt and manganese suggesting they may also have metallic driers based on those metals.

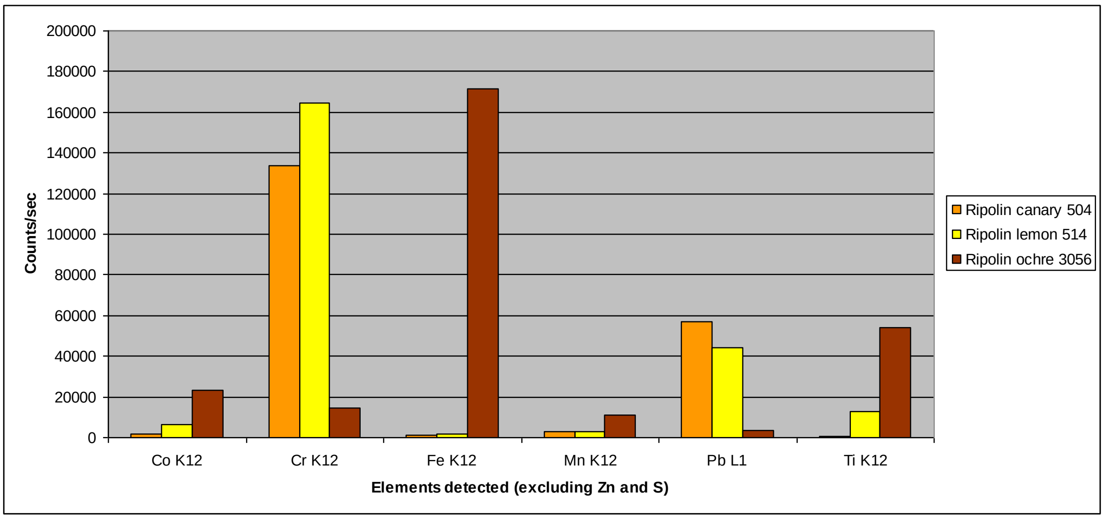


Figure 98. Ripolin yellow colours. PXRF comparison of counts detected in low mass mode (excluding the result for zinc and sulphur). Image: Paula Dredge

The red 16 in gloss and flat 516 contain the coal-tar pigment, toluidine red PR3 (o-nitro-p-toluene-azo-β-napthol, $C_{17}H_{13}N_3O_3$) with barium sulphate (Figure 99). There is no zinc oxide in this colour. The use of toluidine red in this particular tint differs from the French chart study in which the pigment in *rouge de Chine 16* was identified as alizarin crimson (PR83) (Gautier et al. 2009). Alizarin was identified in the flat colour maroon lake to shade 1167 from the Wahroonga studio cans. Similarly the red 16 on the British Ripolin chart dating from the 1920s was identified as alizarin crimson, suggesting the use of toluidine red in the Wahroonga studio red 16 was a change in the formulation that occurred after the 1920s.

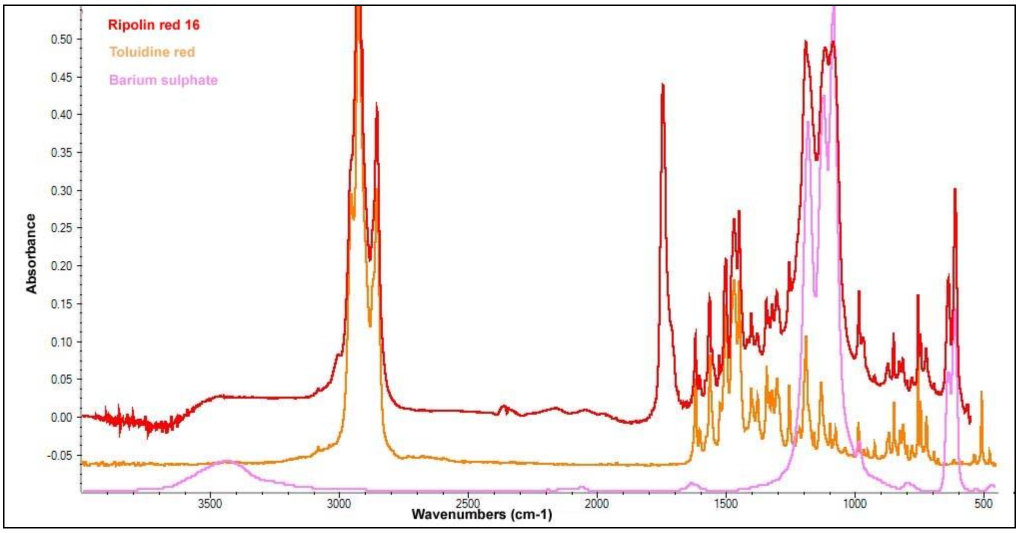


Figure 99. FTIR spectra of Ripolin red 16, toluidine red (© Thermo Fisher Scientific Inc. 1999-2001, 2004) and barium sulphate (© Nicolet Instrument Corp., 1991-1994). Image: Paula Dredge

There may be potential for darkening of the Ripolin red 16 used on paintings by Nolan. Toluidine red pigment is usually categorised as impermanent as it fades with exposure to light (Myers 2010), but the evidence of the appearance of the paint on the lids of the red 16 and red 516 where exposed to light, demonstrates that it has in fact darkened over time. A comparison FTIR spectrum of samples from the paint on the lid where exposed and darkened compared with unexposed and still bright areas, is shown in Figure 100. The results confirm that the paint on the lid is pigmented with toluidine red and barium sulphate, like the paint inside the can. The differences in the spectra between exposed and unexposed paint show changes have occurred in the chemistry of the pigments. The exposed and darkened paint shows an increased broad peak area in the region of 3000cm^{-1} due to oxidation. The multiple sharp peaks in the fingerprint region, 500-1500 cm^{-1} related to the presence of toluidine red (PR3) have become less sharp and clear in the sample that has darkened with exposure to light

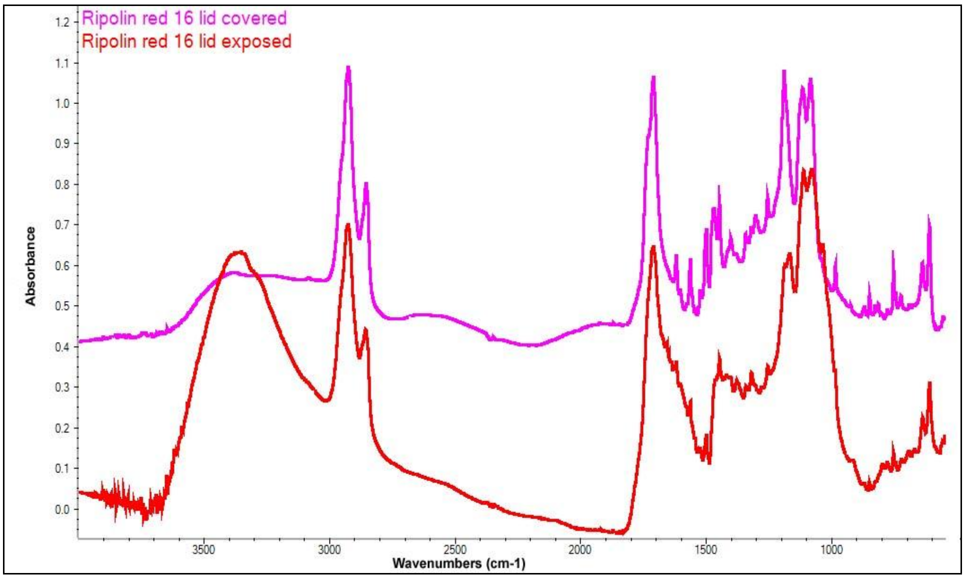


Figure 100. FTIR spectra of paint on lid of Ripolin red 16, covered against light and exposed to light. Image: Paula Dredge

The flat black 505 contains a bone-derived black identified by the characteristic FTIR sharp peak centred at 2015cm^{-1}, the broad double peak group from 990-1160cm^{-1} and the two sharp peaks at 601 and 565 cm^{-1} (Figure 101). Bone black is a pigment made from charred animal bones. The most valuable bone pigment was ivory black traditionally made from charred ivory. By the twentieth century the name ivory black was assigned to good quality bone black pigments that were not derived from ivory (Gettens & Stout 1966, p. 123).

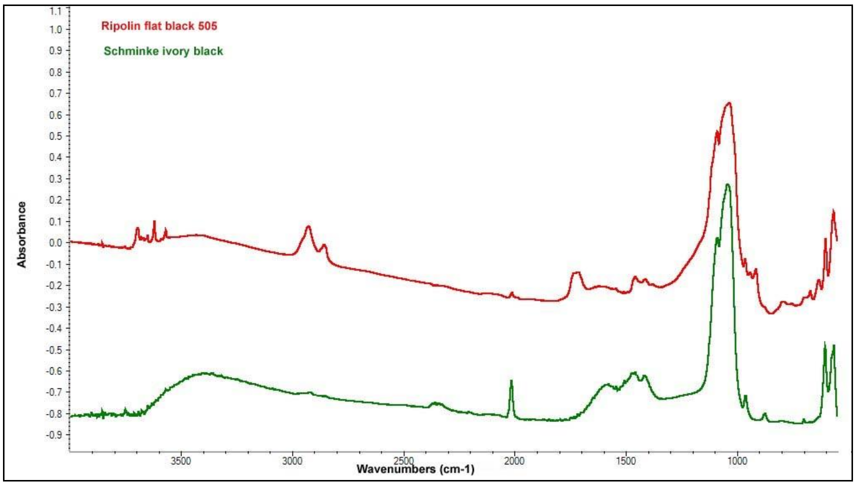


Figure 101. FTIR spectra of Ripolin flat black 505 and Schminke ivory black pigment. Image: Paula Dredge

Black paints are difficult to formulate. Carbon black pigments have no inherent drying ability and the use of base white pigments which aids drying and adds opacity and covering power cannot be used with black paints as they turn the colour grey. Drying therefore must be achieved with the use of driers or resins. Achieving the balance between using sufficient driers while avoiding the problem of film wrinkling is difficult and does not appear to have been entirely successful in the Ripolin gloss black 1105 as demonstrated by the paint-outs. PXRF of this black shows significantly high count rates for the elements cobalt, iron and manganese. These do not appear to be pigments when examined with SEM, and are probably present in the paint as driers.

Most of the flat colours in addition to coloured pigments contain kaolin. These silicates are readily characterised by the group of unusual FTIR spectral peaks in the 3550-1370 cm^{-1} region. This is due to the platelet structure of kaolin with weak hydrogen bonding that is responsive to infrared radiation at low energy. The typical quartet of peaks (3697, 3668, 3652, 3620 cm^{-1}) can be seen in the spectrum for Ripolin black 505 in figure 100. The flat Ripolin colours all showed characteristic peaks for aluminium silicate but when the same samples were examined with SEM and analysed with EDX spectroscopy, magnesium was also identified in association with aluminium and silicon platelets, suggesting this addition of mixed silicates may be in the form of natural clay containing both talc and kaolin. Clays were added to paints to assist with keeping the pigments in suspension, and this may have been an issue with the thin solvent-based liquids in the flat colours more than the thicker oil liquids of the gloss colours. It is probable also that the clay also assists with giving the dry paint a matte finish.

The English-language, Dutch-manufactured Ripolin colour chart dating from about 1923 was examined, and colours with direct correspondence to the colours from the Nolan studio were analysed with PXRF and Attenuated Total Reflectance (ATR) FTIR. The results are shown in Table 4.5. As no further examination of these colour samples was undertaken with microscopy or Raman spectroscopy, these results are potentially incomplete. The ATR-FTIR spectra were of poor quality compared to those undertaken with transmitted FTIR, although the presence of Prussian blue and zinc soaps suggesting zinc oxide, ivory black and lead chromate were all readily detected with this technique. PXRF provided confirmation of these inorganic pigment groups.

As previously noted, differences were detected with the pigment in the red 16 in which the toluidine red of the studio cans was not found in the corresponding paint swatch on the chart. The ATR-FTIR spectrum for this chart colour was poor, but some peak assignments suggest the chart swatch pigment is alizarin. The ultramarine 13 also differed from the Nolan cans with a peak in ATR-FTIR for the presence of Prussian blue and a corresponding iron peak on PXRF. Copper phthalocyanine, not Prussian blue, was present in the corresponding colour from the studio cans. It is unsurprising that copper phthalocyanine is not present in the colour on the 1920s chart, as this pigment was not manufactured until 1935.

Table 4.4 Pigment analysis of Dutch-made Ripolin chart colours

Ripolin colour chart c. 1923 swatch numbers [corresponding name from Wahroonga studio cans]	Pigments identified (trace pigments)[possible pigments] (FTIR and PXRF)
1 [White]	Zinc oxide (barium sulphate, lead chromate)
56 [Ochre]	Zinc oxide, iron oxide, lead chromate
16 [Red]	Barium sulphate, calcium carbonate, (zinc oxide) [alizarin]
40R [Blue deep]	Prussian blue, (lead chromate, barium sulphate)
PE5 [Blue]	Zinc oxide, Prussian blue, (lead chromate)
13 [Ultramarine]	Zinc oxide, Prussian blue, barium sulphate, (lead chromate)
1105 [Black]	Carbon black
5 [Black]	Bone black
4 [Canary]	Lead chromate/ lead sulphate
14 [Lemon]	Lead chromate
65 [Pink very light]	Zinc oxide (coloured pigments not detected)

The paint on the colour chart compared with the English-made Ripolin from Nolan's studio demonstrates good matches between the pigments in corresponding colours. Differences noted were principally in the use of toluidine red and copper phthalocyanine in the paints made in England sometime after 1935, compared to those on the Dutch-made chart from the 1920s.

Comparison of the pigment analysis of the Nolan English Ripolin in cans with the French Ripolin study Table 4.6, also suggest good correlation between most colours that are numbered similarly. Some differences are noted particularly in the use of toluidine red and copper phthalocyanine blue, (similarly to the differences noted with the Dutch-made Ripolin colour chart) but these are also likely to be evolutions in the formulations over time. The flat bright yellow colour *Jaune clair 4* was recorded in the French study as zinc chromate (Gautier et. al. 2009), but a later listing by the same researchers of a French colour chart dating from the 1930s gives this colour as lead chromate/lead sulphate as for the Canary 504 Wahroonga can (Casadio & Gautier 2011). Similarly the latter study has a change noted on the colour *Rose pâle 65* in which lead chromate was possibly detected, although not the basic lead chromate form which was found in the Nolan studio cans. The BLT white 1 from the Nolan studio while predominantly zinc oxide as for the French chart study, did show distinct trace elements for barium sulphate, lead chromate and iron oxide. The French study noted that the body-white used in many of the coloured paints on a chart dating later than the others, c. 1930s-1940s, was a mixed white made from zinc oxide, barium sulphate and titanium dioxide pigments. The olive green 590 from the Wahroonga studio cans differs from the French chart *vert wagon 90*, as it is without the presence of Prussian blue, but darkened with the use of carbon black. Finally, both the yellow ochre 3056 from the Nolan studio and the colour 56 on the Dutch-made paint chart were found to have a significant amount of zinc oxide, which was not noted in the corresponding colour in the French chart study.

Despite these specific differences between the English manufactured paint from the cans, and the two colour chart studies (Dutch and French) it is remarkable how consistent the pigments analysis is given the expected effect on pigment formulation not only by the use of newly developed pigments, but also trading shortages, adulteration and local manufacturing conditions and sourcing. These comparative results between colour charts of paint manufactured in two different countries and cans of English-made paint from a date after 1935, suggest that the Ripolin paint formulations were, with a few aberrations, surprisingly consistent over time and between different manufacturing sites.

Table 4.5 Pigment comparison between Wahroonga studio Ripolin paints from cans and French Ripolin colour charts

Wahroonga studio Ripolin	Pigments identified in Wahroonga studio cans (trace pigments)	Pigments detected in corresponding French Ripolin colour charts (Gautier et al 2009)
Old white	Zinc oxide, barium sulphate, titanium dioxide, calcium carbonate, aluminium silicate, iron oxide, lead chloride-contaminant?)	Zinc oxide
BLT white 1	Zinc oxide (barium sulphate, lead chromate, iron oxide)	Zinc oxide
BLT ochre 3056	Zinc oxide, iron oxide, lead chromate, titanium dioxide	Lead chromate, iron oxide
Red 16	Barium sulphate, toluidine red (PR3)	Alizarin crimson, calcium carbonate, iron oxide
BLT blue deep 40RD	Prussian blue, (lead chromate, barium sulphate)	Prussian blue, barium sulphate
BLT blue PE5	Zinc oxide, Prussian blue, (lead chromate)	Zinc oxide, barium sulphate, titanium dioxide, Prussian blue
BLT ultramarine 13	Zinc oxide, copper phthalocyanine, barium sulphate, (lead chromate)	Ultramarine blue
Black 1105	Carbon black	Carbon black
Flat white 501	Zinc oxide, barium sulphate, titanium dioxide, aluminium and magnesium silicates, lead chromate, iron oxide.	Zinc oxide (gloss)
Flat canary 504	Lead chromate/ lead sulphate, aluminium and magnesium silicates	Zinc potassium chromate, lead chromate (gloss)
Flat lemon 514	Lead chromate, aluminium and magnesium silicates	Lead chromate (gloss)
Flat red 516	Barium sulphate, toluidine red (PR3), aluminium and magnesium silicates	Alizarin crimson, calcium carbonate, iron oxide (gloss)
Flat maroon lake to shade 1167	Alizarin, calcium carbonate	Not on French chart
Flat pink very light 565	Zinc oxide, barium sulphate, titanium dioxide, chrome yellow, chrome red (phoenicochroite), carbon black, aluminium and magnesium silicates	Zinc oxide, barium sulphate, titanium dioxide, alizarin crimson (gloss)
Flat blue deep 540RD	Prussian blue, aluminium and magnesium silicates	Prussian blue, barium sulphate (gloss)
Flat black 505	Bone black, aluminium and magnesium silicates	Bone black
Flat olive green 573	Zinc oxide, lead chromate, aluminium and magnesium silicates, carbon black	Zinc oxide, barium sulphate, titanium dioxide, lead chromate, Prussian blue (gloss)
Flat peacock green 582	Zinc oxide, Prussian blue, lead chromate, (aluminium and magnesium silicates)	Lead chromate/lead sulphate, Prussian blue, barium sulphate (gloss)
Flat green dark yellowish 590	Zinc oxide, Prussian blue, lead chromate, aluminium and magnesium silicates	Zinc oxide, barium sulphate, titanium dioxide, lead chromate, Prussian blue (gloss)

4.3.3 Analysis of media

FTIR analysis of the liquids from the Ripolin cans invariably identified the primary binder as oil. This is best illustrated with a FTIR spectrum of the dry black 1105 paint that has no interference from pigments when compared with a dry film of refined linseed oil (Figure 102). Similar results were found in all the Ripolin paint in the cans, which in many cases could be separated from the pigment solids by decanting the liquids from the top of the can. No synthetic resin, such as alkyd, was indicated in any of the Ripolin paint in cans from the Wahroonga studio analysed with FTIR.

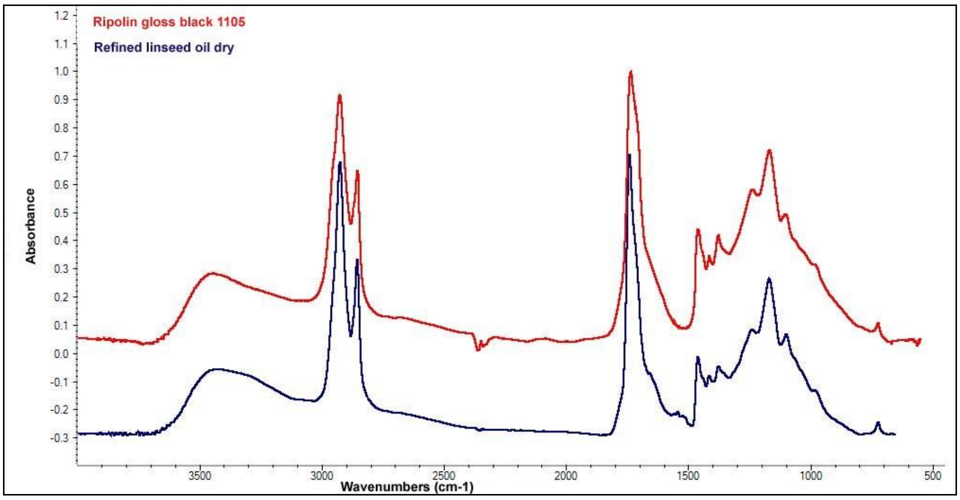


Figure 102. FTIR of Ripolin gloss black 1105 and dry linseed oil (© AGNSW 2003-2013). Image: Paula Dredge

FTIR examination of the same black 1105 paint decanted directly from the can while still in liquid form, gave some differences in the absorbance spectra compared to the dry paint (Figure 103). The peak at 968cm^{-1} suggests the presence of a pre-polymerised oil in the Ripolin black 1105. This marker is no longer visible after air drying but it is preserved in the liquid, unoxidised contents of the aged paint in the can. This demonstrates that important analytical information may be obtained by undertaking FTIR studies on paint freshly decanted, in addition to paint that has dried.

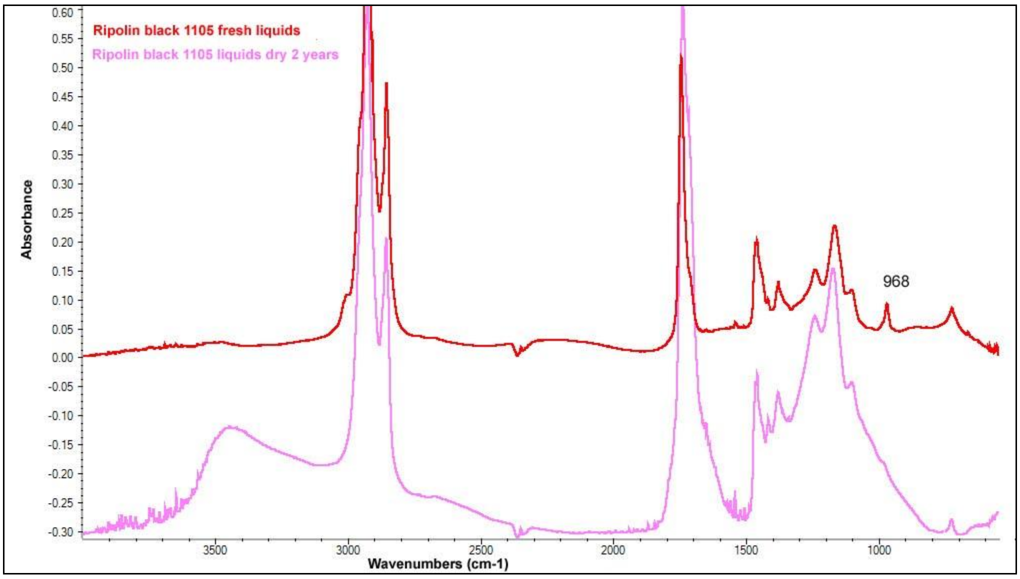


Figure 103. FTIR of Ripolin black 1105 liquids directly from can and liquids dry two years. Image: Paula Dredge

Similar FTIR spectra were obtained from the still wet contents from the can of thinnings for gloss Ripolin which is compared here to a FTIR spectrum of the contents from a bottle of Talens linseed stand oil, also from the Nolan studio contents (Figure 104). This FTIR spectra suggests that the Ripolin thinnings are principally oil with the distinctive 968cm^{-1} marker for a pre-polymerised oil.

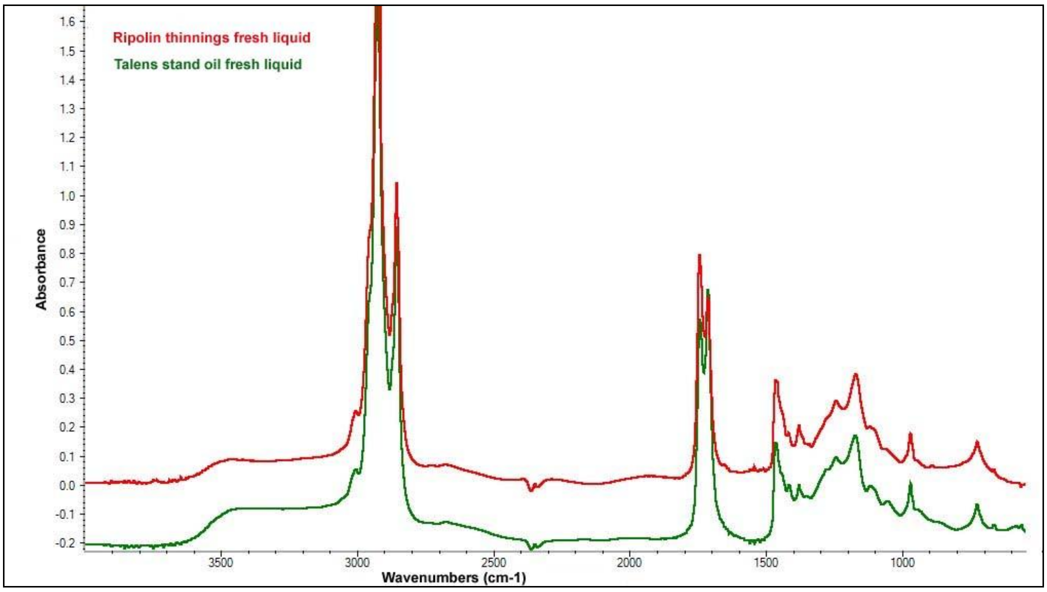


Figure 104. FTIR of Ripolin thinnings and Talens linseed stand oil aged 60+ years in sealed jar. Image: Paula Dredge

Meth-Prep gas chromatography/mass spectroscopy (Meth-Prep GC/MS) on a selection of ten samples decanted from the cans which included all the gloss paints and three of the flat colours was undertaken at the Getty Conservation Institute by Joy Mazurek. The samples for analysis were taken from dry paint films prepared by remixing the contents in similar proportions of liquids and solids as present in the cans, painting out on glass slides and leaving to air dry for a year. The experiment setup is discussed in detail in Appendix iv.

Meth-Prep GC/MS identified drying oils in all ten samples on the basis of the fatty acid composition and proportions of palmitic (P), stearic (S) and azelaic (A) acids and found the presence of copal resin and colophony in some samples (Table 4.7). A typical total ion chromatogram showing all these components for the sample of Ripolin gloss black 1105 is shown in Figure 105.

Table 4.6 Meth-prep (II) analysis of 10 Ripolin paints from Wahroonga studio cans

Ripolin colour	Palmitic/stearic acid ratio	Azelaic/palmitic acid ratio	Suberic/azelaic acid ratio	Compounds identified with markers
BLT white 1	1.3	0.9	0.4	Castor oil
BLT ochre 3056	1.4	0.8	0.4	Copal Colophony
Red 16	1.5	0.7	0.7	None
BLT blue deep 40RD	1.4	0.6	0.5	Copal Colophony
BLT blue PE5	1.5	0.8	0.4	Colophony
BLT ultramarine 13	1.3	0.5	0.4	Copal
Black 1105	1.3	0.6	0.6	Copal Colophony
Flat white 501	1.4	0.4	0.5	None
Flat blue deep 540RD	1.5	0.6	0.5	None
Flat black 505	1.4	1.4	0.3	Copal

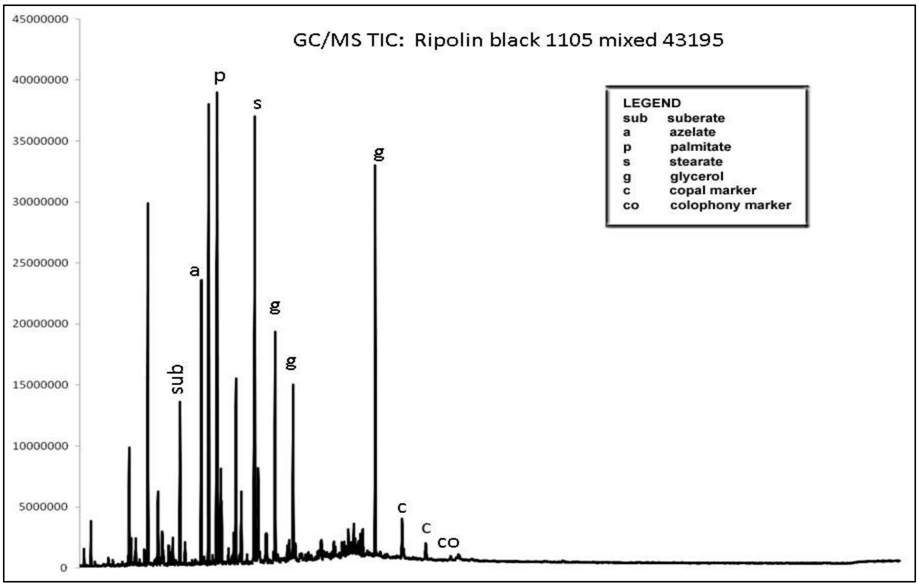


Figure 105. GC/MS total ion chromatogram of Ripolin black 1105. Image: Joy Mazurek and Getty Conservation Institute

The gloss paints in general, contain a greater percentage of fatty acids (2.7 to 4.9%) compared with the flat paints tested (0.9 to 1.3%), supporting the observation (on opening the cans) of a higher oil content in the gloss colours. There are different proportional measurements of the fatty acids found in drying oils that yield useful information.

The ratio palmitic to stearic acid (P/S) has been commonly used to identify oil type. The three types of drying oil found in Old Master paintings have P/S ratios in the region of 1.5 for linseed, 3 for walnut and 5 for poppy oil (Mills & White 1994). P/S ratios on the 10 Ripolin samples are all within the accepted range for linseed oil, 1.3 to 1.5. The difficulty with the analysis of twentieth century oil-based paints is the increased range of oil types that may be present. Two of these alternative oils, tung oil and dehydrated castor oil, have P/S ratio of 1.0. This is a similar P/S ratio to that of linseed oil. The identification of these three oil types from each other by palmitic and azelaic acid ratios is therefore not possible by this methodology (Schilling, Mazurek, and Learner 2006, p. 130). Both tung and castor oils have identifying fatty acid markers however, that may assist in their detection. A castor oil marker was found in the mass spectra of the Ripolin BLT white 1 paint. This marker is ricinoleic acid (12-hydroxy-9-cis-octadecenoic acid), a fatty acid type specific to castor oil. Although a slow drier, dehydrated castor is a pale oil compared to the more traditional drying oil linseed and for this reason was a good choice for the white paint colour. Castor oil also forms a more flexible paint film and may have been used in the white paint film that was predominately zinc oxide, to offset the inherent brittle nature of paint films made from this pigment.

Tung oil has a fatty acid marker, eleosteric acid, (*cis*9, *trans*11, *trans*13-octadecatrienoic acid), but this fatty acid is quickly consumed with oxidation and drying. It may be identified in freshly decanted paint liquids by a FTIR peak at 992 and 965cm^{-1} (Schönemann and Edwards 2011). A FTIR spectrum obtained from freshly decanted liquids from an aged can of Taubmans Solvro gold enamel for example, (not from Nolan's studio) show these distinctive tung oil peaks (Figure 106), but they were not found in the liquids examined fresh from the Ripolin cans (Figure 102). Anna Schönemann who has studied tung oil extensively, is uncertain whether the FTIR tung oil marker peaks are always present in aged but unoxidised paint, and suggests that the absence of these peaks in the Ripolin paint in cans is not authoritative for the absence of tung oil [Schönemann personal communication 2012].

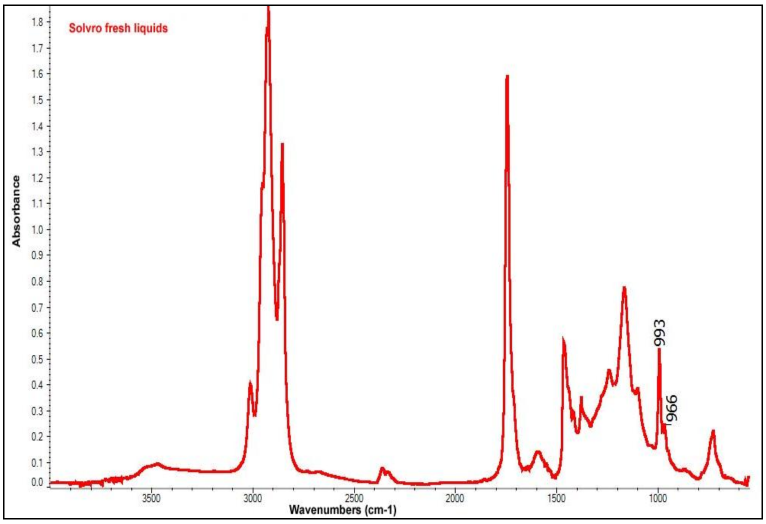


Figure 106. FTIR spectrum of freshly decanted liquids from Taubmans Solvro gold enamel giving identifying tung oil peak at 993cm^{-1}. Image: Paula Dredge

The proportion of azelaic to palmitic acid (A/P) is another useful measure comparing fatty acid types. A/P ratios below two generally indicate the effective drying and cross-linking of the oil structure (Corbeil, Helwig & Poulin 2011). The results of the Ripolin sample A/P ratios are in the range of 0.4 to 1.4 (Table 4.7) demonstrating they have formed well-polymerized paint films, as expected for drying oils. The presence of cobalt peaks in the PXRF spectra of most of the Ripolin paints, and small manganese peaks detected in a number of the dark colours, such as gloss black 1105, suggests that metallic driers were used in these paints, although their exact form has not been identified. Driers typically catalyse the oxidation of oil based paint films and assist with the rapid formation of polymer cross-linking.

The proportion of suberic to azelaic fatty acid (Sub/A) above 0.4 indicates the presence of heat-bodied oils (van den Berg et al. 1999). These proportions were above 0.4 in all the Ripolin paints tested, except for the flat black 505 containing bone-black, which was just below this level at 0.3. In addition, markers for heat-bodied oil (m/z 105 and 290) were also found in several of the paints. Heat-bodied (stand) oil is typically used in enamel paints to assist with the formation of smooth flat paint films (self-levelling) and rapid drying, especially when heated with driers.

Copal, (a hard fossil resin), and colophony, (a softer resin derived from pine), were both identified in a number of the Ripolin samples. The copal resin in several samples is identified as Brazilian, African, or Congo, due to the presence of eperuic acid. It most closely matches a Brazilian copal (Jotobá resin) by the mass spectrum with good correspondence to an epi-labdanoid that is typically found in Brazilian copals (Figure 107) (Doménech-Carbó et al. 2009). Eperuic acid, associated with the copal resin in the Ripolin samples, was well oxidized. This oxidation was probably a result of heating. The addition of copal resins to paint involved liquefying the hard insoluble resin by heating it to a high temperature and ‘running’ it into hot oil. The addition of copal resin to oil-based enamel paint imparted gloss, hardness and assisted with drying, although it also could increase the tendency of the paint to yellow and become brittle (Standeven 2011 p. 36).

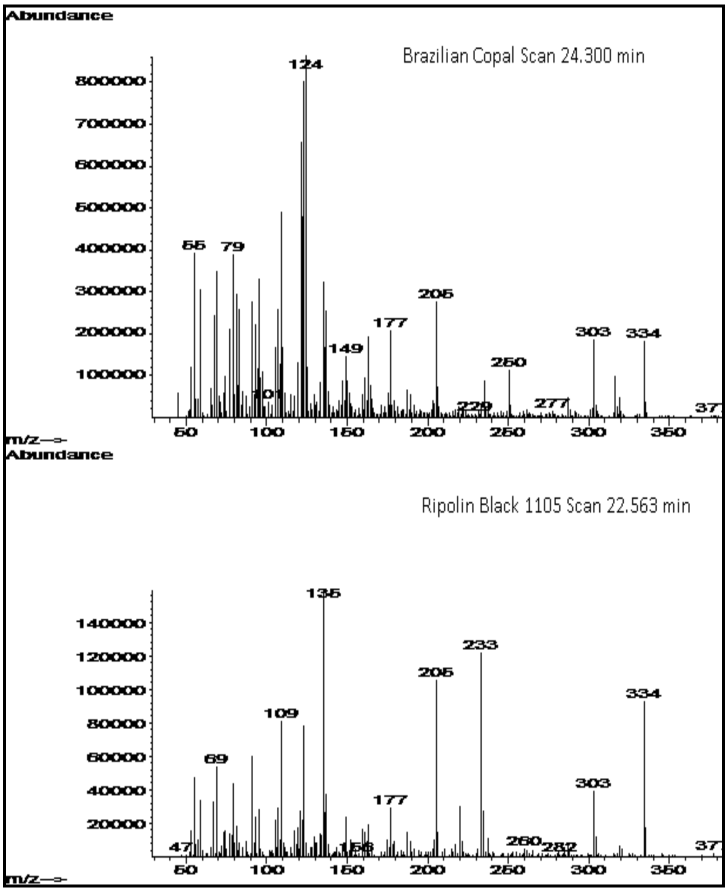


Figure 107. Mass spectra scan of Brazilian copal at 24.3 minutes and Ripolin lack 1105 at 22.56 minutes. Image: Michael Schilling and Getty Conservation Institute

Colophony is less stable than copal in this respect and found in a number of Ripolin colours, is a surprising addition. Ripolin enamel was considered the highest quality enamel and suitable for outside exposure where the deterioration of colophony would be greater due to exposure to weathering. Although present in a number of colour tints along with the copal, there are a number of colours in which the colophony is the only resin detected. The colophony is not therefore an adulterant of the copal. The abietic acid derived from the colophony, identified with Meth-Prep GC/MS, was so oxidized that it had completely converted to 7-oxo dehydroabietic acid. This suggests significant heat treatment of the colophony, associated with some form of pre-processing. Processed colophony products were more stable than unprocessed colophony and include ester gum, a combination of glycerol and colophony, and metallic resinates used as driers produced by reacting colophony with lead, cobalt or manganese (Standeven 2011 p. 29-30.). Glycerol which may be a tag for ester gums is present in the GC/MS chromatograph associated with the oil and cannot be used to distinguish ester gum from oil. However, as the identification of colophony in the black 1105 and blue deep 40RD is consistant with the larger pXRF peak counts detected for cobalt and manganese in those two colours, the colophony is likely to be present in the form of a resinate drier.

The addition of these types of 'cooked' materials; heat-bodied oils, processed colophony and liquefied copal to the Ripolin paints as found in the results from the Meth-Prep GC/MS analysis, is consistent with the historically documented types of processing commonly used in the preparation of oil enamels of the period (Standeven 2011).

4.3.4 Analysis of driers and zinc soaps

The combination of the fatty acids in oil and the metallic zinc ions in the body white react in paints to form a variety of zinc soaps. While commonly found in dry and aged paint films, the liquid paint in the Ripolin cans containing zinc white were also found to contain these types of reactive products. The circumstances under which zinc carboxylates form, migrate and aggregate in dry and hardened paint films is still the subject of extensive investigations. Gillian Osmond (2012) has written an extensive review of the current research. Some of the catalysts which may be implicated she suggests include zinc oxide particle size and shape, the addition of other metallic compounds such as titanium dioxide and lead white in the paint mixture, and environmental conditions such as humidity and temperature, including rapid cycling of temperature.

Zinc oxide can be difficult to detect in FTIR as although it has a broad peak 400-550 cm^{-1} with onset at approximately 600 cm^{-1} (McMillan 2013) and can be seen in the FTIR spectrum for BLT white 1 (Figure 89), this may be difficult to distinguish in paints with a mixture of pigments particularly those with titanim dioxide and/or kaolin. FTIR spectra of the Ripolin oil-based paints containing zinc oxide generally gave a large rounded peaks in the carboxylate region 1500-1600cm^{-1}. The Ripolin colours without zinc oxide gave no FTIR peak result in this region. Comparison of FTIR spectra for two blue gloss paints for example, both containing Prussian blue, but one mixed with zinc oxide, blue PE5, and one without zinc oxide, blue deep 40RD, demonstrate this FTIR carboxylate feature and its association with those Ripolin paints with zinc oxide (Figure 96.) This peak in the FTIR spectra for Ripolin colours containing zinc oxide and its absence in those without zinc oxide (1500-1600cm^{-1}), was substantiated in all the examples examined from samples of the Ripolin colours in cans.

Cobalt and manganese driers such as cobalt resinate or naphthenate, are often credited with a peak in the same region as zinc soaps (1500-1600cm^{-1}) and FTIR spectra of a still liquid sample taken from the bottle labelled 'cobalt naphthenate in turps' from the Nolan studio, does give a broad carboxylate peak in the region 1500-1600cm^{-1} . However a sample of the dried residue on the outside of the same bottle gives a more specific FTIR spectrum, with peaks at 1707 and 1605cm^{-1} (Figure 108). These peaks are outside the area of interest regarding zinc carboxylates and are unlikely to confuse the identification of driers with zinc soaps if present in the same sample.

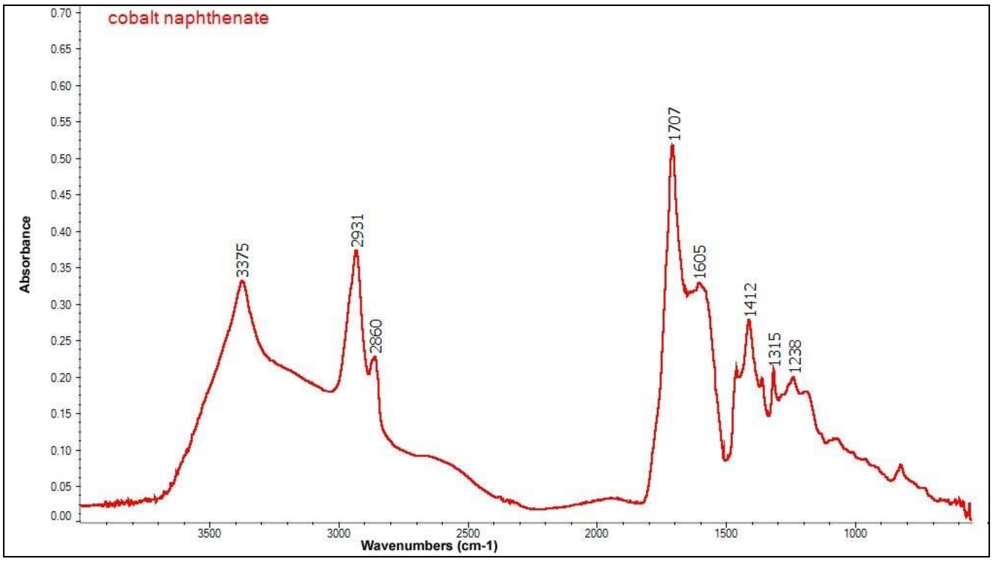


Figure 108. FTIR of cobalt napthenate in turps dry residue on outside of bottle from Nolan studio. Image: Paula Dredge

Some interesting variations on the standard FTIR rounded carboxylate peak associated with zinc oxide and oil, was found with some of the Ripolin colours from the sealed cans. In many samples, small and hard aggregates were visibly distributed within the zinc oxide solids in the can and created seed-like lumps in the paint-outs. Thin cross-sectional samples of recently painted out samples of BLT ultramarine 13, BLT white 1 and flat white 501 examined with the Infrared Beam-line at the Australian Synchrotron produced informative infrared spectral maps (Figure 109). Areas associated with these 'seeds' (seen in upper Figure 109 in two views of the thin section of paint film white 1 as clear spherical areas), had sharp FTIR carboxylate doublet peaks at 1551 and 1533cm^{-1} and a shoulder at 1597cm^{-1}. This corresponds well with observed FTIR spectral patterns for zinc oleate (zinc 9-octadecenoic acid) (Corbeil, Helwig & Poulin 2011 p. 72). The paint surrounding these soap aggregates (dark matrix surrounding clear area) conversely showed a broad, non-specific carboxylate peak in the area 1650-1500cm^{-1} with no sharp peaks. This demonstrated that the zinc oleate, was confined to the seed-like aggregates.

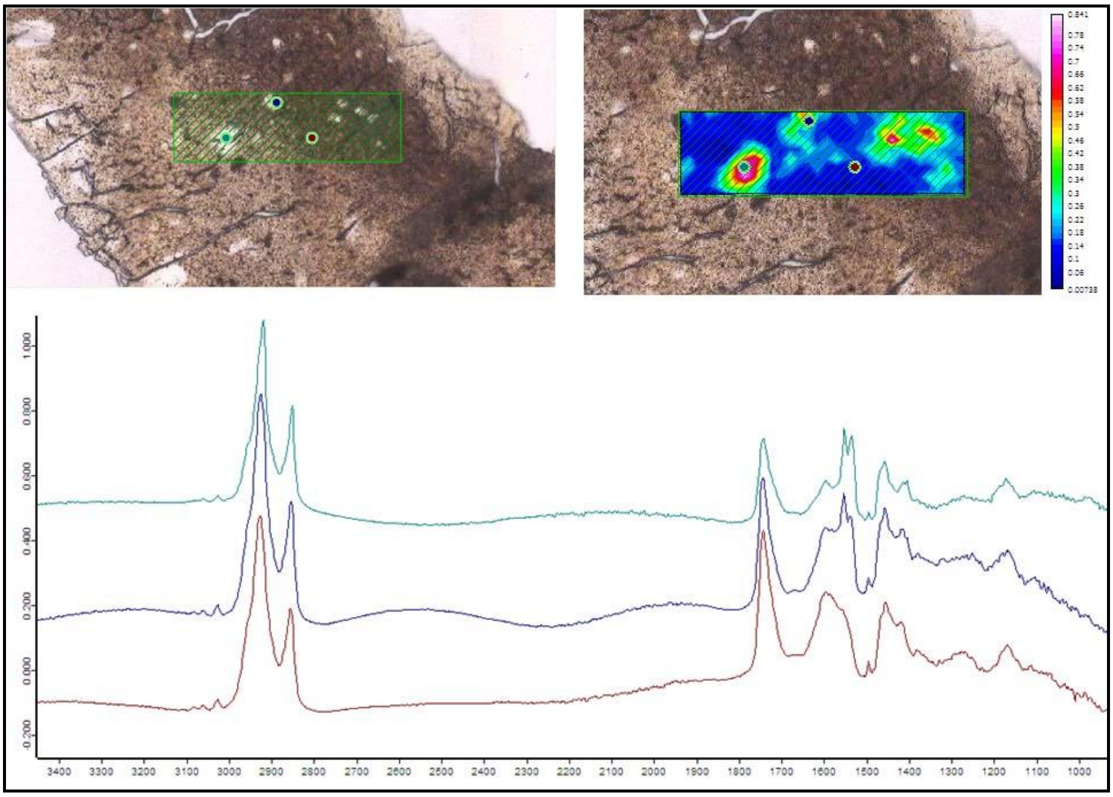


Figure 109. Australian Synchrotron infrared spectral map of Ripolin white 1. Spectral peaks at 1550-1530 integrated in mapped area indicated upper left and showing relative peak heights at right (highest pink/ lowest blue) and three typical FTIR spectra from different areas of sample at upper left. Image: Paula Dredge, Ljiljana Puskar

As discussed by Corbeil, Helwig and Poulin (2011) the unsaturated fatty acid, oleic, in paint slowly oxidizes and reduces in concentration in well hardened and dried paint films. This suggests that the zinc oleate soaps observed in the sealed Ripolin paint from the cans when freshly decanted, may not be present in aged and dried paint films in which the oleaic acid has oxidised to stearic/palmitic acid.

In one unusual sample from the Ripolin cans, flat pink very light 565 was observed to have a brittle waxy layer at the interface between the liquids and the solids. This was identified with FTIR as a unusually pure zinc stearate with sharp spectral peaks at 2953, 2918, 2848, 1541, 1464, 1398cm^{-1} and a doublet at 742 and 723cm^{-1} (Figure 110). The soap had not formed spherical aggregates but a distinct layer, and was in the stearate form, identified by the strong peak at 1541cm^{-1} and other contributing peaks visible in the spectrum, not the oleate as for the other soaps analysed from the sealed cans. It is probable that, in this instance, the zinc stearate was added as an ingredient to the paint rather than having formed *in situ*. Zinc stearate was used as an additive to manufactured paints, principally to reduce pigment settling while the can was on the shelf (Atherton 1969 p. 55).

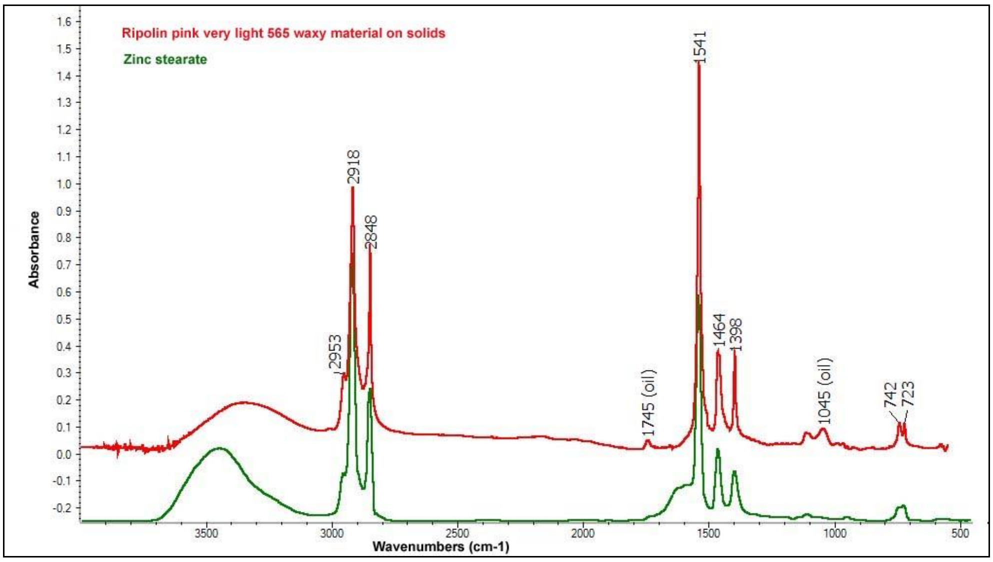


Figure 110. FTIR of waxy material on solids in can of Ripolin flat pink very light 565 compared to zinc stearate (© Nicolet Instrument Corp., 1991-1994). Image: Paula Dredge

4.3.5 Analysis of paint in travel case and two additional cans

Examination of the leather satchel travel case from the Wahroonga studio (SID 44139) shows it to be adapted to the purpose with twelve metal canteens with screw top lids, separated and held upright with cardboard dividers (Figure 111).

Figure 111. Leather satchel travelling case for paint. Photo: Felicity Jenkins and the Art Gallery of New South Wales

When the cans in the satchel are viewed from the back the thick build-up of paint on the inside edge of each divider is revealed, created as Nolan withdrew his brush and scraped it across the cardboard (Figure 112). The colours from each container can be assigned according to these dry paint build-ups. They include three cans of white towards the front (rear in the photograph below), bright yellow and red also in the front, three blues in the back row with black, and a dark green pale red and pale yellow in the centre row.

Figure 112. Nolan satchel viewed from back showing paint buildup on card edges. Photo: Paula Dredge

A loose can was lifted from the satchel and was found to be painted in khaki green paint and embossed with the inscription No 75/1/UCC 7/43 (Figure 113). The back of the same container showed that it had originally had a clip that had been brazed off in order to fit it into the case. These cans, according to Chris Goddard, Assistant Curator, Military Heraldry and Technology at the Australian War Memorial, were made for the Australian Army by the Union Can Company (UCC) of South Melbourne in July 1943 (as stamped). The Union Can Company pioneered the development of the screw cap lid and was commissioned by the Australian Army to make many different types of cans for the troops, although an exact use for these particular cans in Nolan's satchel could not be determined [Chris Goddard personal communication 2012]

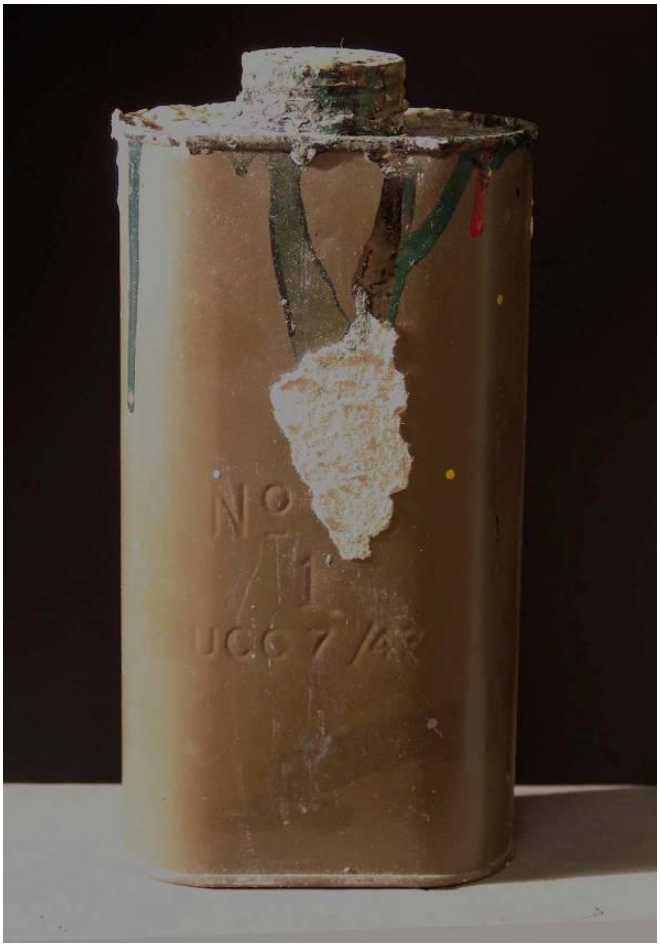


Figure 113. Paint can from leather satchel.
Photo: Paula Dredge

This satchel and cans appear to be 'requisitioned' items from Army stores which were adapted by Nolan to carry his liquid paints. The Army attributes suggest strongly that this satchel and their contents date from Nolan's period in the Australian Army, although they also must post-date the production date of the can (July 1943).

Analysis with FTIR of the paint contents from the satchel (SID 44139) and two additional cans (SID 44141 and 44142) give results consistent with oil-based binders. Using pXRF and FTIR, the analytical results of the dried paints from the cans in the satchel and two other unlabelled cans and their suggested matches with Ripolin tints from the labelled cans, are given in Table 4.8. However paint samples taken from the dried cans embedded in polyester and prepared as cross-sections examined with incident light and ultraviolet microscopy demonstrate the contamination of these paint with other colours (Figure 114). Some caution is warranted with these results, although this does reflect the circumstances of analysis on dried paint films on actual paintings in which colours are likely to be found in these mixed forms.

Figure 114. Cross-section of white paint sample from can 5 photographed with incident light at x 100. Photo: Gillian Osmond and Paula Dredge

Table 4.7 Analytical results from paints in satchel

Paint cans 44139 Numbered from back left to front right	Contents identified (trace) [uncertain]	Suggested match with paint in labelled cans
Can 1 gloss pale blue	Oil, zinc oxide, Prussian blue (lead chromate)	Ripolin blue PE5
Can 2 gloss black	Oil, zinc oxide	Ripolin black 1105 + zinc oxide and resin
Can 3 gloss blue	Zinc oxide, barium sulphate, copper phthalocyanine, (lead chromate)	Ripolin ultramarine 13
Can 4 gloss dark blue	Oil, Prussian blue	Ripolin blue deep 40RD + resin
Can 5 white	Oil, zinc oxide (lead chromate)	Ripolin white 1
Can 6 gloss green	Oil, Prussian blue, lead chromate	No gloss green in labelled cans
Can 7 flat pale red	Zinc oxide, lead chromate [organic red not identified]	No matched labelled can
Can 8 gloss yellow	Oil, lead chromate, zinc oxide	No gloss yellow in labelled cans
Can 9 white	Oil, zinc oxide (lead chromate)	Ripolin white 1.
Can 10 white	Oil, zinc oxide (lead chromate)	Ripolin white 1
Can 11 gloss yellow	Lead chromate, lead sulphate	No gloss yellow in labelled cans
Can 12 gloss red	Oil, barium sulphate, toluidine red	Ripolin red 16
44141: gloss white	Oil, zinc oxide (lead chromate)	Ripolin white 1
44142: gloss yellow	Oil, lead chromate [lead sulphate]	No gloss yellow in labelled cans

The paint in one can, the pale red can 7, does not match well with any extant labelled Ripolin can from the Wahroonga studio. It is a darker tint than the pink very light 565. The pale red in the satchel may either be a paint mixed by Nolan, or a Ripolin colour no longer present in the stock of studio cans. Although there are also no extant examples of Ripolin in labelled cans from the Wahroonga studio for gloss colours yellow and green, the use of lead chromate and Prussian blue for similar colours in the flat range suggests that these two colours in the satchel are also Ripolin paints.

The three white paints from the satchel, can 5, 9 and 10, and the white paint can (SID 44141) are identical under PXRF analysis. They are all dominantly zinc with trace elements lead, chrome, iron, barium and cobalt. FTIR spectra from samples of the same white paints show very similar features with peaks for oil and carboxylates (1500-1600cm^{-1}) dominating with the formation of a minor side peak at 1541cm^{-1} (zinc stearate). These FTIR spectra and pXRF results correlate well with the analytical results on the Ripolin BLT white 1 paint in the labelled can (Figure 115) however the FTIR spectra could all be equally true for any zinc oxide paint in oil as demonstrated by a very similar spectrum in van der Weerd, van Loon and Boon (2005). Peaks not directly associated with either oil or zinc oxide at 873, 1059 and 1319cm^{-1} are present in both the samples of white from the cans and van der Weerd's spectrum for zinc oxide in oil, suggesting that other functional groups are being formed in these paints. Van der Weerd suggests the peak at 873cm^{-1} is a calcium carbonate contaminant, but as there was no calcium detected in the Ripolin BLT white 1 with pXRF it is likely to be a by-product such as zinc carbonate as suggested by Osmond (2012).

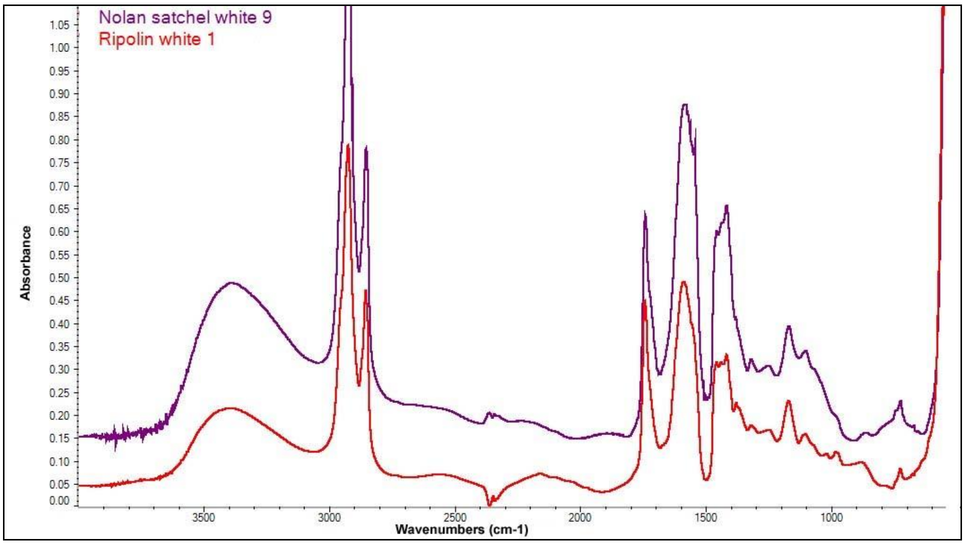


Figure 115. FTIR of white from satchel can 9 and Ripolin white 1. Image: Paula Dredge

Colours other than white, therefore, offer a better FTIR fingerprinting comparison with the paints from labelled cans. For example, the red can 12 from the satchel gives excellent correspondence with toluidine red and barium sulphate as found in Ripolin red 16 (Figure 116)

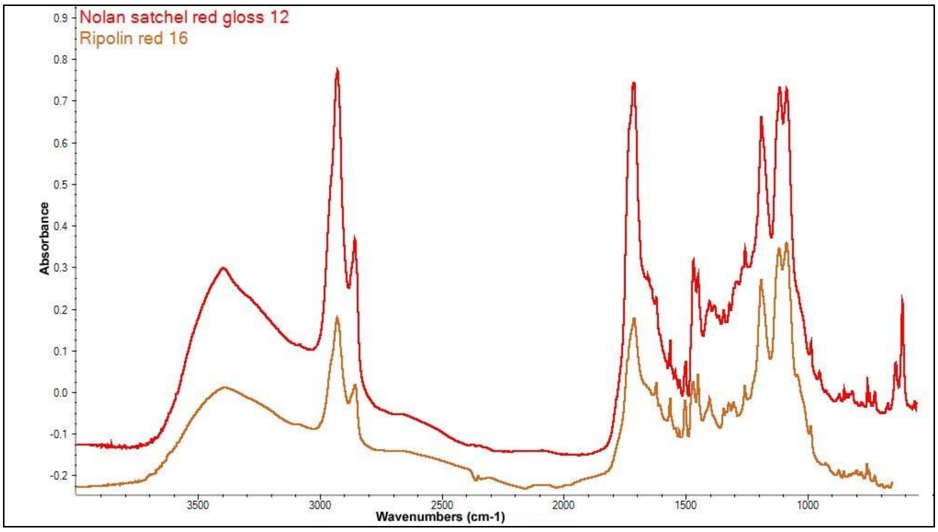


Figure 116. FTIR of gloss red from satchel and Ripolin red 16 from labelled can. Image: Paula Dredge

Attempts to sample the internal contents of yellow can 11 unexpectedly extracted a layer of dark brown sticky residue sitting on top of the solids. This was analysed with FTIR and gave a result with a good match with the Talens stand oil (SID 44153) from the sealed bottle in the studio contents (Figure 117). The double carbonyl peaks at 1716 and 1734cm^{-1} and the large peak related to the C-O ester bond at 1244cm^{-1} are features of unoxidised oil. This suggests it is an oil-based material, which has not dried despite being in an open can. It is perhaps a non-drying oil. It signals the potential for the addition by Nolan of non-standard materials to his paints.

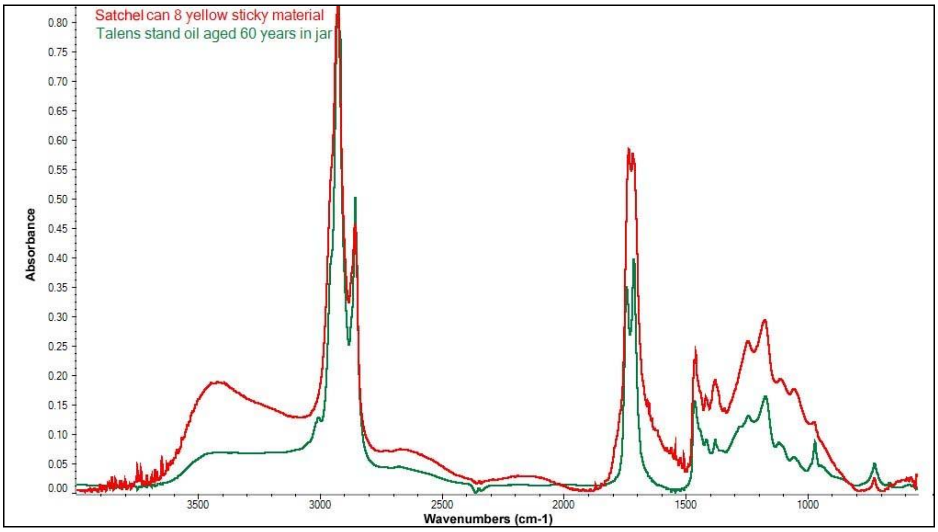


Figure 117. FTIR of sticky residue in satchel can 8 and Talens stand oil unoxidised. Image: Paula Dredge

4.3.6 Analysis of Ripolin paste

The Ripolin paste, now dry in the can, is a dense white material with a brown skin on the surface. FTIR analysis of a dry sample gives good correlation with oil and carboxylates between 1500-1600cm^{-1} . The large sharp side peak at 1541cm^{-1} and other well-developed peaks for zinc stearate, suggests the Ripolin paste is pigmented with zinc oxide (Figure 118**).**

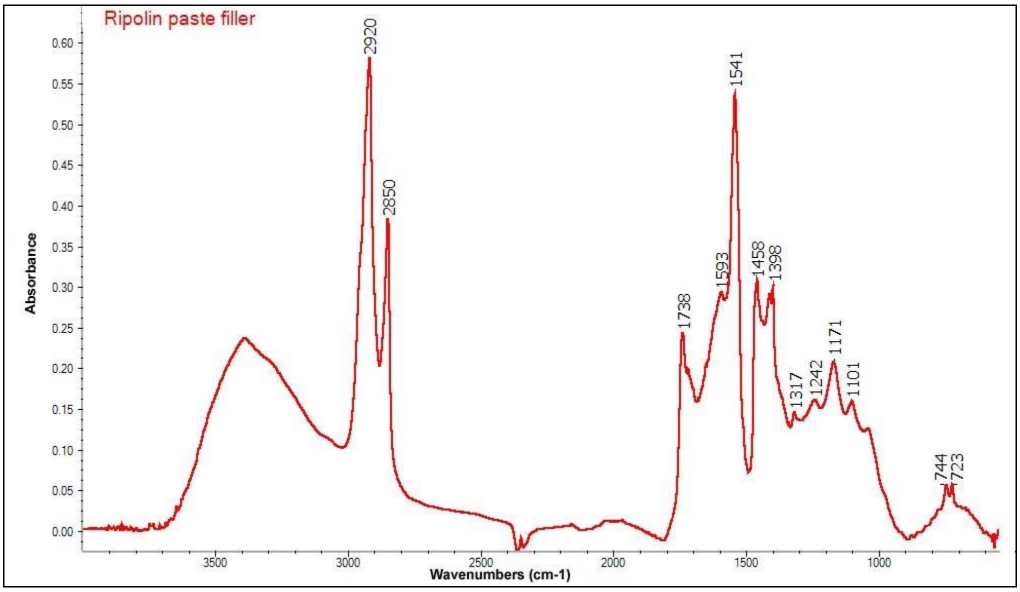


Figure 118. FTIR spectrum of Ripolin paste filler dried skin. Photo: Paula Dredge

However, FTIR analysis of a sample of the solids beneath the surface is dominated by another white pigment, calcium carbonate with a broad peak in the lower wavenumber region with inception at approximately 850 cm^{-1} suggesting the presence of titanium dioxide. This significant difference between samples taken from the surface of the dry material in the can with those taken lower demonstrate the importance of thoroughly sampling different parts of dried paints (Figure 119).

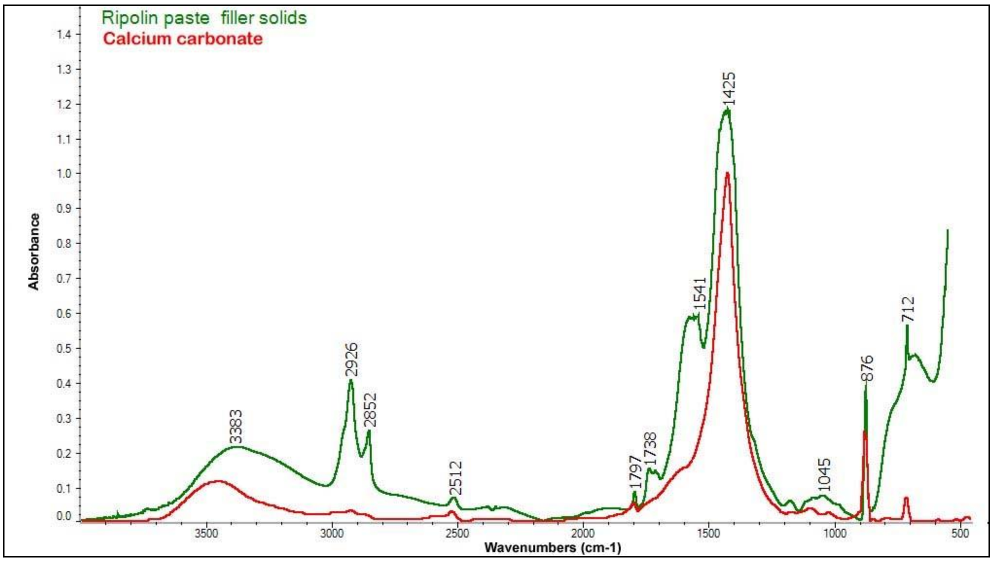


Figure 119. FTIR of sample of Ripolin Paste filler solids in can and library spectrum of calcium carbonate (© Nicolet Instrument Corp. 1991-1994). Photo: Paula Dredge

PXRF of a sample from the dried contents gives results for titanium, barium, calcium, cobalt and zinc. Ripolin paste is therefore a pigment-rich zinc oxide and oil mix with calcium carbonate, titanium dioxide and barium sulphate. This is similar to the flat Ripolin white 501 and would be entirely compatible with the Ripolin paint when used to fill losses in a support prior to painting.

4.3.7 Analytical conclusions on Ripolin paints

Examination of the contents of this collection of Ripolin paints has demonstrated the complex formulation of the British-made Ripolin paint. Not only are combinations of coloured pigments selected for each tint, but the white pigments and fillers also vary between colours. Likewise the binders appear to be formulated for each colour with copal resin, colophony and castor oil being detected only in some colours. The use of heated oils and resins is consistent with the historical literature regarding the preparation of oleoresinous vehicles for enamel paints.

There are some shared features between the different Ripolin colours. The principal binder in both the flat and gloss Ripolin paints are drying oils. In general, the gloss range utilises a higher proportion of oil compared to the flat colours. The flat range of colours conversely has a higher proportion of volatile solvent to the gloss colours. This, along with the addition of kaolin and talc (clays), assists in the formation of matte paint films. While zinc oxide is the principal white pigment in most of the Ripolin paints from the cans, there are a number of deep colours that do not contain zinc oxide. Barium sulphate is present in some of these colours others contain no white solids at all. Chalk was identified in the can of old white and maroon lake 1167. Titanium dioxide was identified in the flat white 501, the old white and the can of pink very light 565. The principal coloured pigments identified were Prussian blue, copper phthalocyanine, lead chromate (yellow and red shades), iron oxide, toluidine red, carbon and bone-based blacks. All these pigments were commonly used in house paints of the period and combine the features of powerful tinting strength, semi-permanence and relative cheapness.

Comparison of the pigment analysis of the Nolan studio Ripolin with the French Ripolin study suggests good correlation between most colours that are numbered similarly. Some differences are noted particularly in the use of toluidine red and copper phthalocyanine blue, but these are likely to be evolutions in the formulations over time. Otherwise it is remarkable how consistent the pigments are, both over time and across different manufacturing countries.

The ability to identify the presence of Ripolin on paintings by Nolan is enhanced by the success of the pXRF and FTIR analytical systems to identify pigments and oil binders within the Ripolin paints from the cans. The application of these methodologies and the use of standard FTIR and pXRF spectra gathered from the paint in cans to positively identify the presence of Ripolin, is tested in Chapter 5 by the examination of samples from paintings by Nolan.

4.4 Alkyd paint study

As a counterpoint to the analytical work on the Ripolin oil-based enamel paints, a similar study is offered on Nolan’s other stated choice of ready-made gloss paint of the period; alkyd-based Dulux. As this appears to be Nolan’s principal paint of choice prior to the arrival of the Ripolin, an ability to distinguish each paint type would be an advantage for cataloguing and for planning conservation care and treatment.

As no analytical studies of this popular brand of alkyd paint have yet been published, it is not possible to make an analytical comparison between these products manufactured in Australian by B.A.L.M. and those made during the same period by I.C.I. and Dupont in the UK and USA. However, the identification of typical pigments, resins and oils may form the basis for future comparative studies.

4.4.1 Dulux

Alkyds, such as Dulux, are manufactured by heating phthalic anhydride (polybasic acid) and a polyalcohol at high temperature and high pressure. In air-drying alkyds, the polyalcohols are usually either glycerol or pentaerythritol. This alkyd resin can be made into a brushing paint by incorporating drying oils such as linseed or tung. Dehydrated castor, soyabean and other drying oils may also be used. An important development in alkyd manufacture for brushing paints was the substitution of pentaerythritol (PE) for glycerol as the polyalcohol sometime after the Second World War. The exact date at which PE became the dominant polyalcohol in alkyds is not clear in the literature. Tom Learner initially suggested PE may have become common place in alkyds as late as 1960 (Learner 2005 p. 18) but Schilling, Mazurek and Learner subsequently analysed and found PE alkyds on paintings by Jackson Pollock dating from 1949 (Schilling, Mazurek & Learner 2007 p. 137). This corresponds well to an article dated 1949 in which PE is described as a new type of polyhydric alcohol being used in alkyd formulations in the USA (Hovey 1949).

As it is uggested by Nolan’s correspondence with Sunday Reed, that Nolan was using Dulux alkyds from at least 1942 and possibly again after the war, the presence of PE alkyds may be a useful dating reference for the alkyds identified in his paintings. There is a single can of black Dulux 388 brushing-line paint in the Wahroonga studio contents (Figure 2). It was not known prior to analysis if this can dated from prior to or after the Second World War. The label on the extant can differs from the image of the can used for the product launch in 1931 ('DULUX launch' *Decorator & Painter for Australia & New Zealand* 1 December 1931, pp. xii-xiii). In 1931 the Dulux slogan read: ‘A distinctive interior & exterior finish superseding enamels’ whereas the can from Nolan’s studio reads ‘The synthetic finish superseding enamels’. This altered slogan is found in a picture of a can of B.A.L.M. Dulux from an advertisement dating to 1947, prior to the post-war relaunch of the product (Figure 60).

FTIR analysis of the dry black paint on the outside of this can compared with published FTIR spectra (Learner 2005), gives a positive identification for alkyd resin in the fingerprint region from 500-1500cm^{-1} particularly in the broad peak at 1281cm^{-1}. The black pigment does not have a presence in the FTIR spectrum of the paint, suggesting that it is a carbon-based colour. Table 4.9 outlines the peaks in the FTIR spectrum obtained from the Dulux can from the studio and the assignments to alkyd functional groups compared with typical drying oil FTIR absorbance peaks identified in the example of Ripolin Black 1105. Some of the similar peak positions are attributable to the oil component present in alkyd paints. The FTIR spectral comparison of the black Dulux paint from Nolan's studio with the Ripolin black 1105 (oil-based) demonstrates the clear spectral differences between these two binders (Figure 120).

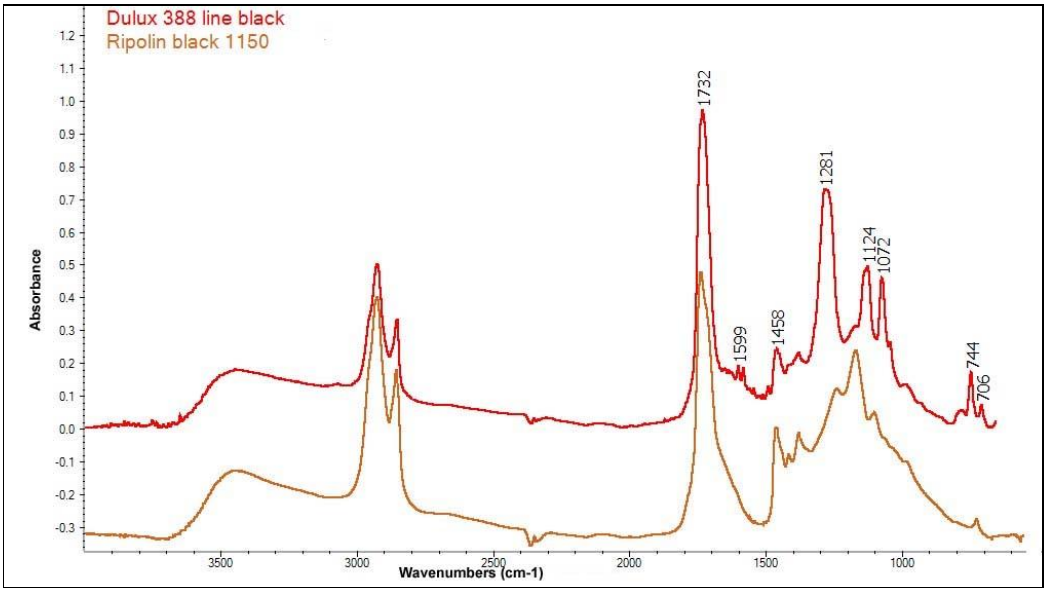


Figure 120. FTIR of Dulux 388 black and Ripolin black 1105. Image: Paula Dredge

Table 4.8 FTIR absorption spectral peaks for Dulux black (alkyd) compared to Ripolin black (oil)

Dulux black FTIR absorbance peaks (cm^{-1})	Ripolin black 1105 FTIR absorbance peaks (cm^{-1})
3437 (b)	3444 (b)
3072 (w)	-
2979/2856 (s)	2927/2854 (s)
1732 (s)	1736 (s)
1599/1579 (w)	-
1456 (w)	1462 (w)
1379 (w)	1379 (w)
1282 (s)	1238 (s)
1124 (s)	1169 (s)
1072 (s)	1101 (s)
1042 (w)	-
987 (w)	904 (w)
744 (s)	752 (w)
708 (w)	-
651 (w)	-

Key: (s) strong (w) weak (b) broad

Derivatised Py-GC/MS at the Getty Conservation Institute of a sample of dry paint from the can of black Dulux from the Nolan studio material confirmed the identification of alkyd resin by a significant peak for phthalate (10.2min) and also the presence of the polyalcohol, pentaerythritol, at 8.25mins (Figure 121). Comparison of the palmitic to stearic acid peak ratio gives a percentage weight ratio in the area of 1.1, which could indicate the presence of linseed, tung or dehydrated castor oil. As the fatty acid marker for castor oil was not identified, castor oil is unlikely to be present.

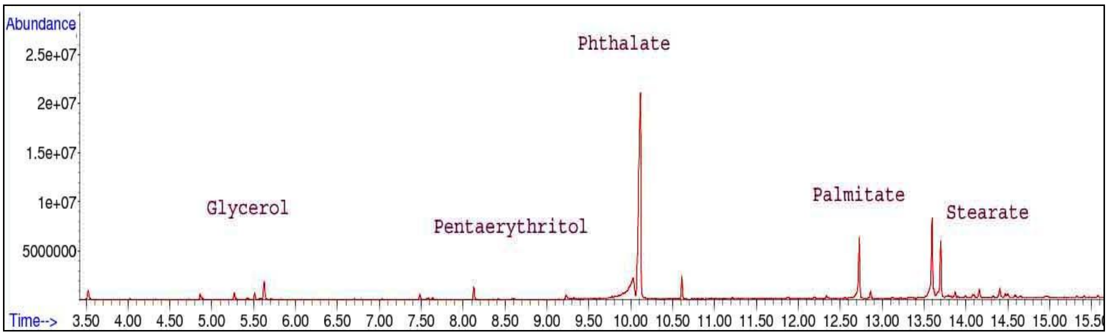


Figure 121. TMAH Py-GC of Dulux Black 388 from Nolan's studio. Image: Michael Schilling and Getty Conservation Institute

Comparison of the trace elements identified with pXRF in low mass mode with those of the Ripolin black 1105 is potentially a useful technique to examine trace elements that might be present as driers (Figure 122). While the comparison of counts between the two samples is not normalised to take account of the different thicknesses of the samples, it provides a useful representation of the proportions of elements within each paint sample. Dulux black has largest counts for the elements of lead, iron, calcium and manganese. The lead in the Ripolin black 1105 is found in addition to a peak for chrome and is present in the paint as lead chromate, whereas the lead in Dulux black has a relatively small chromate peak, suggesting its presence is related either to lead white, lead sulphate (neither of which are present in the FTIR spectrum) or a lead drier. The calcium in the Dulux black may also be present as a drier. Ripolin black (1105) however has the highest count in all elements detected in the paint for cobalt and both black paints have peaks for manganese. These results suggest that metallic driers are used in both these paints, but that they vary in type.

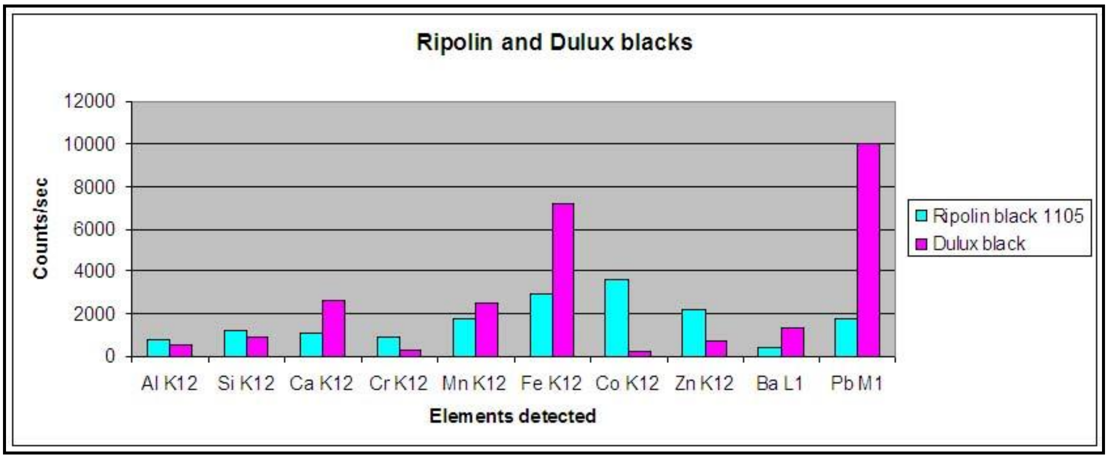


Figure 122. PXRF results of samples in low mass mode of Ripolin Black 1105 and Dulux Black. Image: Paula Dredge

An additional can of Dulux exists in the group of Wahroonga studio material gifted to the National Gallery of Victoria. This can is described on the label as a synthetic undercoat, white brushing surfacer. It appears to have been tinted to grey with finger prints on the outside of a black paint (Figure 123).

Figure 123 Dulux white brushing surfacer can from Sidney Nolan Wahroonga studio contents, National Gallery of Victoria. Photo: Paula Dredge & National Gallery of Victoria

The FTIR spectrum of the white paint dried on the outside of the can is dominated by the spectral peaks associated with the pigments kaolin and titanium dioxide (Figure 124). The high proportion of pigments compared to binder is also represented in the FTIR spectrum by the relatively small carbonyl peak in the region 1740cm^{-1}. This result suggests that the use of Dulux white brushing surfacer as a ground layer on paintings by Nolan may not be readily distinguished as an alkyd paint by FTIR of samples due to the dominant spectral response of the white pigments.

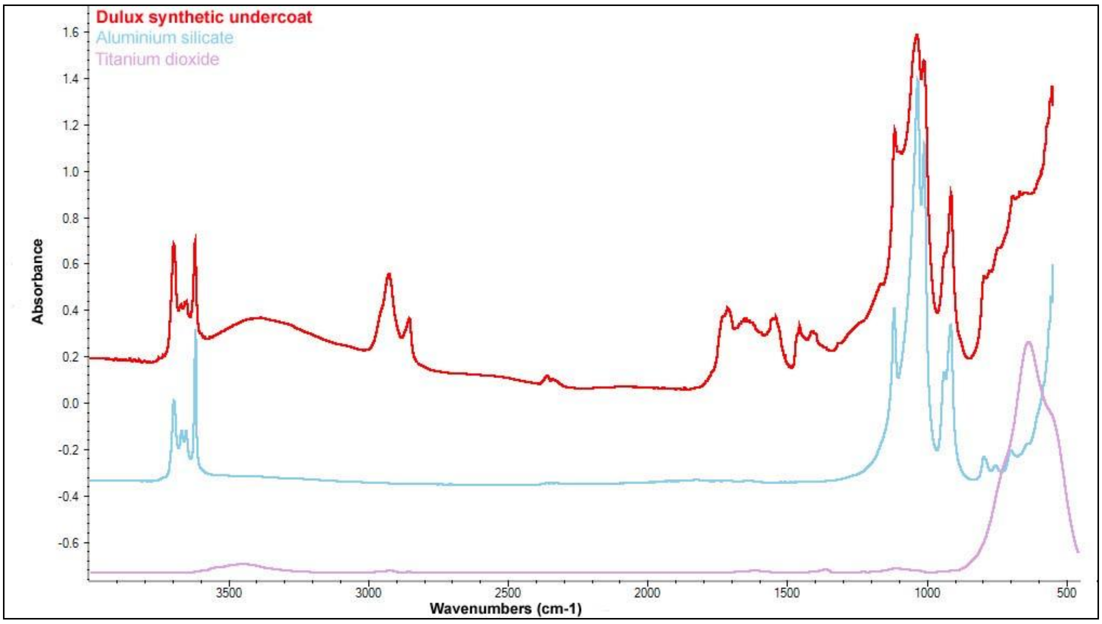


Figure 124. FTIR of Dulux synthetic undercoat from Nolan studio (National Gallery of Victoria). Image: Paula Dredge

4.4.2 Alkyd resins manufactured by I.C.I.

Further information regarding Dulux production is Australia is offered by the examination of a collection of early synthetic resins manufactured by Imperial Chemical Industries (ICI) ANZ called Paralac and gifted to the Powerhouse Museum in 1934. Two of the air drying alkyd resins selected as most likely to be the resins used in Dulux paints of the period, from this collection were sampled for this study. These were Paralac 18T and Paralac 17 described in the letters on file at the Powerhouse Museum from I.C.I. as oil modified alkyds made from phthalic anhydride and glycerol (Imperial Chemical Industries ANZ 1934).

The type of oil used in the resins is not described in the museum acquisition information, but an article written in 1941 offers further information (Technical Service Department of I.C.I. ANZ 1941). It states that Paralac 18T was a tung oil-based alkyd with a long oil length (37-65% oil) and was often used with an amount of Paralac 17, 'a very long oil, linseed oil modified alkyd' for brushing alkyds. This may well describe the formulation of the Dulux 388 brushing line.

FTIR analysis of the two Paralac resins (aged but not dry) show identical spectral peaks which are consistent with those published for typical oil-modified alkyd resins (Learner 2005) and identical with the FTIR spectra for the Wahroonga studio can of Dulux (Figure 130). These two FTIR spectra of the 1934 I.C.I. Paralac resins are identical to each other and no differences can be attributed to the use of different types of oil. The FTIR spectral results also show clearly that the use of different polyalcohols in Paralac 17 and 18T, (both glycerol) (Figure 130) has no appreciable effect on the FTIR peak positions compared to the pentaerytrithol (PE) alkyd (Figure 120). This is contrary to that proposed by Francesca Cappitelli in which she says the C-H bending absorbance peak differs between glycerol based alkyds at 1447cm^{-1} and PE alkyds at 1465cm^{-1} (Cappitelli 2003). The associated FTIR absorbance peak in the alkyd resins tested in both glycerol and PE forms are 1458cm^{-1}. TMAH-Py-GC/MS analysis of these two base Paralac resins confirmed the absence of PE in these pre-war resins. FTIR therefore is ineffective at distinguishing glycerol from PE alkyds in the manner suggested.

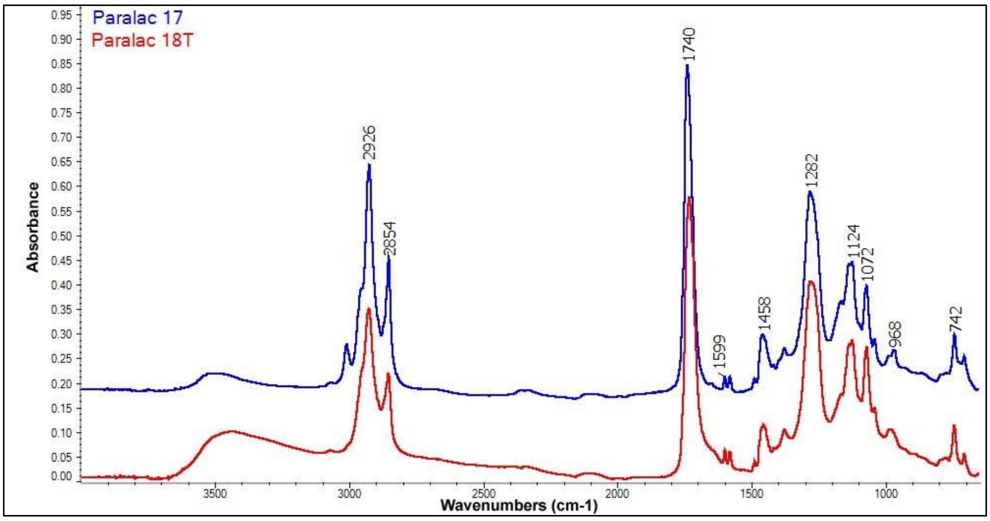


Figure 130. FTIR of Paralac 18T and 17 from Powerhouse Museum. Image: Paula Dredge

4.4.3 Additional Dulux cans

Two more cans of Dulux were examined for this study, spotlight green and orange. These cans were kindly lent to the project by Dion's Bus Company in Wollongong which had stores of materials used on the maintenance of the bus rolling stock. FTIR of the liquids from the cans gave identical results to those from other Dulux sources, with some small difference in the carbonyl peak and a shift of the 1458 peak to 1464cm^{-1} (Figure 131). Analysis with TMAH-Py-GC/MS identified PE in the Dulux spotlight green. There was no PE in the orange Dulux. These differences in the presence of PE did not show in the FTIR spectra of the two resins any difference in the position of the 1464cm^{-1} peak.

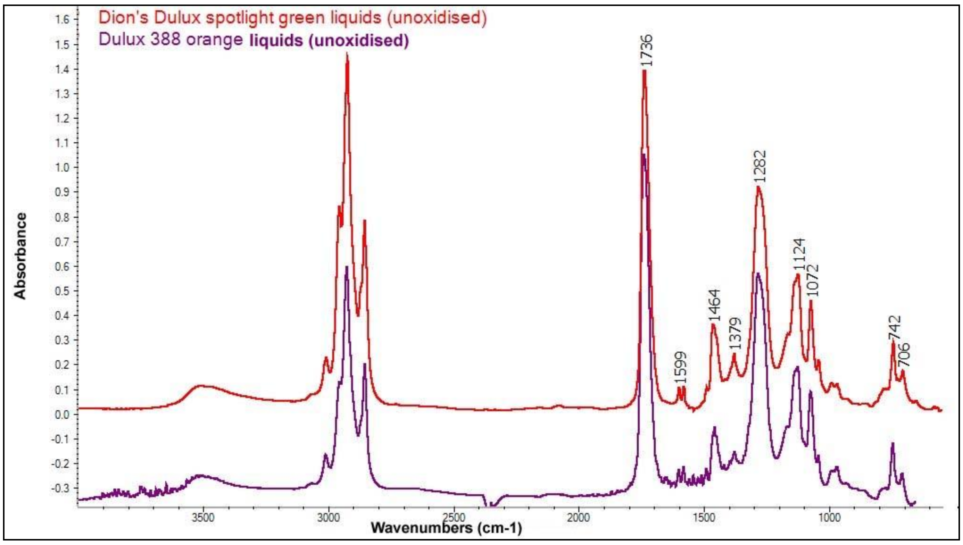


Figure 131. FTIR of liquids from Dion's Dulux Spotlight green (red) and Orange (purple). Image: Paula Dredge

The pigments in these two paints were of interest as the presence of PE in the Spotlight green suggested a post-war Dulux and glycerol in the other a pre-war Dulux. The post-war spotlight green Dulux was based on a titanium dioxide white whereas the orange Dulux was a lead chromate with no white pigment. When analysed with Raman Spectroscopy, the spotlight green paint gave peaks corresponding to the rutile form of titanium white at 143, 232, 446 and 609 cm^{-1}. Rutile titanium white is associated with post-Second World War production techniques and is therefore confirmation of the post-war status of this can of Dulux suggested by the presence of PE.

4.4.4 Conclusions on Dulux study

Study of the contents of three paint cans of Dulux manufactured by B.A.L.M. Australia in the pre- and post-Second World War periods conclusively demonstrated the presence of alkyd resins in all three cans. The FTIR spectra obtained from these samples have identical spectral features related to the binder. This is despite the use of different polyols in these paints which were identified with TMAH-Py-GC/MS. Although historic documentation suggests that both tung and linseed oil may have been used in early pre-war alkyd resins, such as the Paralac 18T, and Dulux orange, these could not be identified with either FTIR or TMAH-Py-GC/MS.

The use of titanium white in the pale coloured post-war Dulux paint identified as a PE alkyd spotlight green, is consistent with the historic literature as outlined in Chapter 3. It suggested that most house paints substituted titanium white for lead white after the Second World War. If confirmed this would be a useful dating tool for the Australian-made Dulux range, but unfortunately the only non-PE Dulux alkyd paint (pre-war) tested during this study, Dulux orange, did not contain any white pigment.

The study of typical resin and pigment formulations in the Dulux paint range, as manufactured in Australia, requires a larger sample group to provide detailed analytical information of pigments used across the colour range and to distinguish Dulux from any other type of alkyd paint. These results, however, demonstrate that Dulux paint in Australia was an alkyd resin and did undergo a change in the polyol content. Limited pigment analysis suggests that there is also potentially useful information in the pigment formulations that may be indicative of manufacturing dates.

4.5 Duco and Dynamel

Unfortunately, there were no extant cans of Duco or Dynamel in Nolan's Wahroonga studio to provide reference spectra for the identification of these paint brands that may be found on paintings. Two cans of paint were however located to attempt to provide reference material for paint types described in Nolan's letters to Sunday Reed. These were a can of B.A.L.M. Duco brushing lacquer (Figure 132) and a can of Taubmans Dynamel (Figure 134).

Figure 132. Can of B.A.L.M. brushing lacquer grass green c. 1930s. Collection: Dulux History Project. Photo: Trudy Scott and Dulux History Project

FTIR spectra obtained from the degraded solids in the can of Duco gave an excellent match with an aged nitrocellulose. Typical nitrocellulose peaks are found in the spectrum at 1651, 1281, 1057 and 849cm^{-1} (Figure 133). This is consistent with the nitrocellulose absorbance peaks identified by Learner (2005). Typically for nitrocellulose lacquer a large carbonyl peak is also present and relates to the addition of alkyd, oils or other plasticisers. The liquids in this can after decanting and drying gave a good FTIR match with ester gum.

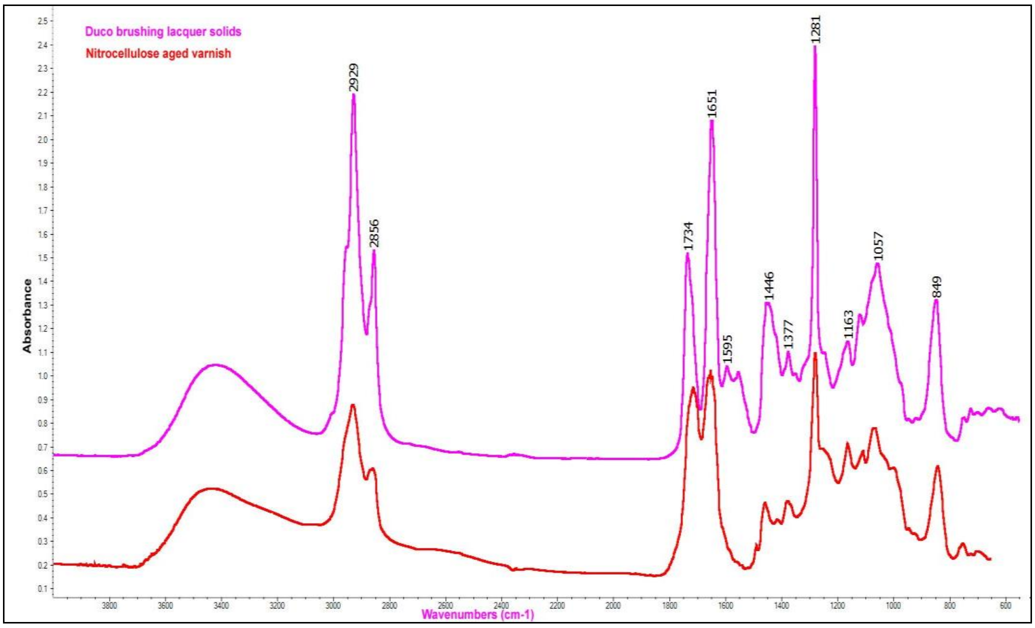


Figure 133. FTIR spectra of solids from can of B.A.L.M. Duco circa 1930s and aged nitrocellulose furniture varnish. Image: Paula Dredge

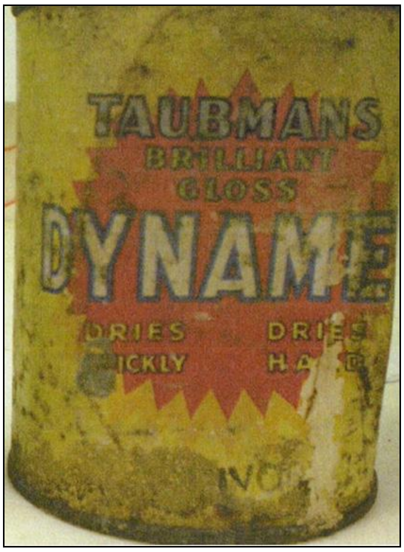


Figure 134. Can of Dynamel from Paint Spot Bentleigh

The liquids decanted and dried from the can of Dynamel was studied with the infrared beamline at the Australian Synchrotron. The FTIR spectra obtained clearly indicate that it is an alkyd-based paint (Figure 135).

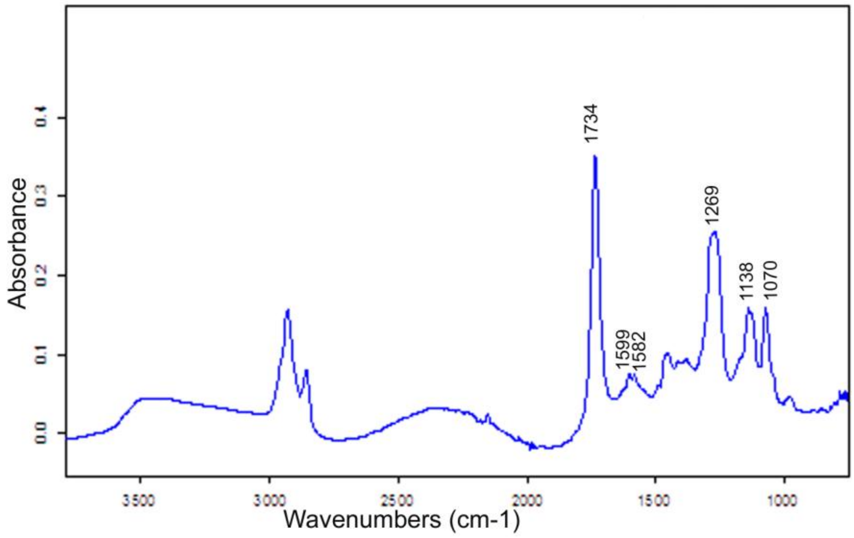


Figure 135. Extracted FTIR spectrum of Dynamel liquids dry

An exact date for the Dynamel is not unknown but the label as it appears on the can, is first used an advertisement in the Australian Womans Weekly on 1 September 1945 (Figure 136). Cans of Dynamel in earlier Australian Women's Weekly advertisements up until production ceased in 1942, were described as 'high gloss', rather than 'brilliant gloss' as for the Bentleigh Paint Spot can. However, although the new style of label appeared in the advertisement in 1945, the text states that the paints were not yet available. It wasn't until 1948 that regular advertisements for Dynamel reappeared in the Australian Women's Weekly. It is likely therefore that the can of Dynamel analysed dates from 1948 to the early 1950s and does not therefore necessarily represent a pre-war paint as used by Nolan in 1942. It is possible therefore that the pre-war Dynamel was based on ester gum as suggested by Todd (1990), and that alkyds were only used in the post war products. More samples of paint from known periods are necessary to try and ascertain the type of binder used in pre-war Dynamel.

Figure 136. Advertisment for Taubmans paint products including Dynamel in the Australian Women's Weekly 1 September 1945

4.6 Other studio materials

The detailed analysis of the large number of materials from the Nolan studio in addition to the Ripolin and Dulux cans, is beyond the resources of this current study. Initial FTIR spectra have been gathered on many of the materials and they form part of an extensive database of reference material (Dredge 2010-2012). Mixtures of organic materials are however extremely difficult to individually identify the components from FTIR spectroscopy alone. As the Ripolin and Dulux studies have shown, while potentially providing broad information on the principal organic material, other components are not well represented in the spectroscopic result. Dried out contents from jars and cans are also problematic for FTIR analysis as oxidation generally causes peak broadening and deterioration of spectral features. The results from the initial FTIR and partial PXRF survey of the remainder of the material are given in Table 4.10 below.

These FTIR results suggest that the contents of the solvent bottles do not always match the labels. There are both hydrocarbon solvents such as turpentine, and alcohols present. The FTIR analysis of the group of small glass jars gave spectral results consistent with oil. Additional peaks at 1082cm^{-1} suggest the presence of a sulphate, possibly barium sulphate, and the shoulder on the carbonyl peak may indicate the presence of a resin. These samples would require GC/MS analysis to clarify the FTIR results. It is possible that these jars represent Nolan's experiments with sun dried and clarified linseed oil as described by Doerner and Mayer (Doerner 1934; Mayer 1940). Similar FTIR results were found with the limited analysis of the dried contents on the outside of the Vegemite jars.

The cans of Kem-Tone gave results for the presence of titanium dioxide pigment. Raman spectroscopy was undertaken by Gillian Osmond and Ying Yu, at the Centre for Microscopy and Micro Analysis, University of Queensland on a sample of the Kem-Tone paint. Due to the rough surface of the paint sample the spectral quality was poor. Fair library matches were obtained for barium sulphate and carbon black. Rutile titanium dioxide may be also present but the match given with the background noise pattern is not sufficient for certainty. The Kem-Tone may not have been used on paintings but for painting the walls of the studio. Similarly, the bitumen paint is more likely a studio construction product, rather than a painting medium. Both materials are included in this study, however, as potential products to be considered in the examination of Nolan's paintings.

Table 4.9 Analysis on additional Wahroonga studio material

SID material	Result
44145 Winsor & Newton distilled turpentine	FTIR match with aged Venice turpentine & Canada Balsam in IRUG library (INR 0235 Philadelphia Museum of Art)
44166 E. Wills methylated spirits	FTIR match with mineral spirits (not alcohol as suggested by label)
44163 Coverwell pure turpentine	FTIR match with aged Venice turpentine but better with Canada balsam in IRUG library (INR 0235 Philadelphia Museum of Art)
44168 Green solvent unlabelled	FTIR peaks 728, 1466 and 1377 all correspond with mineral spirits, but large peak at 1034 relates to alcohol
44150 Fox Bros. pure turpentine	Excellent FTIR match with turpentine hydrocarbon in Coatings Technology Library. Without resinous content of other turpentines.
44164 Ainslie's Scotch whisky	Best FTIR match with Coverwell pure turpentine
43637 Kem-tone	PXRF give peaks for titanium, zinc with small peaks for barium and iron. FTIR strong spectral response for aluminium silicate. Raman; barium sulphate and carbon black detected and rutile titanium may be present.
44152 Winsor & Newton transparent colour	Prussian blue
44157-44161 & 44174 Set of small glass jars with dry transparent solids	Poor FTIR spectra suggesting drying oil
44171 Glass jar with dark brown material in bottom	FTIR match with cobalt naphthenate
44145 Vegemite jar with drip of hard brown material on outside	FTIR spectrum suggests oxidised drying oil
44191 Dry grey paint inside plastic blue cup	PXRF gives peaks for iron, calcium and silicon with small peaks for titanium/barium, strontium and potassium
44144 Kiwi glint polish	FTIR spectra dominated by aluminium silicate. PXRF gives peaks for iron, silicon, aluminium, potassium, calcium and titanium/barium
44149 Winsor & Newton winton picture varnish	FTIR spectra gives result for polycyclohexanone type varnish
44169 Mosquito repellent	FTIR match with dimethyl phthalate
44190 Pink powder	FTIR match with magnesium carbonate
44184 Jar of yellow pigment labelled ochre Fox	FTIR match with aluminium silicate and iron oxide; natural yellow ochre
43386 Euston white lead in oil	Lead white, oil
43389 Reely bitumen paint	FTIR dominated by aluminium silicate and mineral oil
44174 Berger liquid stain pale chrome	FTIR of dry contents gives strong spectral response for oil and lead chromate/lead sulphate

Two jars were considered not to have been used for painting materials, but rather as mementos of Nolan's period in the Australian Army. These are the bottle of mosquito lotion and the jar of pink powder. The mosquito lotion gave an excellent FTIR spectral match with dimethyl phthalate. This is consistent with the literature that suggests this was the common mosquito repellent offered to Australian soldiers (Todd 2007). The FTIR spectrum of the pink powder gave a match with magnesium carbonate. This was less easily associated with a specific use by Nolan. It seems unlikely to be an additive for paint, and more likely a powder for personal use.

4.7 Conclusion

This chapter undertook detailed analysis of the contents from cans of Ripolin left in Nolan's Wahroonga studio and demonstrated that the binder used in all colours tested was oil, and the principal white pigment was zinc oxide. Other pigments detected were Prussian blue, copper phthalocyanine, barium sulphate, titanium dioxide, lead chromate, iron oxide, toluidine and alizarin red with bone black and kaolin and talc in the flat colours. Although an exact production date for the Wahroonga studio cans of Ripolin paint has not been determined, the presence of copper phthalocyanine offered a narrowing of the original date range suggested in Chapter 3. If all the cans are contemporary with each other, then they could date from any time between 1935 and 1953.

PXRF was demonstrated to be a useful partner technique to identify the inorganic elemental components as a comparison and confirmation alongside the FTIR interpretation. Raman spectroscopy and GC/MS were also useful tools for the additional identification of components. Raman was able to distinguish between lead chromate (yellow) and basic lead chromate (orange to red) and also between anatase and rutile forms of titanium dioxide. GC/MS gave further information regarding the presence of copal resin, colophony and castor oil in some colours. GC/MS and Raman spectroscopy are not readily available for analysis of art works and therefore the following chapter, in which actual paintings by Nolan are compared against the analytical references, tests the ability to identify Ripolin paint by FTIR and pXRF alone.

The presence of oil and the pigments found in the cans of Ripolin if found on paintings by Nolan would be a strong indication of the use of Ripolin. While oil enamel paints based on zinc oxide as found in the Ripolin cans were available in Australia, they were not common. Lead white was by the most dominant white pigment used in Australian-made paints from the corresponding period (Chapter 3), and this pigment was not used in the Ripolin paints. The presence of lead white in paintings by Nolan would indicate an alternative type of paint to Ripolin. The detection of an alkyd or nitrocellulose resin would exclude the use of Ripolin paint.

The analysis and examination of the materials from Nolan's Wahroonga studio does confirm that Nolan continued to pursue an interest in other materials and experiment with his own paint formulations, even with a significant stock of Ripolin paint on hand. Some of the additional materials present in the studio contents are lead white oil paints, wax polish, cobalt napthenate driers, ochre pigments and commercial tinters such as Surtint. Also suggested by the historical survey in Chapter 2, but not found in the studio contents, other materials that may have been used by Nolan include; aniline dyes, black pigment, shoe polish, Duco (nitrocellulose) and Dynamel.

Chapter 5. Analysis and investigation of Sidney Nolan's paintings 1938-1949

5.1 Introduction

The previous chapters outlined the history and analysis of many of the materials from Sidney Nolan's Wahroonga studio. Although this research is of broad use for the study of commercial paint materials of the 1940s to 1950s, its primary purpose is to apply this knowledge to the study of paintings by Nolan. The building of a detailed analytical inventory of a large number of paintings by Nolan is not the focus of this research. Instead, it is intended to address specific analytical issues and questions as outlined in this thesis, regarding Sidney Nolan's practice.

The primary question to be assessed in this chapter is the ability to identify Ripolin on Nolan's paintings using the reference standards provided by the cans of Ripolin paint in the Wahroonga studio. Another issue to be examined is the identification of the paints used by Nolan prior to the arrival of the Ripolin in February 1943. The study of a number of those works in which Sunday Reed noted in her 1942 diary as being painted in 'DU LUX' (her separation of the trade name) are of particular interest. The relevant diary entries and some suggestions for the paintings to which they refer are offered in Appendix i. Two early paintings with thick paste-like paint will also be analysed to determine if Nolan could have used artists' tube oil paint, or if he was, during this early period committed to the use of commercial paint products. The formation of zinc soaps in the zinc oxide, oil-based Ripolin is also to be investigated as this may be an issue for conservators undertaking future conservation treatments on these paintings. Finally, the analytical study of Nolan's ground layers are of interest, as these were not standard commercial applications onto artists' canvases, but generally applied by the artist (and probably Sunday Reed in the 1942-43 period) to second-hand supports, and may therefore provide useful dating and provenance information.

Fourteen paintings by Sidney Nolan dating from the period 1938 to 1949 were examined analytically for this study. The media descriptions as catalogued prior to this study are given for each work in Table 5.1. The different cataloguing styles and inconsistencies are retained in this list.

Table 5.1 Paintings by Sidney Nolan included in analytical study

Painting title	**Inscribed date**	**Catalogued date**	**Catalogued medium description**	**Collection**
Head of Rimbaud		1938-9	Oil and boot polish and pencil on cardboard	Art Gallery of NSW
Untitled-abstract		c.1939-1940	Oil on photograph	Art Gallery of NSW
Luna Park		1941	Enamel on canvas	Art Gallery NSW
Bird	4 Dec 1941	1941	Synthetic polymer on cardboard on composition board	Heide Museum of Modern Art
Dimboola	5 Dec 1942	1942	Synthetic polymer on cardboard	Heide Museum of Modern Art
Waterwheel, Luna Park		1942	Synthetic polymer paint on composition board	Heide Museum of Modern Art
Wimmera landscape (landscape with train)		c.1942	Ripolin enamel on composition board	Heide Museum of Modern Art
Head Dimboola	4 January 1943	1943	Enamel on composition board	Heide Museum of Modern Art
Self portrait	March 1943	1943	Ripolin enamel on hessian sacking	Art Gallery of NSW
Bathers	14 April 1943	1943	Ripolin enamel on canvas	Heide Museum of Modern Art
First-class marksman	12 Dec 1946	1946	Ripolin enamel on hardboard	Art Gallery of NSW
The camp		1946	Ripolin enamel on hardboard	Art Gallery of NSW
Colonial head	4 April 1947	1947	Ripolin enamel on cardboard	Art Gallery of NSW
Burke and Wills expedition, 'Gray sick'	30 November 1949	1949	Synthetic polymer paint and oil-based red ochre on hardboard	Art Gallery of NSW

5.2 Sampling

Removing paint samples from paintings for analytical study has far greater ethical and practical considerations than sampling unused or left over painting materials from an artist's studio. Removing original material from art works must be undertaken with care to minimise damage and loss. All samples removed for analysis as part of this study were accompanied by University of Melbourne, Centre for Cultural Materials, *Checklist for the Conservator* and *Sample Request Form* as well as verbal discussion with the owner representative regarding place of sampling, size of samples and the intended use of the samples.

No removal of sample material was required for pXRF undertaken on paintings at the Art Gallery of New South Wales. FTIR required a microscopic scraping from the paint surface removing material less than 10 cubic microns ($^{1}/_{100}$ mm^3) with a scalpel. This left an undetectable mark on the paint surface. Paint samples intended for use as cross-section studies to be mounted in resin and polished, involved more significant amounts of material typically 200-500 microns in height and width and the depth of the paint film (approximately 100-200 microns). These types of samples were only taken from paintings selected as having previously damaged areas with pre-existing paint losses. Paint samples from *Colonial head* 1947 (Collection: Art Gallery of New South Wales) had been retained on file during a previous conservation treatment and were incorporated into the study.

Nolan’s paintings are generally in excellent condition and it can be difficult to justify removing these types of samples. However, as most are painted on solid supports, either Masonite or cardboard, edges under frame rebates often show many small chips and losses and can be sampled at these sites. Unfortunately, in the examination of ageing characteristics such as the development of zinc soaps, samples taken from edges are usually covered and protected from light and other surface interactions. This means that samples from edges covered by frames are not typical.

Additionally, problems are evident with sampling paintings that have been varnished or undergone previous conservation treatments. Paintings with extensive restoration can produce confused results if materials added to paintings during conservation or restoration treatments are sampled. Varnish layers have strong infrared absorption under FTIR and can confuse the spectral results, but these can be difficult to exclude when sampling. Paintings were selected, where possible, without varnish layers.

Sampling was particularly problematic with a pivotal work for this study *Luna Park* 1941 (collection: Art Gallery of New South Wales), as the fragile condition of the paint film ensured it had undergone a number of treatments. As a result the evidential value of this painting may be compromised. The canvas had been lined and it has several thick varnish layers and extensive retouching of paint losses. When sampled the paint film was so friable and fragile that it had a tendency to powder. *Bird* 1941 (collection: Heide Museum of Modern Art), a painting of the same date and with similar ageing characteristics without the history of intervention, provided a crucial comparative example.

Another painting selected because of its specific dating by Nolan to the month prior to the arrival of the Ripolin paint and included in Sunday Reed's diary as a painting in Dulux, *Head Dimboola* 4 January 1943 (collection: Heide Museum of Modern Art) could not be effectively sampled. The varnish on this work is thick and well adhered to the paint film, while the paint film is extremely thin. Samples taken from this painting and examined as polished cross-sections, demonstrate the difficulty in sampling the red pigmented paint film, for example, which sits above two priming layers (Figure 137). Apart from the examples described, the paintings selected provided excellent samples for analysis.

Figure 137. Cross-section sample from Dimboola head 1943 showing thin red paint at top over two thick ground layers. Incident light x 200. Photo: Paula Dredge

PXRF has different problems to FTIR when used with paintings to identify inorganic pigments used in colour areas. The most difficult of these is the interference from lower layers of paint or ground, which may also contribute to the spectral result. Some of this interference from ground layers can be subtracted by overlaying a reading gathered from a PXRF spectrum taken with the same settings on an area with ground only. Peaks that correspond with peaks present in the ground layer are visually compared and discounted. The ground layers without paint layers may be present at tacking edges when commercially primed canvases are used by the artist, but in Nolan's case that is rare. Fortunately, Nolan often utilised the ground as part of the image layer, leaving areas for measurement without interference from paint layers. In practice, however, the subtraction of ground spectral results from sample spectra is not straight-forward. Paint layers, depending upon their inorganic composition, will block x-rays to different extents. The higher mass elements such as lead and barium, when present, are more effective at blocking x-rays than lower mass elements such as calcium, aluminium and magnesium. Zinc is a mid-range mass element that does block the low energy x-rays emitted from the pXRF, especially in low mass mode operating at 15kV. The ability to distinguish between elements present in paint layers as compared to elements in ground or lower paint layers, is developed with experience, recognising how different types of materials, thicknesses of paint and elements react to low energy x-rays emitted by the instrument. A useful guide to the proper use and limitations of PXRF in the examination of paintings is provided by Chris McGlinchy (2012)

5.3 Can Ripolin be identified on paintings by Nolan?

In Chapter 4 the instrumental analysis of the contents from cans of Ripolin left in Nolan's Wahroonga studio demonstrated that the binder used in all colours tested was oil, and the principal white pigment was zinc oxide. Other pigments detected with FTIR were Prussian blue, copper phthalocyanine, barium sulphate, titanium dioxide, lead chromate, toluidine and alizarin reds with bone black and kaolin in the flat colours. The oil content of the gloss Ripolin gave a large carbonyl peak in the $1740cm^{-1}$ region. In tints without the interference of pigments in the region 1000-$1300cm^{-1}$ such as black and white colours, the oil fingerprint (peaks at 1100, 1170 and $1240cm^{-1}$) can also be seen. Several paintings dating from the months following Nolan's receipt of Ripolin paint in February 1943 have been selected for the first case studies to test the comparison of paint from the Ripolin cans with those from paintings.

5.3.1 Case study 1: *Self portrait,* March 1943

Self portrait 1943 (collection: Art Gallery of New South Wales) is dated by Nolan on the front of the work at the lower left 'March 43', and makes a useful case study for his proposed uptake of the Ripolin paint from the beginning of February 1943 (Figure 29). This work corresponds well to Sunday Reed's diary entry for 22 March following receipt of a work she titles '*Head-Nhill'*. For this work, Reed gives the medium as Ripolin and hessian (Appendix i) (Reed 1943 entry for 22-24 March 1943).

Painted on a piece of coarse hessian sacking, it has been prepared with a white ground layer and attached with drawing pins and nails through the face of the canvas onto a wooden strainer before painting. The edges of the hessian cloth and the over-painted heads of the drawing pins are visible along the vertical edges. The unusual preparation of the support demonstrates Nolan's use of found materials which have, in this instance, been retained in their original form.

The white ground layer that is visible as an image layer behind the figure's left proper shoulder was examined with FTIR spectroscopy from a surface scraping (Figure 138). Spectral features associated with the presence of lead white are noted on the spectrum. Although a carbonyl peak at 1740cm^{-1} is present, the type of binder present in the ground could not be identified due to the strong spectral response from the pigments in the fingerprint region 500-1500cm^{-1}. The pigments indicated suggest a complex combination of different white materials. Both lead white (3533, 1404 and 683cm^{-1}) and calcium carbonate (2512, 1800, 1419 and 876cm^{-1}), are present, as are barium sulphate, (large triplet at 1184, 1117 and 1076cm^{-1} with doublet at 636 and 609cm^{-1}) and kaolin, (3693 and 3620cm^{-1} with 1034, 1012 and 914cm^{-1}). The presence of zinc oxide is suggested by the inception of a peak at 600 cm^{-1} along with the presence of a broad carboxylate peak occurring at 1500-1600cm^{-1} with a sharp side peak at 1541cm^{-1} indicating that zinc stearate has formed. The pXRF spectrum of the ground layer is consistent with the FTIR results, indicating the presence of zinc, lead and barium and with small peaks for calcium and silicon. The identification of lead white in the ground sample is counter indicative of the use of Ripolin paint. Ripolin paints, as analysed in Chapter 4 did not contain lead white. This analytical result indicates that the ground layer on this hand-prepared hessian sacking was not Ripolin.

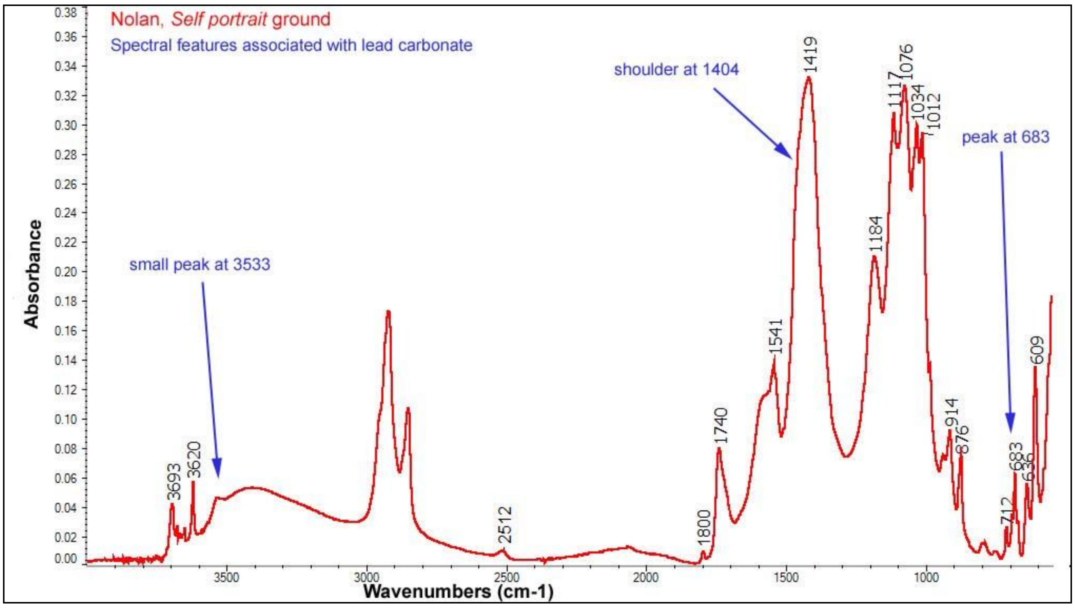


Figure 138. FTIR of ground sample from *Self portrait* 1943 (Art Gallery of New South Wales) Image: Paula Dredge

A cross-section sample taken from an area of the red painted background at the centre of the left edge demonstrates the potential for misrepresenting the ground layer based solely on a surface scraping for FTIR examination (Figure 139). The cross-section, which includes the ground layer, clearly shows when examined with ultraviolet light, the presence of two white ground layers, the lower one dominated by the bright specular fluorescence characteristic of zinc oxide (Figure 140). The surface scraping examined in Figure 138 therefore represents only the upper ground layer with its dull fluorescence typical for a lead-based paint. Double primings are associated with the work of commercially prepared colourmans' canvases in which the smoothest semi-absorbant surface for painting is sought, while the lower layer, usually coarser, fills the gaps in the weave texture of the canvas. It is difficult to reconcile this meticulous preparation with an artist's priming on a rough burlap cloth. However, double primings are present on a number of paintings by Nolan examined in this study, suggesting it was a deliberate strategy. The purpose remains elusive. It is possible that canvases prepared by Sunday Reed using a zinc rich material and sent on the train, arrived in need of a second coat and that a lead-rich paint was used by Nolan for this additional layer.

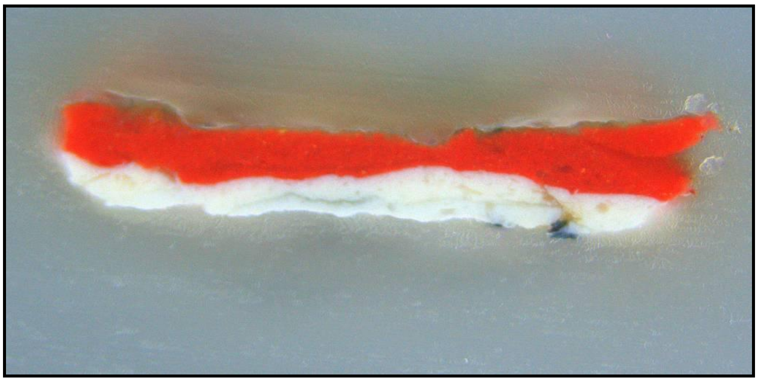


Figure 139. Paint sample from *Self portrait* 1943 red paint on centre left edge. Incident light x 200. Photo: Paula Dredge

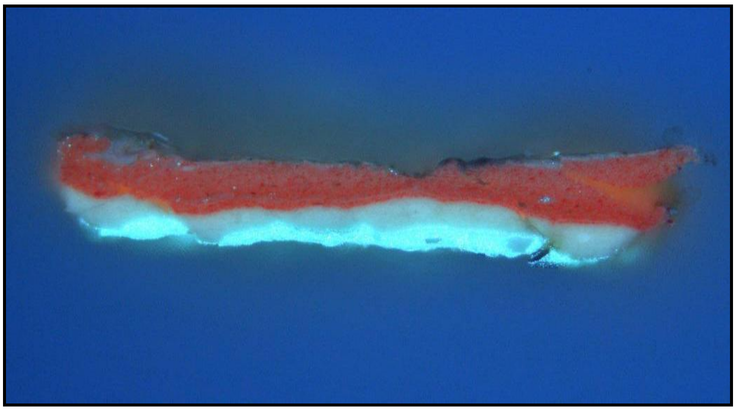


Figure 140. Paint sample from *Self portrait* 1943 red paint on centre left edge. Ultraviolet illumination x 200. Photo: Paula Dredge

The FTIR results of samples from the coloured paint layers of the work give a quite different result to that of the ground layer. Six colour areas were selected for analysis on *Self portrait*. FTIR was undertaken on the red background and black paints. PXRF was done on the red background colour, the blue stripe on the face, the white and yellow swatches on the palette and the black of the picture frame at the upper right. The black paint FTIR spectrum demonstrates a good match with a typical oil spectrum (Figure 141). No peaks in this result are associated with black pigment and this suggests the black in this colour is carbon-based. The FTIR spectrum is a good match with the spectral features of the Ripolin black 1105 from the can although it cannot be excluded that this could be any carbon black pigment mixed with oil.. The small peak at 2092cm^{-1} is a positive match for Prussian blue in the sample from the painting and this is consistent with the appearance on the work of a blue and black paint being mingled with each other *in situ* on the canvas. The broad peak in the carboxylate area between 1500 and 1650cm^{-1} is not present in Ripolin black 1105 sample from the can and suggests soaps are present from zinc oxide either in the mixing of the sample with blue paint, or originating from the lower paint or ground layers.

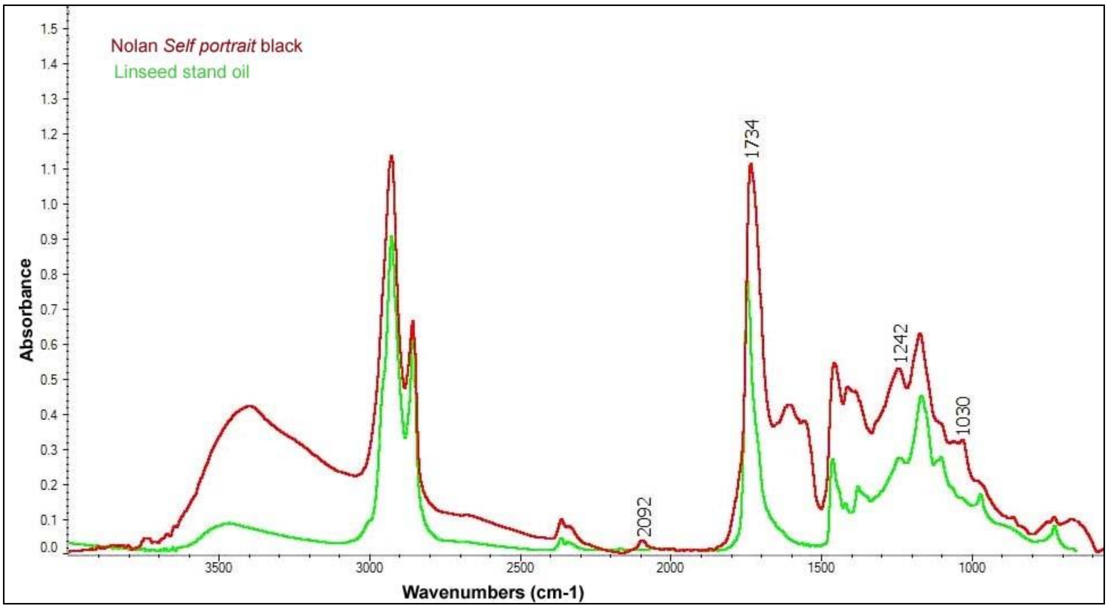


Figure 141. FTIR of black paint from *Self portrait* 1943 and linseed stand oil (© AGNSW 2003-2013) Image: Paula Dredge

The FTIR spectra of the red background in *Self portrait* 1943, is a good match with toluidine red (PR3) and barium sulphate pigments, both of which are found in the Ripolin red 16 colour from the Wahroonga studio cans (Figure 142). The peak triplet typical for oils between 1090 and 1246cm^{-1} is obscured by the barium sulphate triplet and so a clear identification of oil is not possible, however no absorbance peaks were identified that could indicate the presence of either nitrocellulose or alkyd. A shoulder in the carboxylate region between 1500 and 1650cm^{-1} suggests the presence of zinc soaps that are not present in the can of Ripolin red 16 and may be associated, as in the sample of black, with zinc oxide used in adjacent or underlying paint layers that has migrated into the paint film.

PXRF of a larger number of colour areas on *Self portrait* 1943 give results for zinc in the white, lead and chrome in the yellow (lead chromate) and iron, potassium and zinc in the blue (Prussian blue and zinc oxide). The PXRF spectrum for the black area is almost identical to the spectra for the ground layer as there were few high mass elements in this colour to block the xrays and prevent them from penetrating to the ground layer. This is consistent with a black paint based on carbon black.

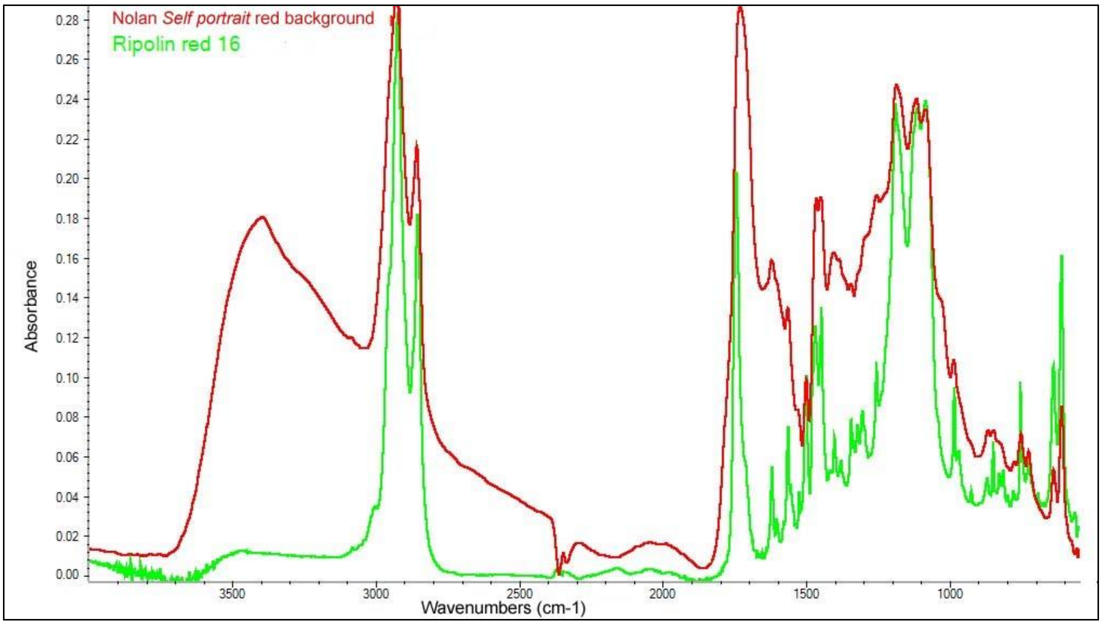


Figure 142. FTIR of red paint from *Self portrait* 1943 and Ripolin red 16 Image: Paula Dredge

Table 5.2 *Self portrait* analytical results

Self portrait	**Medium (FTIR)**	**Pigments (FTIR and PXRF)**
Lower ground	Not tested	Zinc oxide suggested by ultraviolet fluorescence of cross-section
Upper Ground	Obscured	Lead white, calcium carbonate, zinc oxide, barium sulphate, kaolin
Red	Obscured	Toluidine red, barium sulphate, zinc stearate
Blue	Not tested	Prussian blue, zinc oxide
Black	Oil	Carbon black
Yellow	Not tested	Lead chromate
White	Not tested	Zinc oxide

The black paint tested with FTIR from *Self portrait* 1943 is oil enamel. Pigments detected from a range of colour areas include zinc oxide, lead chromate, toluidine red, and Prussian blue. There were no alkyd resins or other types of synthetic binders detected in the two samples examined with FTIR. The PXRF results from the examination of *Self portrait* all give elemental matches with the Ripolin paints, red 16 (barium), blue PE5 (zinc and iron), white 1 (zinc) and black 1105 (no significant metallic elements detected). The lead chromate-based yellow is the same as the yellow colours in the flat range, without the presence of silicates. The analytical results are outline in Table 5.2 above. The limited testing of *Self portrait* gave no inconsistencies between the coloured paint layers and the paints analysed from the cans of Ripolin paint from the Wahroonga studio. The upper white ground layer had a complex mixture of white and colourless pigments, including lead white that indicates it is not Ripolin paint.

5.3.2: Case study 2: *Bathers*, April 1943

Bathers 1943 (collection: Heide Museum of Modern Art) offers a comparative study to that of *Self portrait* 1943 (Figure 143). Dated on the canvas turn-over '12/4/43' *Bathers*, is probably the work in Sunday Reed's diary listed as being received on 17 of April, 'Bathers, dated April 43, Ripolin canvas, 30' x 25'' (Reed 1943). The measurements by Reed given in inches, are very similar to the dimensions of *Bathers.*

Figure 143. Sidney Nolan, *Bathers*, April 1943, Ripolin enamel on canvas, 64 x 76.5cm (25 x 30'). Collection: Heide Museum of Modern Art. © Trustees of the Sidney Nolan Trust

Bathers 1943, is painted on a densely woven canvas that has the appearance of cotton. Like *Self portrait* 1943, it was originally attached to the stretcher with drawing pins; their rusty circular marks are left on three canvas edges and are still extant along the right edge (Figure 144). Remnants of a hard, pink adhesive around tacking edges may relate to previous framing. The matte white priming is left exposed in large areas of the painting as part of the image layer representing the buildings, diving board and towels laid out on the decking.

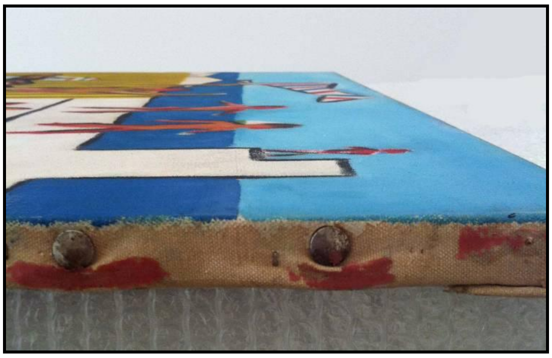


Figure 144. Sidney Nolan, *Bathers* detail: upper right tacking edge showing use of drawing pins to attach canvas to stretcher Photo: Paula Dredge

FTIR analysis of the ground layer gives a similar spectrum to the upper ground layer on *Self portrait* 1943 (Figure 145). Lead white, calcium carbonate, kaolin, zinc oxide were all detected with proportionally reduced peaks related to the presence of barium sulphate compared to the ground on *Self portrait* 1943.

Examination of a cross-section sample from the red strip of the towel at the lower left edge of *Bathers* suggests that there is a single ground layer (Figure 146). When this ground layer is viewed in ultraviolet light the strong specular fluorescence suggests that there is a significant amount of zinc oxide in this layer (Figure 147). The comparison of FTIR spectra from the upper ground on *Self portrait* with the ground on *Bathers* which suggests a good match with the two spectra, is therefore counter indicated in the very different appearances of these two layers under ultraviolet fluorescence.

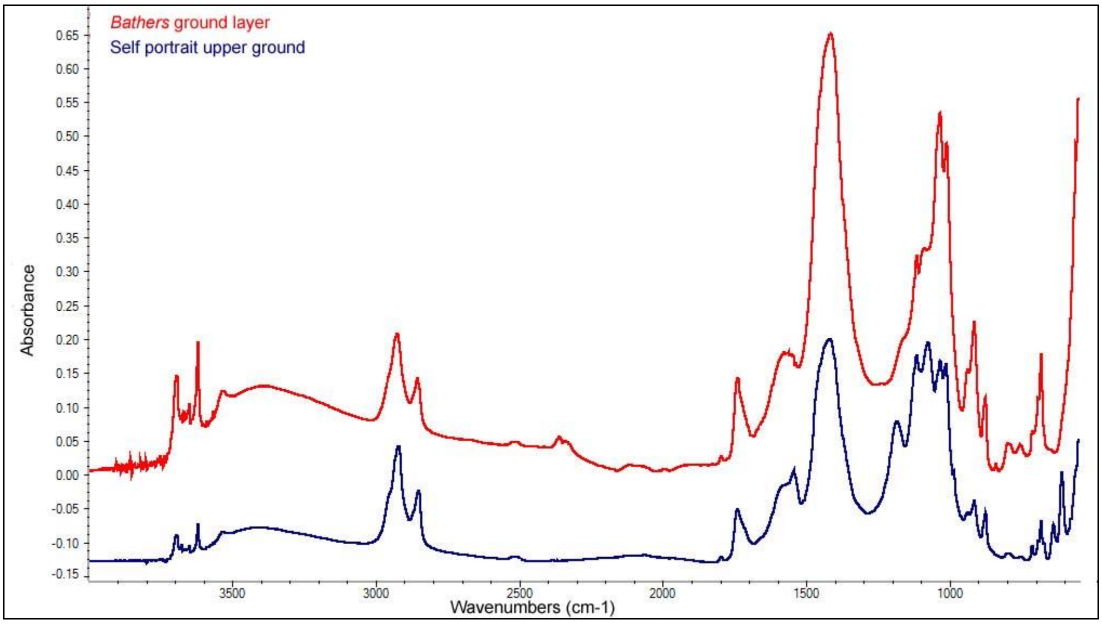


Figure 145. FTIR of ground layers on *Bathers* 1943 and *Self portrait* 1943 Image: Paula Dredge

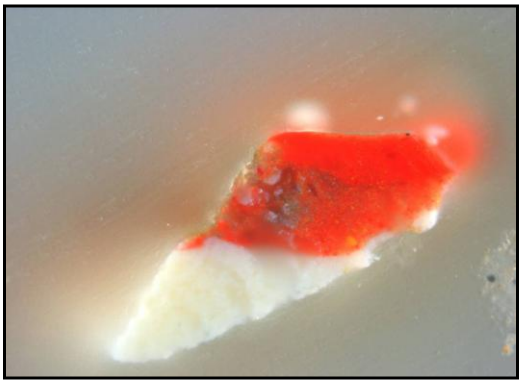


Figure 146. Paint sample from *Bathers* 1943 red paint on lower left edge. Incident light x 200 Photo: Paula Dredge

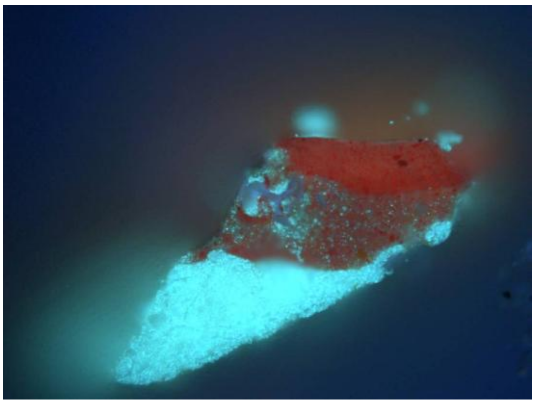


Figure 147. Paint sample from *Bathers* 1943 red paint on lower left edge. Ultraviolet light x 200 Photo: Paula Dredge

The paint colours on *Bathers* are restricted to the primaries; yellow, red and blue (two shades) and black and white. This is a less painterly work than *Self portrait* with flat areas of colour and little mixing in-situ. Comparison of the FTIR region 600- 2200cm^{-1} of all four colour areas demonstrate the trends of all samples towards oil, with spectral shifts associated with pigment differences (Figure 148). The pale blue sample from the sky gives a strong FTIR spectral response to an oil binder seen in the oil triplet, but also Prussian blue (2096cm^{-1}) and a broad carboxylate peak from 1500-1650cm^{-1}. This is very similar to the FTIR spectra obtained from the can of Ripolin blue PE5. The black sample is very similar to that obtained from *Self portrait* as most of the FTIR spectral properties relate to the oil binder. The yellow sample obtained from the underside of the sample of black taken from the stripe at the left edge, gives a strong response to the presence of lead chromate (triplet centred around 856cm^{-1}) and this sample also displays a carboxylate region with a side peak at 1550cm^{-1} which suggests lead soaps may have formed. The red sample gives an excellent match with toluidine red and barium sulphate, as found in the cans of Ripolin red 16, although in this case it appears to have been mixed with zinc oxide as it has a broad carboxylate peak with a large sharp side peak at 1541cm^{-1} corresponding to zinc stearate. A small peak at 2090cm^{-1} in the red sample indicates some Prussian blue is also present in this sample. The presence of zinc oxide mixed with the red is indicated in the cross-section sample, in which two layers of red paint are the present. The lower layer viewed under ultraviolet light demonstrates the typical specular fluorescence of zinc oxide, whereas the upper layer displays a more diffuse fluorescence as typical for Ripolin red 16 which does not contain zinc oxide.

The black, blue and yellow paint samples taken from *Bathers* are oil-based. The oil features in the FTIR of the red sample are more difficult to distinguish from the peaks associated with barium sulphate. The pigments seen in FTIR of samples from *Bathers* 1943, are lead chromate, toluidine red and Prussian blue. There are indications of zinc oxides by the formation of broad carboxylate features in the blue and zinc stearate in the red sample, and possible lead stearate in the yellow. These results of the coloured paint layers summarised in Table 5.3 below, are all consistent with FTIR results obtained from cans of Ripolin paint from Nolan’s studio. The ground layer is not Ripolin paint due to the presence of lead white.

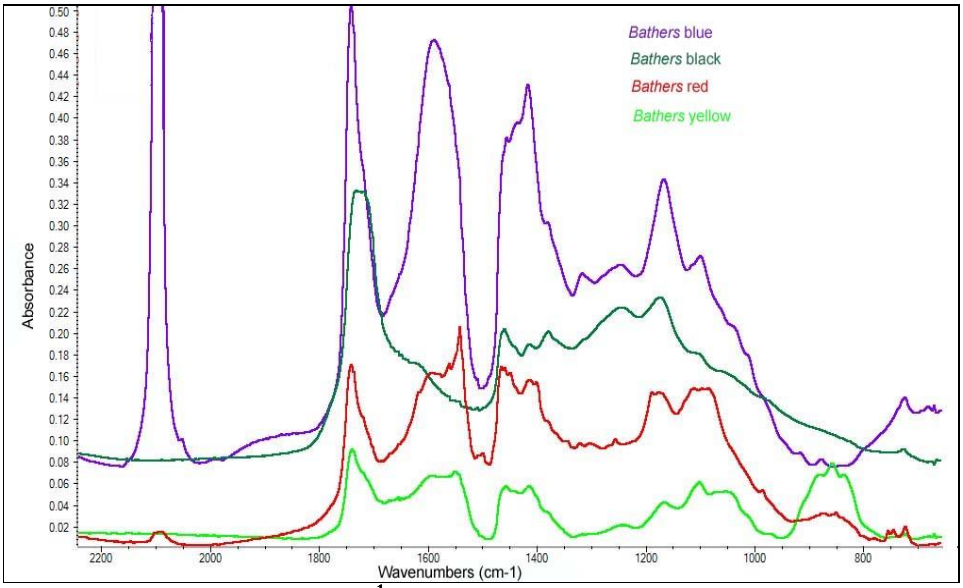


Figure 148. FTIR region (550-2200cm^{-1}) of four colour areas from *Bathers* 1943. Image: Paula Dredge

Table 5.3 *Bathers* analytical results

Bathers	**Binder (FTIR)**	**Pigments (FTIR)**
Ground	Obscured	Lead white, calcium carbonate, zinc oxide, barium sulphate, aluminium silicate
Black	Oil	Carbon black
Blue	Oil	Prussian blue, zinc oxide
Yellow	Oil	Lead chromate
Red	Obscured	Toluidine red, barium sulphate (Prussian blue)

Self portrait and *Bathers* offer two examples of paintings by Nolan with inscribed dates corresponding to the months after he received the Ripolin paint. Both works also provide matches with diary entries by Sunday Reed in which she records their paint mediums as Ripolin (Appendix i). FTIR analysis of a number of colours gives spectral results that correspond well with the FTIR study of Ripolin from the cans including a significant carbonyl peak associated with a high proportion of binder, and pigments found in corresponding colours from the cans of Ripolin from the Wahroonga studio. PXRF confirms the presence of elements associated with these same colours. Both white ground layers on the paintings contain a number of different white pigments which by the presence of lead white, indicate that they are not Ripolin paint. These results suggest that FTIR and pXRF analysis of paintings by Nolan may be effective in indicating the presence of materials that match the composition of Ripolin in his possession.

5.4 What are the paint media of Nolan's Wimmera paintings prior to February 1943?

As a comparison with the two case study paintings above, three paintings were chosen with well-documented dates prior to the described arrival of the Ripolin paint in February 1943. These works are *Waterwheel, Luna Park* 1942 (collection: Heide Museum of Modern Art), *Dimboola* December 1942 (collection: Heide Museum of Modern Art) and *Head, Dimboola* January 1943 (collection: Heide Museum of Modern Art)

5.4.1 Case study 3: *Waterwheel, Luna Park*, 1942

Waterwheel, Luna Park is painted on the textured side of a piece of Masonite (Figure 149). There is no priming layer present and the coloured paint layers are applied directly to the dark coloured board. As the work has been framed without covering the edges with a rebate and these edges have many damages and paint losses, sampling was greatly facilitated. Three paint colours were selected for analysis blue, white and yellow. A work described as being received by Sunday Reed on the 5 January 1943 which she titles '*Waterwheel-Luna Park'* and describes as 'MASONITE DU LUX, 3ft x 2ft ' is a good match with this work (Appendix i).

Figure 149. Nolan, *Waterwheel, Luna Park* 1942, synthetic polymer paint on composition board, 61 x 92cm (24 x 36'). Collection: Heide Museum of Modern Art. © Trustees of the Sidney Nolan Trust

The blue sky and yellow bottom edge samples gave positive FTIR spectral results for alkyd-based mediums with the peaks at 1284, 1137, 1077 and 744cm^{-1} . The samples have good correspondence to the alkyd spectrum obtained from the can of black Dulux from the Nolan studio (Figure 150). The yellow paint also shows FTIR peaks corresponding with lead chromate at 874cm^{-1} and possibly lead white at 1410 and 680cm^{-1}.

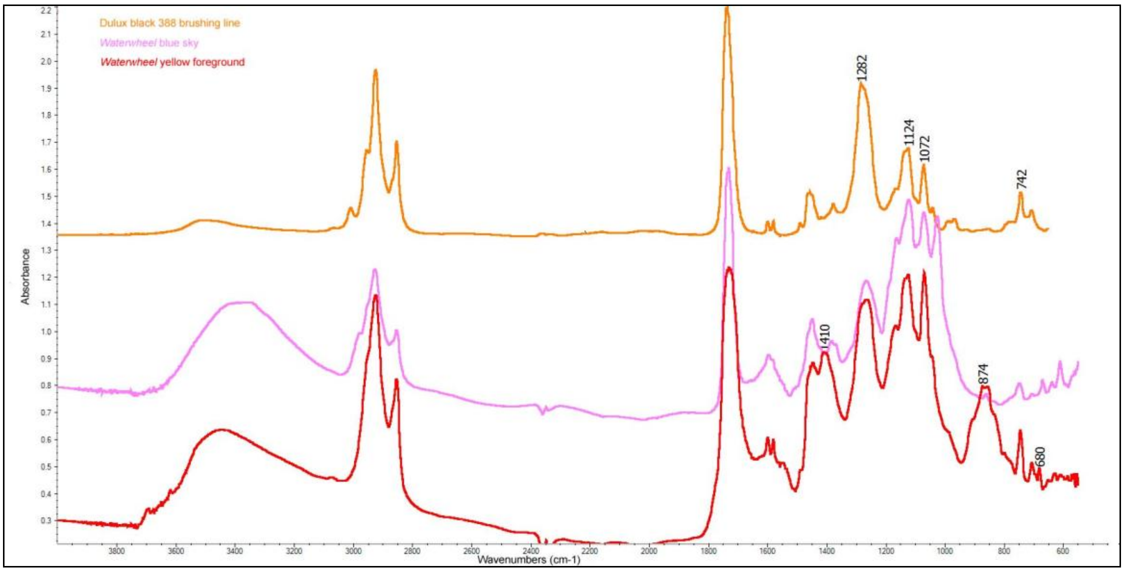


Figure 150. FTIR of alkyd sample from Dulux and paint samples from Waterwheel, Luna Park, yellow and blue. Image: Paula Dredge

Due to the presence of overlapping peaks in the blue paint sample it is more difficult to identify the pigments by FTIR. Prussian blue is not present in this sample as the distinctive C=N absorbance peak at 2080-2094 cm^{-1} is not seen. It is probable that barium sulphate is present (1080 and 610cm^{-1}) along with ultramarine blue (1010 and 602cm^{-1}). The medium intensity broad peak in the carboxylate region (1600 cm^{-1}) along with the peak at 744 cm^{-1} (although this peak at 744cm^{-1} is also associated with the alkyd) may indicate the presence of antimony trioxide that has been noted by Bruce Leary [personal communication 2013] from his examination of the Dulux historic records as present in some early B.A.L.M. Dulux formulations. Unfortunately, the opportunity to examine this painting with pXRF was not available.

The FTIR spectrum of a white paint sample from the upper right edge of *Waterwheel, Luna Park* is dominated by overlapping peaks associated with pigments, limiting the identification of the binder. Assignment of identifying absorbance peaks in the FTIR spectrum give matches with calcium carbonate 2522, 876 and 710cm^{-1}, barium sulphate 632 and 609 cm^{-1} with obscured triplet in 1000-1300 cm^{-1} region, and lead white distinctive peaks at 3535 cm^{-1} and shoulder at 687 cm^{-1}, suggesting a complex mixture of pigment is present in the white paint (Figure 151). The lack of peaks in the carboxylate region suggests that zinc oxide is not present in this paint as would be expected in a white Ripolin colour.

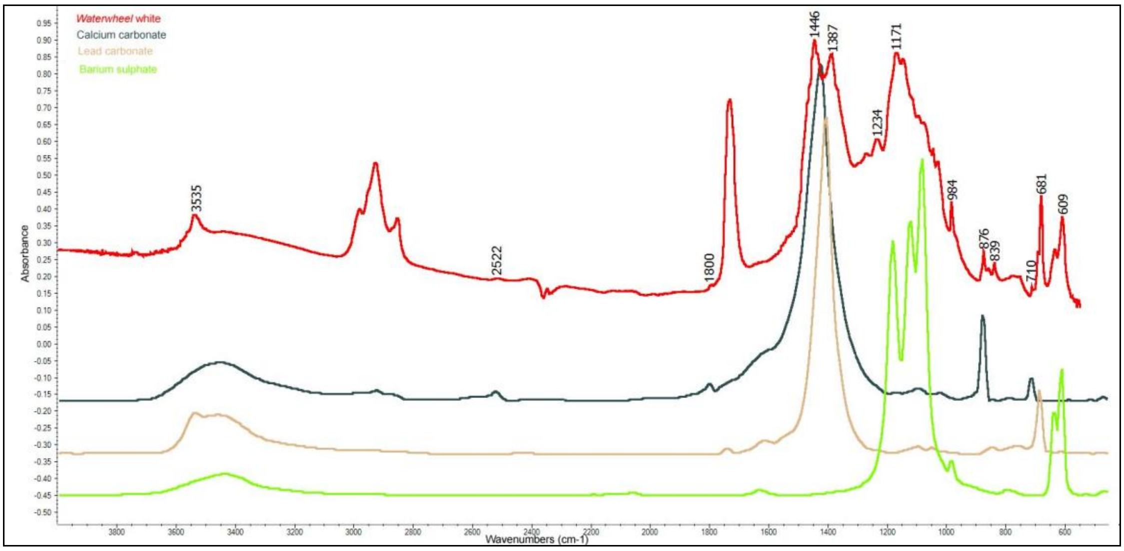


Figure 151. FTIR of white paint sample from *Waterwheel, Luna Park*, with library reference spectra (© Nicolet Instruments Corp. 1991-1994). Image: Paula Dredge

The FTIR analysis of two paint samples from *Waterwheel*, *Luna Park* is consistent with alkyd based paints (Table 5.4). The presence of alkyd resin and lead white (lead white) is counter indicative of Ripolin. Confirmation of assignment of FTIR absorbance peaks to other pigments requires further analytical work and they remain tentative at this stage.

Table 5.4 *Waterwheel, Luna Park* analytical results

Waterwheel, Luna Park	**Binder (FTIR)**	**Pigments (FTIR) [possible pigments]**
Blue	Alkyd	[Barium sulphate, French ultramarine, antimony oxide]
Yellow	Alkyd	Lead chromate, lead white
White	Obscured	Lead white, calcium carbonate, barium sulphate

5.4.2 Case study 4: *Dimboola* 1944

When examined Dimboola 1944 (collection: Heide Museum of Modern Art) displayed many visual features associated with the use of Ripolin paint (Figure 30). These included fluid paint application, transparent whites and a broad palette of colours beyond the bright primary colours. The date inscribed by the artist prominently at the lower edge was difficult to interpret and had caused a number of different dates to be entered into the collection catalogue. At the time of the viewing it had been catalogued as 5-11-44. Re-examination of the date inscription suggested that the date might be 5-12-42. This date corresponds well with the painting received by Sunday Reed on the 5 of January 1943 titled Dimboola 30' x 25', and noted as Dulux on board (Appendix i).

This painting was considered to be a good case study for a pre-Ripolin dated work. Three paint samples were taken from edges, pale blue sky at top left corner, black from the left edge and a white sample from the right edge. All three FTIR absorbance spectra of the paint samples from Dimboola show the paints to have typical FTIR spectra for alkyd-based paints (1284, 1126, 1072 and 744cm^{-1}) (Figure 152).

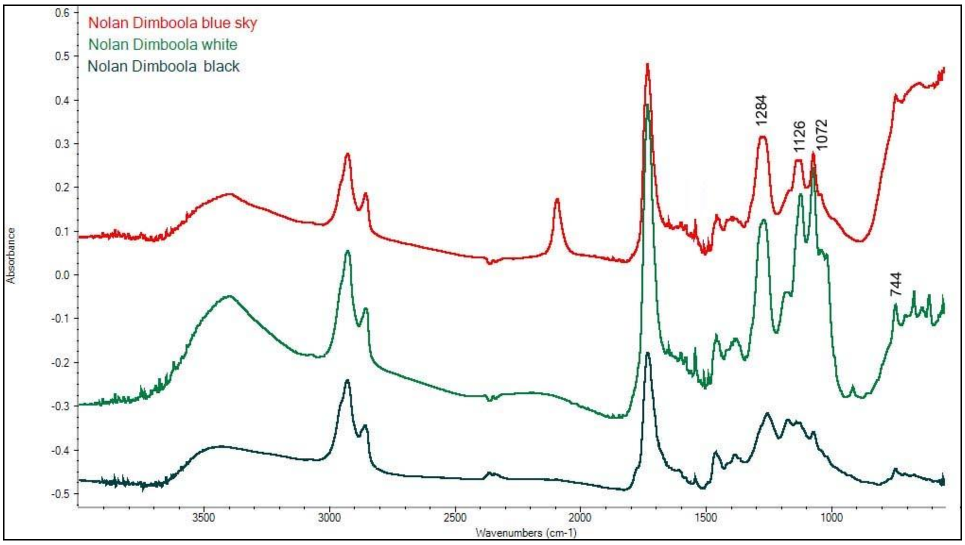


Figure 152. FTIR of paint samples from *Dimboola* blue, white and black . Image: Paula Dredge

The spectrum for the black paint shows spectral features only associated with alkyd resin, suggesting it is pigmented with carbon black, which does not have a presence in FTIR. The pigmentation of the blue paint sample is different from that of the blue sample from *Waterwheel, Luna Park.* The blue sky in the sample from *Dimboola* gives the distinctive 2098cm^{-1} peak associated with Prussian blue (C=N absorbance). A rise in the FTIR spectrum in this sample towards the lower wavelengths also suggests the presence of titanium dioxide. Although both paintings, *Waterwheel, Luna Park* and *Dimboola,* utilise alkyd based paints in the blue colours, the pigments are different.

An examination of the paint cross-section taken from the sky raises some addition questions regarding the analysis. The blue paint on the top layer is not typical of commercial paint. It has large aggregates of dark blue pigments and areas of clear media, which are poorly integrated into the paint film (Figure 153). When the cross-section is examined in ultraviolet light the areas of media are highly fluorescent, suggesting a resin medium or varnish (Figure 154). This paint film is characteristic of a restorer's retouching in which the pigments and varnish resin are mixed on a palette prior to application, rather than a commercial paint in which the pigments are well integrated into the medium. However the blue paint film is cracked like the lower layers and does not flow into the break in the surface as would be expected of a retouching applied later to a cracked painting. The FTIR result of the paint taken from the surface that gives spectral matches for alkyd is also inconsistent with a restorer's retouching medium. It is possible that Nolan himself mixed the paint from pigment and alkyd medium in this instance.

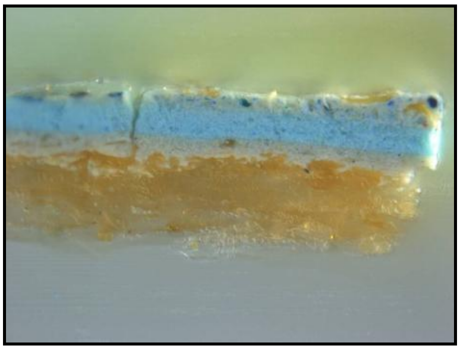


Figure 153. Paint sample from *Dimboola* 1942 blue sky paint. Incident light x 400. Photo: Paula Dredge

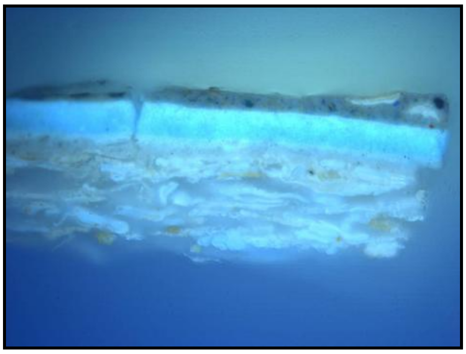


Figure 154. Paint sample from *Dimboola* 1942 blue sky paint. Ultraviolet light x 400. Photo: Paula Dredge

The white paint FTIR spectrum from a sample taken from *Dimboola* is also alkyd resin paint identified by strong absorbance peaks at 1269, 1120, 1072 and 742cm^{-1} . Additional peaks in the spectrum indicate the presence of barium sulphate, titanium dioxide and kaolin. These pigments differ from the pigments (lead white, calcium carbonate and barium sulphate) identified in the white alkyd paint analysed on *Waterwheel*, *Luna Park*, 1942.

All three paint samples taken from *Dimboola* examined with FTIR give small but sharp peaks in the carboxylate region for 1541cm^{-1} indicating the presence of zinc stearate. They are without an associated broad carboxylate peak as typically found in the zinc oxide-based Ripolin paints. Lead white is not indicated in any of these paints examined on *Dimboola*. The dominant white pigment indicated by the analytical results is titanium dioxide. The results of the analysis of the paint samples from *Dimboola* are shown in Table 5.5 below.

Table 5.5. *Dimboola* analytical results

Dimboola	**Binder (FTIR)**	**Pigments identified (FTIR) [possible pigments]**
Blue	Alkyd	Prussian blue, titanium dioxide, zinc stearate [zinc oxide]
Black	Alkyd	Carbon black
White	Alkyd	Barium sulphate, titanium dioxide, aluminium silicate

5.4.3 Case study 5: *Head Dimboola* 1943

Head Dimboola 1943 represents an opportunity to analyse the paint on a work dated firmly by an artist's inscription, 4 January 1943, to just before the arrival of the Ripolin paint (Figure 155). As this work was painted on the smooth side of a Masonite panel over a thick, white priming layer, with an extremely thin paint film and a thick layer of varnish, sampling of the paint film without contamination from the ground and varnish layers was extremely difficult.

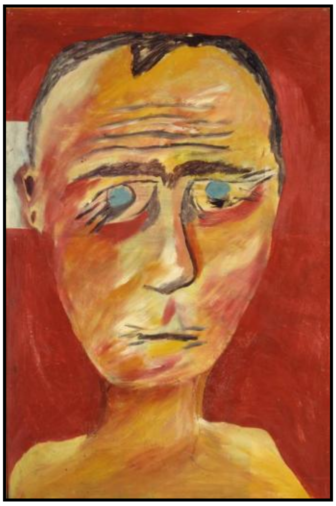


Figure 155. Sidney Nolan, *Head Dimboola*, 1943, enamel on composition board, 91.7 x 60.9 cm, Heide Museum of Modern Art. © Trustees of the Sidney Nolan Trust

A sample of the white paint at the upper left edge was successfully sampled and examined with FTIR spectroscopy. The resulting spectrum shows a similar composition to that of the white paint sample from *Waterwheel, Luna Park* (Figure 156). Both exhibit the distinctive spectral features of lead white, calcium carbonate and barium sulphate, although the calcium carbonate features are more intense in the spectrum for the sample from *Head Dimboola.*

The assignment of an oil or alkyd resin to the two samples is not possible due to the strong spectral features related to the white pigments. This result however suggests that there is a similarity in pigment composition between the white paint on *Head Dimboola* 1943 and *Waterwheel, Luna Park* 1942, but neither of these two paints is typical for Ripolin which is dominated by the presence of zinc carboxylates and oil features in the study of FTIR spectral results.

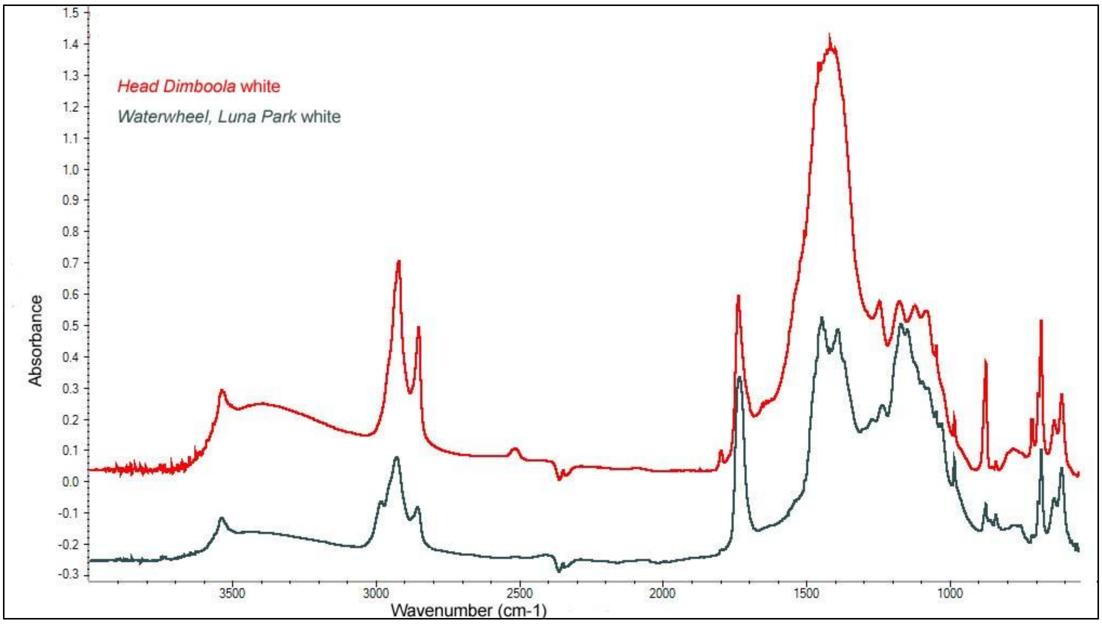


Figure 156. FTIR of *Head Dimboola* white paint sample and *Waterwheel, Luna Park* white paint sample . Image: Paula Dredge

Table 5.6 *Head Dimboola* analytical results

Head Dimboola	**Binder (FTIR)**	**Pigment (FTIR)**
White	Obscured	Lead white, calcium carbonate, barium sulphate

Four of the five case studies of paintings dating from Nolan's time living in the Wimmera 1942-43 outlined, have demonstrated good FTIR spectral matches with either the Ripolin paint from the cans or with alkyd paint. The fifth case study, *Head Dimboola* is inconclusive due to sampling difficulties but the presence of Ripolin can be excluded in the white sample. The results correspond well with the hypothesis that Ripolin became Nolan's paint medium from February 1943, and that prior to that date he was using alkyd paint. The analytical results are also consistent with the diary records kept by Sunday Reed and her recorded media descriptions. This supports the premise that the diaries are accurate records of Nolan's practice in the period October 1942 to April 1943.

5.5 Can Nolan's Wimmera paintings be dated by paint media pre- and post-February 1943?

5.5.1 Case study 6: *Wimmera landscape (landscape with train)* circa 1942

A sixth painting, *Wimmera landscape (landscape with train)* c. 1942 (collection: Heide Museum of Modern Art) offers a new type of case study (Figure 157). In this instance the catalogued date, circa 1942, indicates that an exact date is not known for this work and the presence of either Ripolin paint or alkyd might offer some resolution of the dating uncertainty.

Figure 157. Sidney Nolan, *Wimmera landscape (landscape with train)*, c. 1942, Ripolin enamel on composition board, 61 x 91 cm [24 x 36']. Collection: Heide Museum of Modern Art. © Trustees of the Sidney Nolan Trust

There is a painting which matches well by subject and date noted in Sunday Reed' diary. This is *Troop train (at Nhill)* that was received 9 February 1943, and is described as Ripolin on Masonite 3ft x 2ft (Reed 1943). If this work, *Wimmera landscape (landscape with train)* is *Troop train (at Nhill)*, then it would be one of Nolan's earliest paintings in Ripolin and dated 1943.

This work is painted on the rough side of a Masonite panel. On unframing the work another image was found on the back. It is probable that the smooth faced painting was the first, but was rejected by the artist and he turned the panel and began work on the back. A white ground layer is present and has been used as image layer throughout. No varnish is apparent. Two samples were taken, yellow and blue.

Samples were limited as the work was nailed into the frame and could not easily be removed to expose edges for sampling.

FTIR analysis of the ground layer gives an almost identical spectrum to that of the ground layer sample from *Bathers* 1943 (collection: Heide Museum of Modern Art) (Figure 158). Lead white, calcium carbonate, zinc oxide, kaolin and barium sulphate are all indicated in this spectrum.

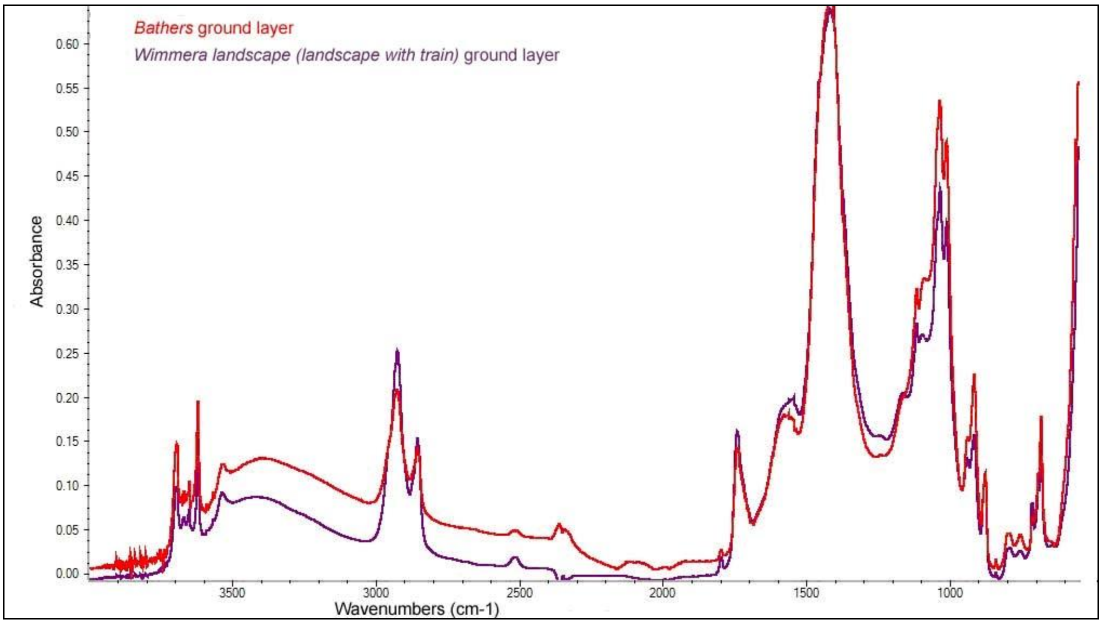


Figure 158. FTIR of ground layer samples from *Wimmera landscape (landscape with train)* 1943 and *Bathers* 1943. Image: Paula Dredge

FTIR analysis of the sample taken from the area of pale blue sky sample gave typical spectral features for oil-based paint, with a small peak associated with Prussian blue at 2090cm^{-1} and a broad rounded carboxylate peak between 1500 and 1650cm^{-1} suggesting the presence of zinc oxide. When compared with the blue sample from *Bathers* 1943 and the Ripolin blue PE5 paint from the can, the similarity between all spectra is apparent (Figure 159). They differ from each other only in the relative height of the peak at 2090cm^{-1} , which is associated with Prussian blue.

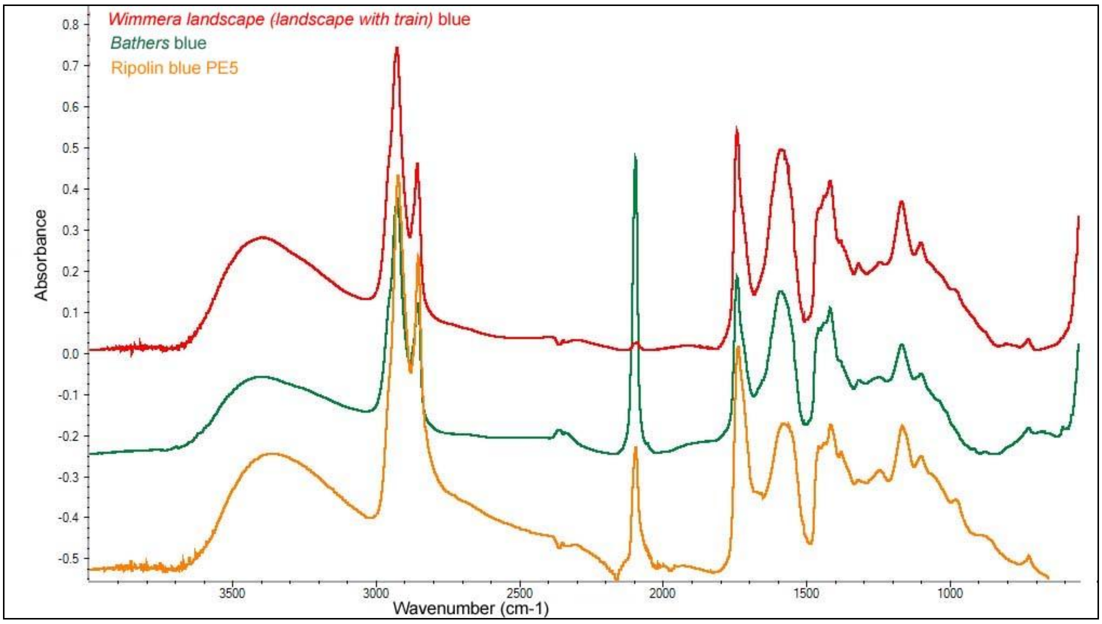


Figure 159. FTIR of blue paint samples from *Wimmera landscape (landscape with train*) c. 1942 *Bathers* 1943 and Ripolin blue PE5. Image: Paula Dredge

The yellow sample taken from the lower left corner, corresponds well to the yellow paint on *Bathers* 1943, being a mixture of lead chromate (triplet at 856 and sharp peak at 627cm^{-1}) with a lead sulphate phase present (1099cm^{-1}) and zinc oxide (broad carboxylate with sharp side peak at 1541cm^{-1}) (Figure 160). Unfortunately, there is not an extant can of Ripolin yellow gloss paint in the studio cans. Ripolin lemon 514 and canary 504 in the flat range are both lead chromate, with lead sulphate phase present in the canary but without the addition of zinc white. A can of decanted yellow gloss oil based paint in the leather satchel can 11 is a good match with these two yellow samples from the paintings with a large broad carboxylate peak with a sharp peak at 1541cm^{-1} corresponding to zinc stearate. This suggests that either zinc oxide is present in a pale yellow version of the yellow sealed cans or added by the artist.

As these two samples taken from the paint on the face of *Wimmera landscape (landscape with train)* c. 1942 are oil-based paints with zinc oxide, Prussian blue, lead chromate and lead sulphate solids they match well with the results of the analysis of Ripolin paint in cans (Table 5.7). In the proposition that Nolan’s first paintings in Ripolin date post-January 1943 this painting must be dated to 1943.

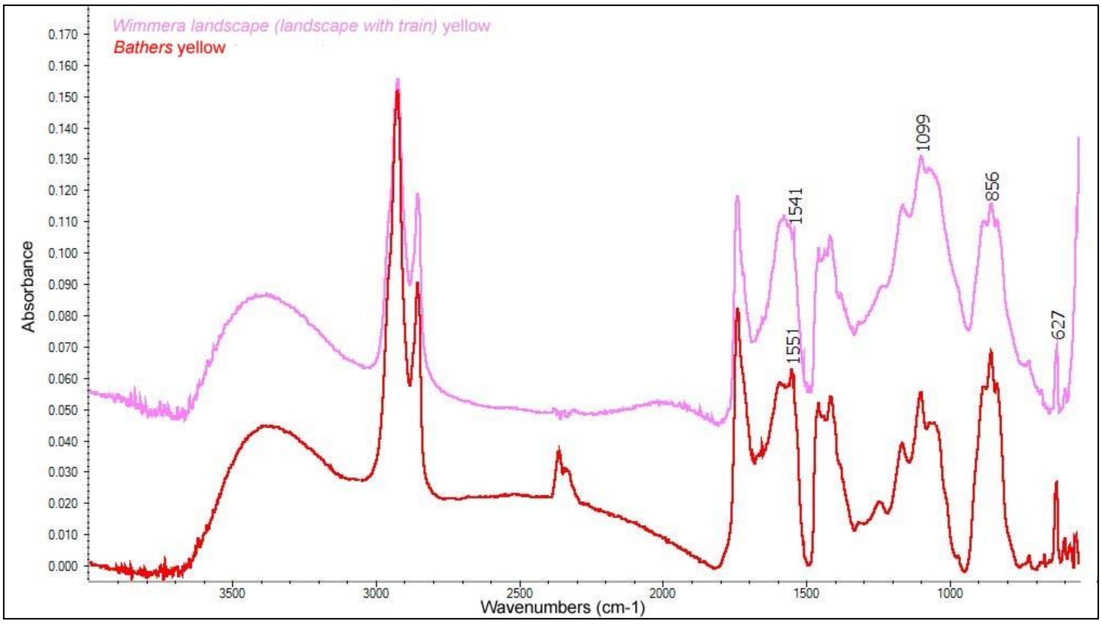


Figure 160. FTIR of yellow paint samples from *Wimmera landscape (landscape with train)*c. 1942 and *Bathers* 1943. Image: Paula Dredge

Table 5.7 *Wimmera landscape (landscape with train)* analytical results

Wimmera landscape (landscape with train)	**Binder (FTIR)**	**Pigment (FTIR)**
Ground	Obscured	Lead white, calcium carbonate, zinc oxide, aluminium silicate and barium sulphate
Yellow	Oil	Lead chromate/lead sulphate/ zinc carboxylates with zinc stearate peak (zinc oxide)
Blue	Oil	Prussian blue, zinc carboxylates (zinc oxide)

5.6 Summary of analytical findings from six Wimmera paintings by Nolan 1942-1943

FTIR case studies of six paintings by Nolan dating from his time in the Australian Army have demonstrated the ability of FTIR to differentiate alkyd and oil binders in most paint samples taken from paintings. These results when compared alongside Sunday Reed's diaries that note the dates that paintings arrived at Heide and their paint media, show excellent correlation and support the hypothesis of a pre- and post-Ripolin date of late January 1943.

On the four paintings studied from the Heide Museum of Modern Art, identification of pigments using FTIR techniques alone is tentative due to overlapping peaks and lack of secondary confirmation by another technique. Ideally, these samples would also be examined with SEM-EDX, but this was beyond the scope of the research. In the case of those samples that demonstrate the presence of oil binder, correlation of FTIR spectral results with paint from the labelled cans of Ripolin shows excellent correspondence. The evidence that these paintings are painted in Ripolin is strong.

The types of pigments indicated by the FTIR examination of samples of the two alkyd paintings, while making use of Prussian blue and lead chromate that are also found in the Ripolin paint, suggest the presence of either lead white pigment or titanium white. While titanium white is present in some Ripolin colours it was not found in the Ripolin blues or gloss white colours from the cans. Lead white is not found in any of the Ripolin colours. The pigment analysis is therefore supportive of the binder analysis. Both sustain the proposition that two paintings examined dated 1942, *Waterwheel, Luna Park* and *Dimboola* are not Ripolin.

As only two paintings from 1942-February 1943 are included in this study, (a third work *Head Dimboola* could not be satisfactorily sampled due to the thinness of the coloured paint layers) a full understanding of the pigmentation of the alkyd paints used by Nolan could not be determined. Neither can the association with Dulux at the exclusion of other brands of alkyd paint be asserted based on the FTIR analysis. The samples from the two alkyd paintings did not produce similar pigment analysis. The FTIR spectrum of the white paint on *Dimboola* indicates the use of titanium dioxide, whereas the white pigments identified on *Waterwheel, Luna Park* are chalk and lead white. A larger analytical study of the Wimmera paintings by Nolan dating prior to February 1943 would greatly improve the study sample set and has the potential to increase understanding about the formulations of these pre-Ripolin alkyd paints used by Nolan.

5.7 What paint media was Nolan using prior to 1942?

If Nolan was not using Ripolin in this early period, as suggested by his comments regarding his need to adapt to it as a new media in 1943, then other paint types must be represented in these early works dated prior to 1942. While Nolan's letters to Sunday Reed dating from his period in the Australian Army 1942 to 1944 have proved to be valuable guides to his use of Ripolin and Dulux, there is less primary documentation resources regarding Nolan's paint media prior to his conscription in the Australian Army. Some clues exist in the 1942 to 1944 letters regarding Nolan's pre-Army interest in aniline colours that he says he could be added to Duco white base (nitrocellulose) (Nolan 27 October 1942) and his previous use of Dynamel, a gloss paint manufactured by Taubman's.

5.7.1 Case study 7: *Luna Park* 1941

When *Luna Park* 1941 (collection: Art Gallery of New South Wales) was examined prior to the Sidney Nolan retrospective in 2006, questions regarding the paint medium were raised in regard to the catalogue and wall labels. No medium analysis was undertaken at that time but this is a critical case study as it was, at the beginning of this research project, the earliest painting by Nolan in the collection of the Art Gallery of NSW.

Luna Park is painted on a thickly woven cotton canvas. The canvas has been later adhered (lined) onto another canvas, probably due to the fragile paint film. The paint exhibits extensive brittle cracks with fragile losses along edges and at centre of impact patterns. It has been retouched to cover these damages. Several thick varnish layers have been applied to disguise the extent of damage. The presence of these varnish layers made visual assessment of the inherent gloss of the paint layers difficult. Obtaining a clean sample without varnish layers for FTIR analysis was challenging. Sampling was also problematic due to the soft and brittle nature of the paint, which readily shattered into powder-sized particles. FTIR spectra obtained from samples taken from the painting are of poor quality compared to other paint samples studied during this research.

A sample of black paint from *Luna Park* shows the typical peaks associated with nitrate group absorbance at 1647, 1279 and 841cm^{-1} , which correspond well with Learner's FTIR absorbance nitrocellulose peaks described in *The analysis of modern paint* (2005 p. 91.) The black paint sample from *Luna Park* also showed strong peaks associated with a bone-derived black at 2013, 1034 and doublet at 604 and 567cm^{-1} when compared to a pigment sample from an ivory black reference (Figure 161). This pigment identification is supported by PXRF of the black areas on the painting which give significant peaks for the presence of calcium and phosphorous found in bone black pigments.

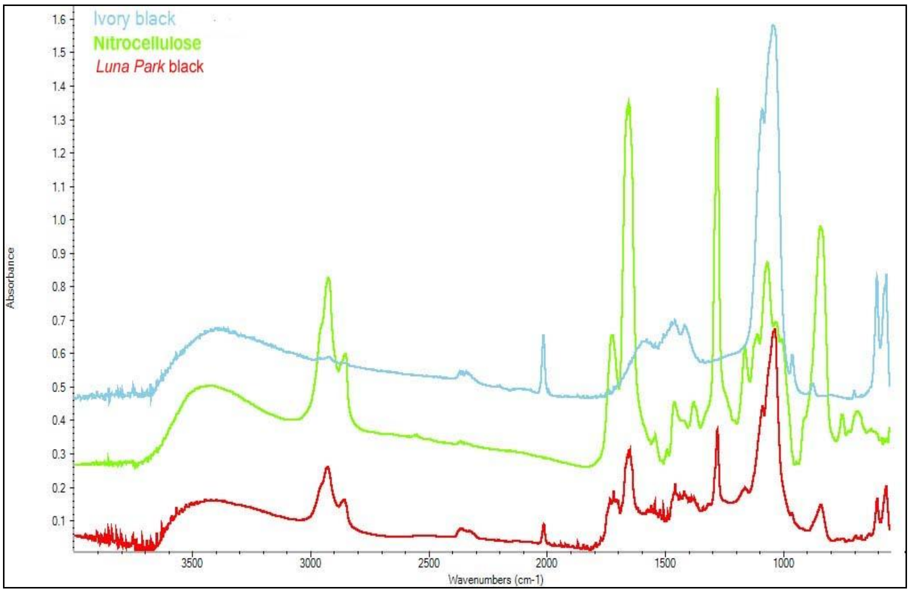


Figure 161. FTIR of black paint from *Luna Park* 1941, nitrocellulose and ivory black library spectra (© Art Gallery NSW 2010-2013). Image: Paula Dredge

The FTIR spectrum of the blue paint from the sky of *Luna Park* is similar to the sample of black paint without the peaks related to bone black but with the same peaks related to nitrocellulose lacquer. The pigments identified in this sample of blue are the same as those found in the sample of blue sky in *Dimboola* (case study 5.4.2), Prussian blue (2090cm^{-1}) and titanium white (broad peak with inception at 850 cm^{-1}), with the differences in spectral peaks in the fingerprint region related to the difference in paint binders alone (Figure 162). The use of titanium dioxide white in nitrocellulose lacquer paints is consistent with the literature, which suggests it was the most suitable white pigment due to its opacity and fine particle size.

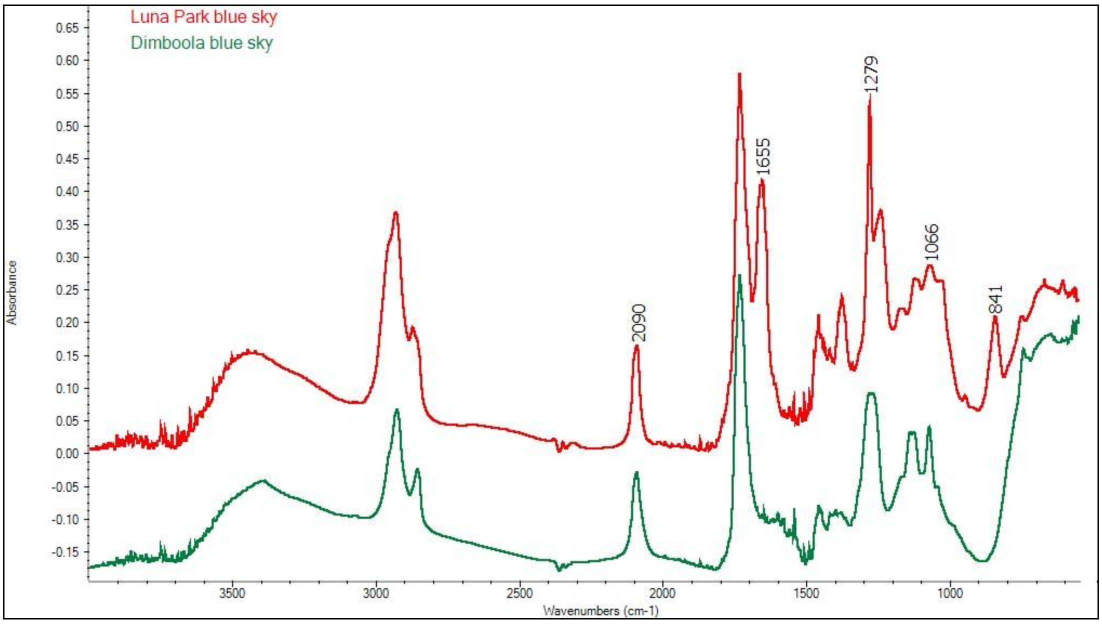


Figure 162. FTIR of blue sky samples from *Luna Park* and *Dimboola* . Image: Paula Dredge

A range of colour areas from *Luna Park* 1941 were additionally examined with PXRF, including yellow, red and white. These all continued to show the presence of titanium dioxide (Table 5.8).

Table 5.8 *Luna Park* analytical results

Luna Park	**Binder (FTIR)**	**Pigment (FTIR and PXRF)**
Black	Nitrocellulose	Bone derived black
Blue	Nitrocellulose	Prussian blue, titanium dioxide
Yellow	Not tested	Lead chromate, titanium dioxide
Red	Not tested	Titanium dioxide, (red pigment not identified)
White	Not tested	Titanium dioxide

A sample of the black paint from *Luna Park* 1941 was also examined with Pyrolysis-GC/MS at the Getty Conservation Institute. Although nitrocellulose itself cannot be identified using this technique, other components in the paint binder may be found. In this instance the resulting pyrologram shows peaks associated with the presence of a phthalate, (probably a glycerol alkyd used as a plasticiser) and colophony (rosin or ester gum) (Figure 163). The presence of the fatty acids, palmitate, stearate and oleate in the mass spectrum, in addition to the carbonyl peak in the FTIR spectrum at $1730cm^{-1}$ indicates the presence of fatty acids from oil. The presence of these additional plasticisers and modifiers is consistent with the reported formulation of nitrocellulose lacquer paints (Standeven 2011).

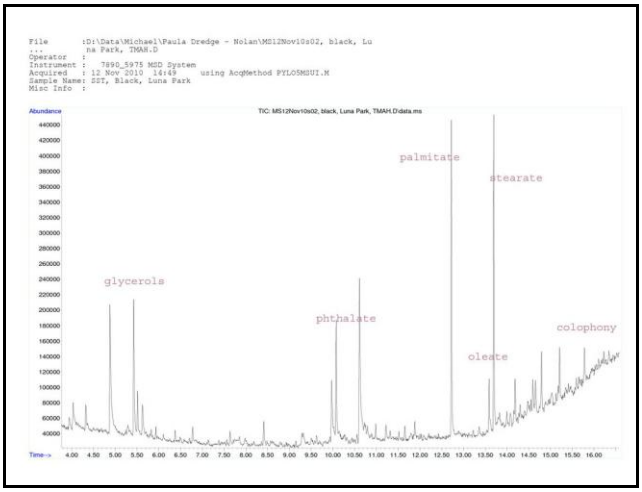


Figure 163. TMAH Py-GC spectra of black paint sample from *Luna Park* 1941 Image: Michael Schilling and Getty Conservation Institute

5.7.2 Case study 8: *Bird* 1941

Another painting by Nolan, *Bird* 1941 (collection: Heide Museum of Modern Art), shared observed features with the paint on *Luna Park* when it was examined in 2011 (Figure 164). The colour palette was similar to other paintings from 1942 and 1943, but the paint film appeared fragile with multiple fractures and cracks visible as a network throughout the painting. The thick build up of paint, although different to *Luna Park*, also suggested the use of an extremely fast drying paint medium.

Figure 164. Sidney Nolan, *Bird*, 4 December 1941, synthetic polymer on cardboard on composition board, 45.5 x 58.5 cm,. Collection: Heide Museum of Modern Art. © Trustees of the Sidney Nolan Trust

Analysis of several paint samples from *Bird* gave FTIR spectral results consistent with the presence of nitrocellulose. The blue sky sample was very similar to that of *Luna Park*, with the same peaks associated with Prussian blue (2090cm^{-1}) in addition to very clear spectral peaks for nitrocellulose (1655, 1279, 1074, 841 and 748cm^{-1}), although the typical broad peak at the low wavenumber end for titanium dioxide is not present (Figure 165).

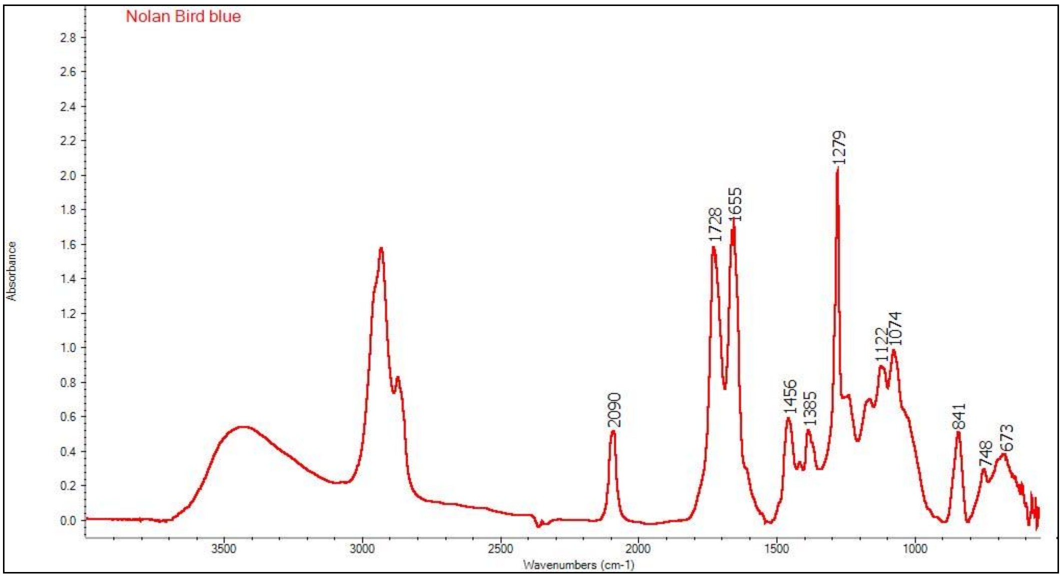


Figure 165. FTIR of blue paint sample from *Bird*. Image: Paula Dredge

A black paint sample from *Bird*, while giving similar FTIR spectral result to *Luna Park* for nitrocellulose lacquer, does not appear to have bone black as it is without the characteristic peaks for that pigment at 2013 and 1034cm^{-1} and a doublet at 604 and 567cm^{-1}. The FTIR absorbance spectrum for the black sample from *Bird* shows only the absorptions of binder and is probably pigmented with carbon black (Figure 166). The FTIR spectrum for the red paint on *Bird* only shows peaks associated with nitrocellulose lacquer and titanium dioxide and no peaks could be assigned to the red colour.

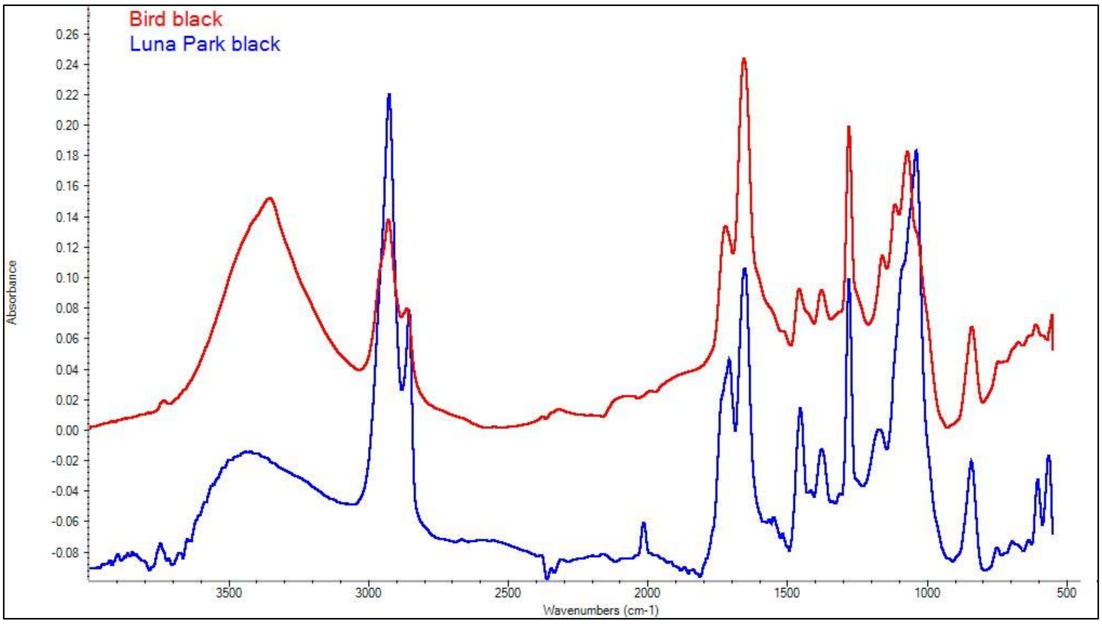


Figure 166. FTIR of black paint from *Bird* and *Luna Park*. Image: Paula Dredge

Table 5.9 *Bird* analytical results

Bird	**Binder (FTIR)**	**Pigment (PXRF)**
Black	Nitrocellulose	Not identified (carbon black)
Blue	Nitrocellulose	Prussian blue, titanium dioxide
Red	Nitrocellulose	Titanium dioxide (red not identified)

5.7.3 Case study 9: *Head of Rimbaud* 1938-39

The painting by Nolan titled *Head of Rimbaud* 1938-39 (collection: Heide Museum of Modern Art) is an enigma in terms of its medium description 'oil, Kiwi boot polish and pencil on cardboard' (Figure 22). When examined in 2011, the three colour areas of paint yellow brown and white, were all extremely hard and did not have the softness expected from waxy shoe polish. Close examination of the surface of the painting suggests that wax may have been rubbed across the surface of the work rather than integrated into the paint. The smearing of some pencil lines suggest that this polish may have been rubbed onto the surface before the paint film was applied but after some drawing had been done. A second set of darker drawing lines are incised into the wet paint film and were added after the paint had been applied. This is consistent with Nolan's biographer, Brian Adams (1987), who noted the cardboard of the work had been prepared with brown shoe polish prior to painting.

The analytical study of this painting offered the opportunity to examine a very early work by Sidney Nolan that did not have the features of an enamel-like commercial paint. Instead, the paint film had the matte surface and thick paste consistency expected from a standard artists' tube oil paint. The excellent condition of the paint on the face of the painting however made sampling unviable. There were paint scrapings on the back of the work that corresponded to the yellow and brown colours on the face of the painting. Two additional colours were present on the verso of the work, which were also tested, a bright blue and a pale yellow. Assertions that these samples relate directly to the paints used on the face of the painting are of course tentative although they are represented in paints used by Nolan from the period.

The darker yellow from the verso of *Head of Rimbaud* gave an FTIR absorbance spectrum very similar to the yellow ochre pigment in the glass jar labelled 'Fox yellow ochre' in the Nolan Wahroonga studio contents (SID 44184) which is a natural yellow ochre with kaolinite (Figure 167). There is very little FTIR response to the binder with a small carbonyl peak, and this was the case with all four paint samples examined from the back of this work.

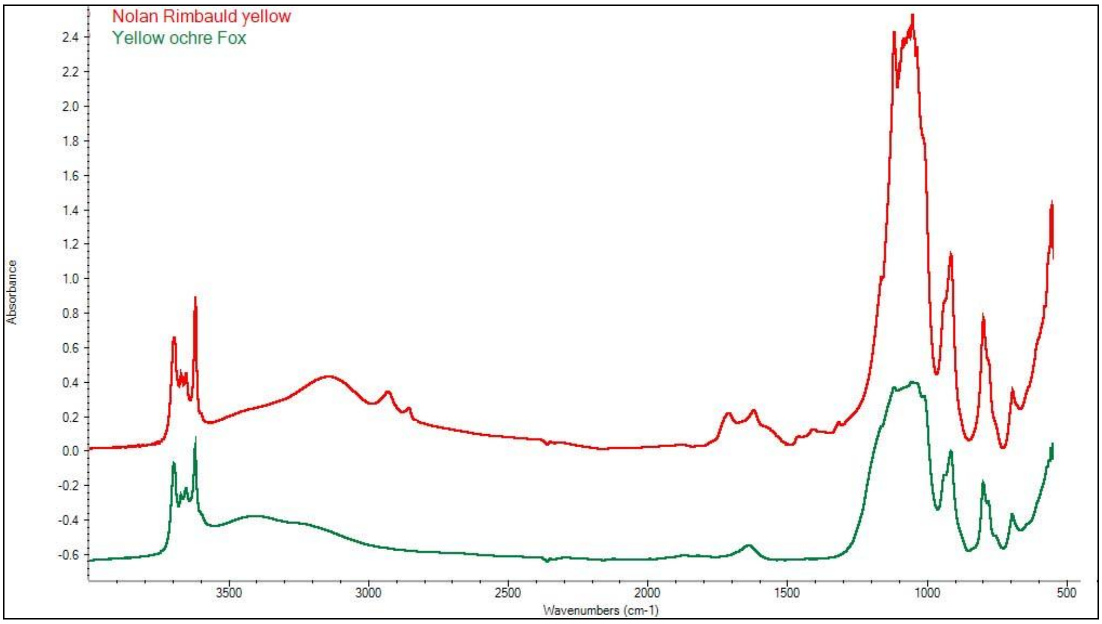


Figure 167. FTIR of yellow verso *Head of Rimbaud* and natural yellow ochre pigment from Nolan studio labelled Fox yellow ochre. Image: Paula Dredge

The pale yellow paint on the verso gave strong FTIR absorbance peaks relating to the presence of lead chromate (characteristic bands at 853cm^{-1} with shoulders at 831 and 820cm^{-1}) and calcium sulphate dihydrate (characteristic bands at 3556, 3402, 1620, 1142, 1111, 670, 602cm^{-1}). The presence of calcium sulphate dihydate (gypsum) in this yellow lead chromate paint is consistent with an example of lead chromate in research undertaken by Otero, Carlyle, Vilarigues and Melo (2012). In this study the authors selected four historic lead chromate formulations from the notebooks of Winsor & Newton, the British artists' paint-maker (colourman). In two of these recipes gypsum was added during the formation of lead chromate. In the first the gypsum was added prior to the formation of the lead chromate and the additional presence of sodium sulphate caused the gypsum to convert entirely into calcium carbonate (chalk). In the second formulation the gypsum was added at the end as a pure extender and the FTIR spectra of the resulting pigment is very close to that produced with the bright pale yellow colour on the back of *Head of Rimbaud*. Whether lead chromates used in commercial paints were similarly prepared is unknown.

The brown paint on the verso of *Head of Rimbaud* gave FTIR spectral peaks associated with a number of white colours and fillers; barium sulphate (characteristic bands at 1169, 634 and 609cm^{-1}), kaolin (characteristic high wavelength pattern at 3697 and 3620cm^{-1} which may be present as an ochre) and calcium carbonate (characteristic bands at 1793, 1417, 874 and 712cm^{-1}). The blue paint was unusual in all the blue paints examined on Nolan's works to date as it gave a very strong FTIR absorbance related to the presence of ultramarine blue (characteristic peaks at 1036 and doublet at 694 and 665cm^{-1}). Ultramarine blue in a mixture is difficult to characterise by FTIR except where it is in large proportion to the other components. In this case the strong FTIR spectrum pattern related to ultramarine blue in the blue paint from the back of *Head of Rimbaud* suggests the paint has a high proportion of this pigment (Figure 168). A small carboxylate peak with a sharp side peak at 1541cm^{-1} suggests there may also be a small amount of zinc oxide in this colour. A fairly pure ultramarine paint with a small carbonyl region related to binder is more likely indicative of artists' oil paint type rather than a commercial paint in which stronger tinting blues were more typically used, such as Prussian blue.

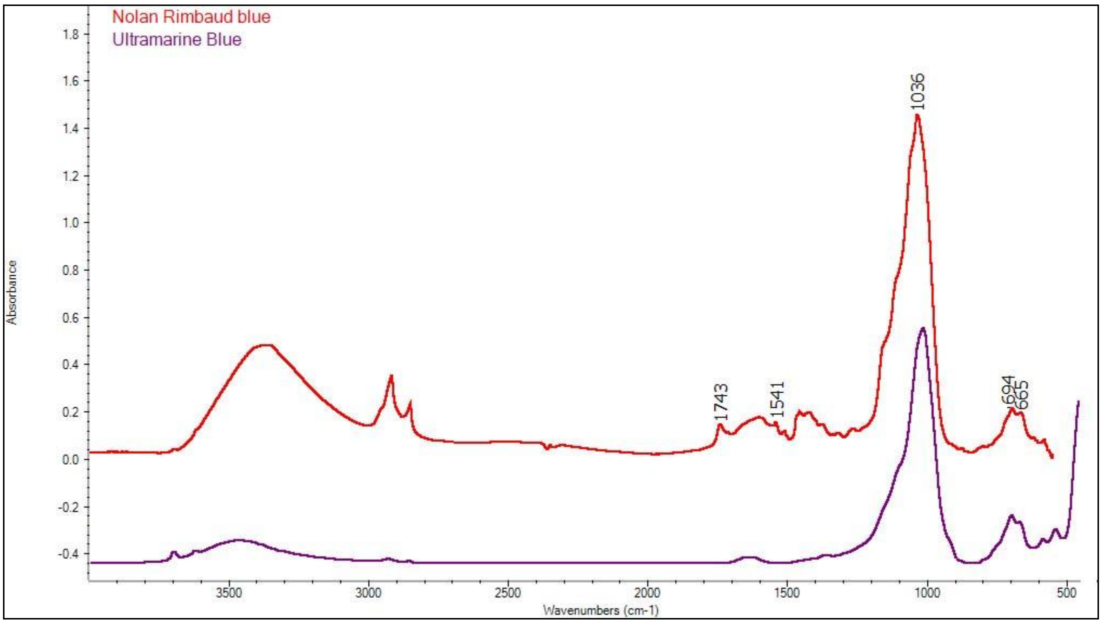


Figure 168. FTIR of blue paint verso *Head of Rimbaud* and French ultramarine blue pigment (© Art Gallery NSW 2011-2013). Image: Paula Dredge

Table 5.10 *Head of Rimbaud* (verso) analytical results

Head of Rimbaud	**Binder (FTIR)**	**Pigment (FTIR)**
Dark yellow	Not identified	Yellow ochre with silicate
Pale yellow	Not identified	Lead chromate/calcium sulphate
Brown	Not identified	Barium sulphate, aluminium silicate, calcium carbonate
Blue	Not identified	Ultramarine

5.7.4 Case study 10: *Untitled-abstract* c. 1939-40

The painting *Untitled-abstract* (Art Gallery of New South Wales) (Figure 7) makes a useful comparison with the paint analysed on *Head of Rimbaud*. It shares with that work a thick paste-like texture, which holds the impressions of the application tool, suggesting it is a standard artists' oil paint. In the case of *Untitled-abstract* the application tool was a stiff haired brush as compared to *Head of Rimbauld* in which the texture suggests the use of a palette knife.

Four colours were tested on *Untitled-abstract* with FTIR spectroscopy, bright red, yellow, blue and black. The black pigment examined with FTIR gave a positive result for the pigments bone black and calcium carbonate with almost no carbonyl peak at 1740cm^{-1} wavenumber region, suggesting the binder is in very small proportion to the pigments (Figure 169).

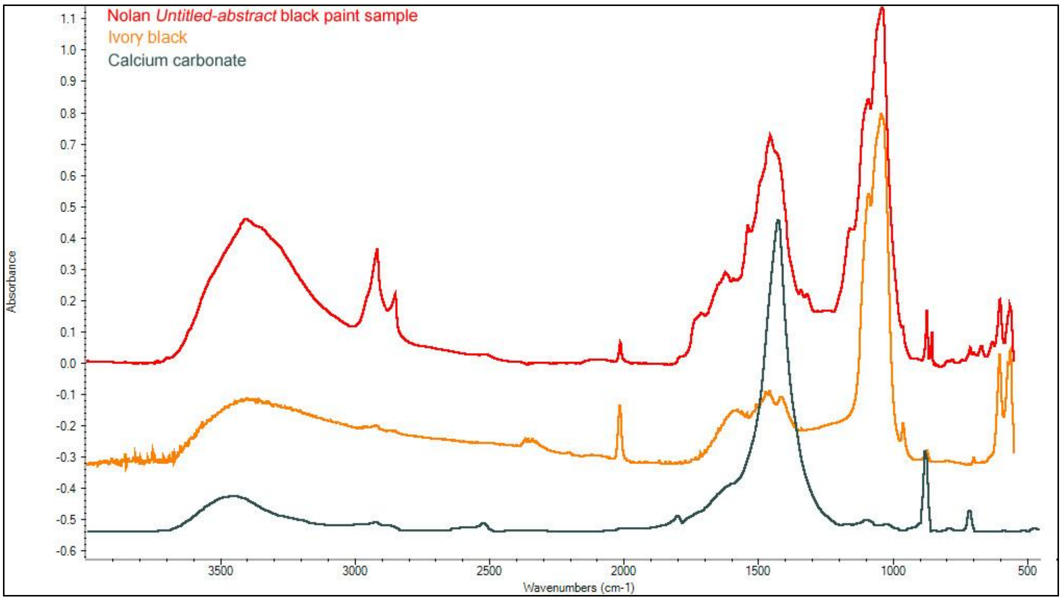


Figure 169. FTIR of black paint from *Untitled-abstract* compared to library spectra for ivory black and calcium carbonate (© Art Gallery of NSW 2011-2013). Image: Paula Dredge

The PXRF of the black areas on the painting gives elemental peaks for the presence of calcium and phosphorous, with additional peaks for zinc, lead and chrome (Figure 170). The zinc, lead and chrome are probably related to a lower layer of yellow paint being detected in this instance, whereas the calcium and phosphorous are related to the bone black and calcium carbonate in the black pigment as supported by the FTIR result. The pXRF spectrum also shows the photograph itself in blue having the elements of silver (Ag) and iron (Fe) suggesting that the photograph is a kallitype print made from iron oxalate and silver nitrate, patented process from 1889 and popular in the late nineteenth century.

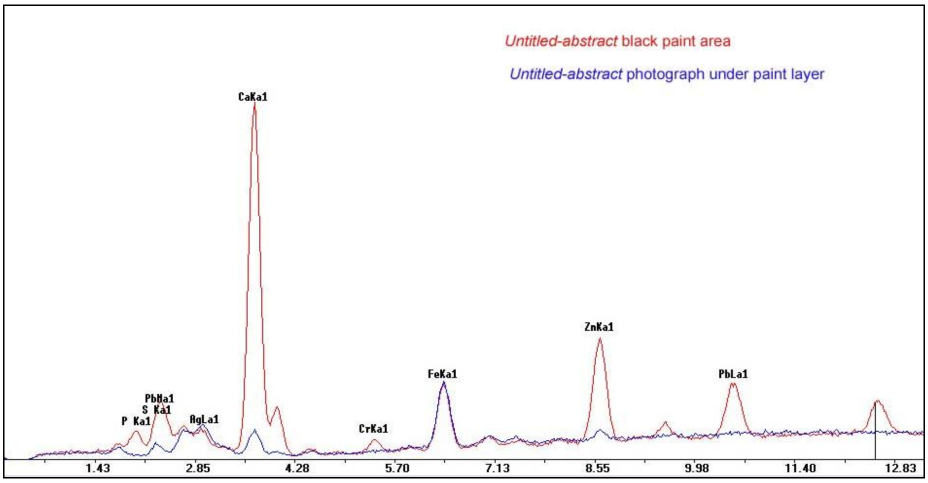


Figure 170. PXRF spectrum (40kV, 1.1uA, 200 sec. vacuum) of black paint area *Untitled-abstract* overlayed against spectrum of underlying photograph. Image: Paula Dredge

The blue paint on *Untitled-abstract* is predominately ultramarine blue pigment similar to that detected on *Head of Rimbauld*, with zinc stearates at 1541cm^{-1} and a small carbonyl peak from the binder at 1741cm^{-1}. *Untitled-abstract* also has calcium sulphate, (gypsum) detected as peaks in FTIR at 3556 and 3402, 1620, 671 and 602cm $^{-1}$ and a shoulder on the main ultramarine peak at 1111cm^{-1} (Figure 171). This is confirmed with pXRF as peaks for calcium and sulphur are both apparent in comparison to the background photograph.

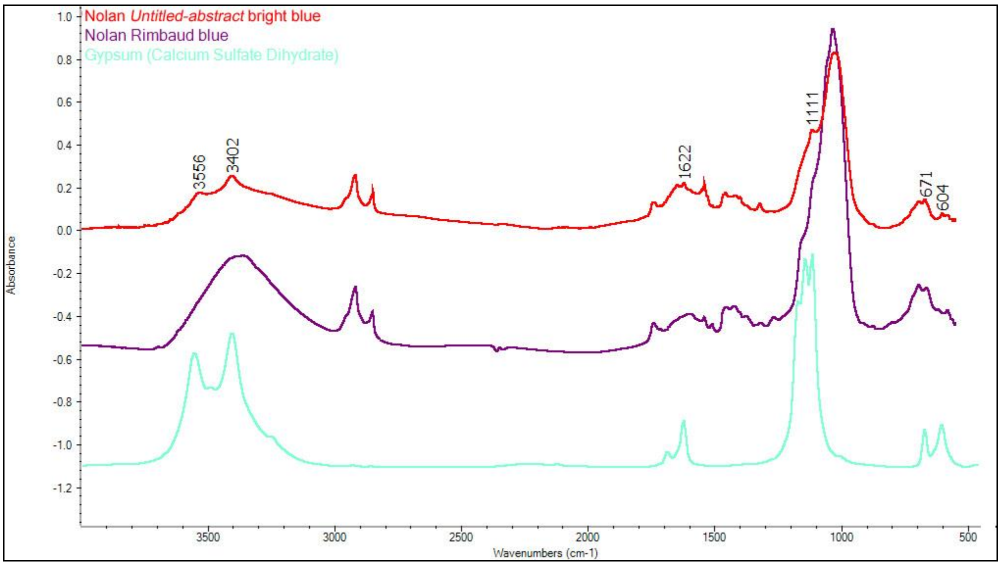


Figure 171. FTIR *Untitled-abstract* bright blue, *Head of Rimbaud* bright blue verso and calcium sulphate dihydrate library spectrum (©Nicolet Instrument Corp., 1991-1994). Image: Paula Dredge

Calcium sulphate (gypsum) is also well represented in the FTIR analysis of the yellow paint sample from *Untitled-abstract*, along with lead chromate. The FTIR spectra for this colour on *Untitled - abstract* is remarkably similar to that from *Head of Rimbaud*, with a small carboxylate peak at 1515cm^{-1} in the *Head of Rimbaud* sample the only feature of difference (Figure 172).

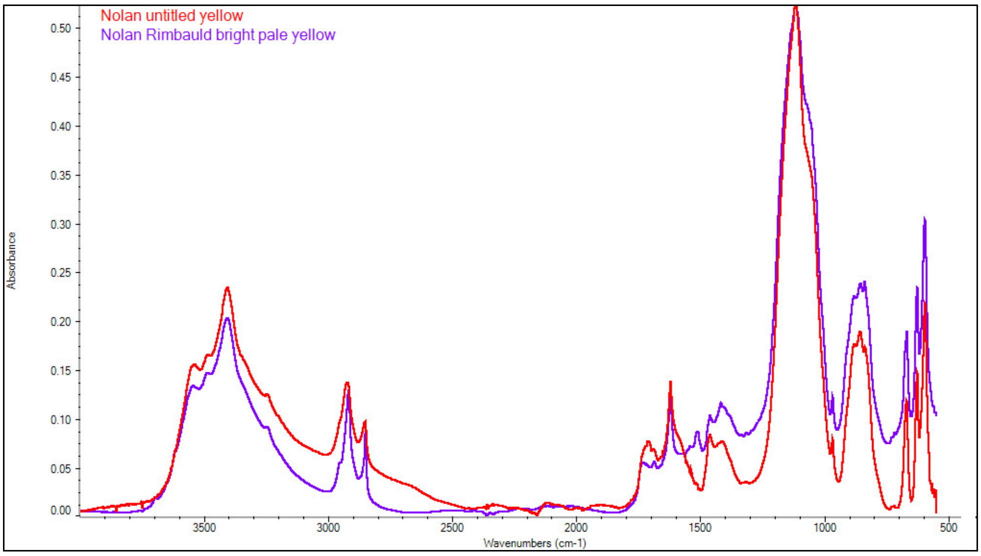


Figure 172. FTIR of bright yellow on *Untitled- abstract* and *Head of Rimbaud*. Image: Paula Dredge

A sample of the bright red paint on *Untitled-abstract* examined with FTIR provides a good match with the coal-tar colour dinitroaniline red with calcium carbonate (Figure 173). This coal-tar colour is given the colour index name of Pigment Orange 5 (PO5) and is described as a ‘reddish-orange shade’ (Chapman & Hall 1966, p. 261). This fits well with the appearance of the colour on the painting that is an orange shade of red, rather than the darker red of the toluidine pigment identified in the Ripolin red 16. It is unclear if this particular coal-tar colour was used in artists’ oil paints of the 1930s, but it is a popular colour in artists’ paint today found in many vermillion hued paints.

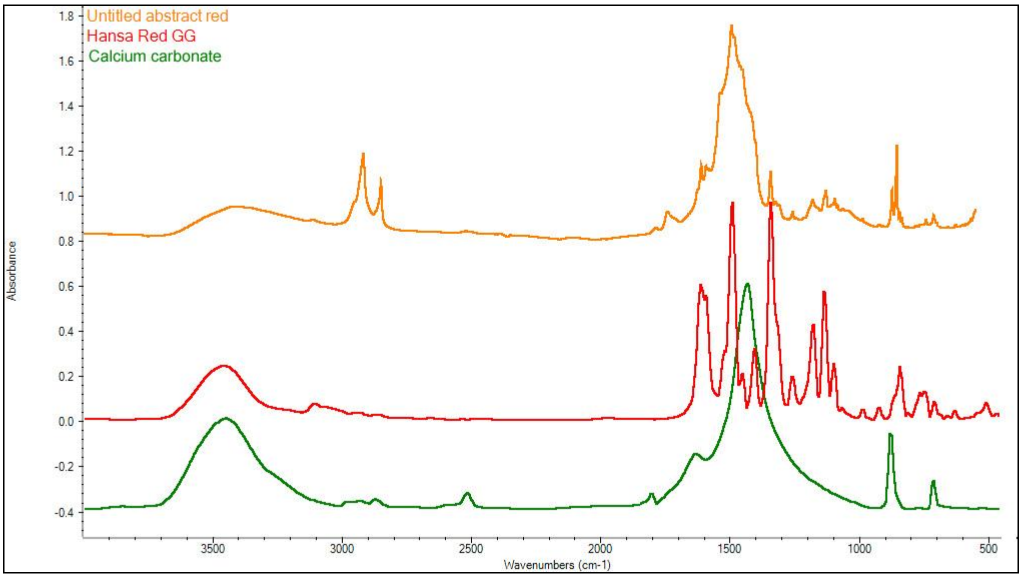


Figure 173. FTIR of red sample from *Untitled-abstract* and dinitroaniline red (hansa red GG) and calcium carbonate (©Nicolet Instrument Corp., 1991-1994). Image: Paula Dredge

Table 5.11 *Untitled-abstract* analytical results

Untitled abstract	**Binder (FTIR)**	**Pigment (FTIR and PXRF)**
Black	Not identified	Ivory black
Pale yellow	Not identified	Lead chromate/calcium sulphate
Red	Not identified	Calcium carbonate, dinitroanaline red (PO5)
Blue	Not identified	Ultramarine, calcium sulphate, zinc stearate (zinc oxide)

5.8 Summary of analytical findings from four paintings by Nolan 1938-1941

Nitrocellulose was identified with FTIR on two paint samples from *Luna Park* and three samples from *Bird*. Both works were painted in 1941. While the two blue paints from the different paintings showed similar pigment results for Prussian blue, the black pigments differed, with only *Luna Park* identified as making use of a bone-derived black. This is similar to the results for the two alkyd-based paintings *Dimboola* and *Waterwheel*, *Luna Park* in which the binders were consistent between paintings but the pigments were not. The differences in pigments suggest that Nolan may have used a number of different brands of paint that, while containing the same binders, were pigmented differently. It is also possible that he mixed pigments directly with the paints to adjust properties as it suited.

The identification of nitrocellulose on two paintings by Nolan dating from 1941 is a significant finding in this study as it has not previously been identified on paintings by Sidney Nolan. There were very few artists who took up the challenge of working with this medium, and it demonstrates Nolan's agility with, and preference for, fast drying paint. The mention of Duco in Nolan's letters to Sunday Reed in 1942 suggested that Nolan was familiar with nitrocellulose paint and may previously have used it (Nolan 27 October 1942). In addition, the use of the term 'lacquer' in Sunday Reed's diaries for several paintings by Nolan dated in October and November 1942 (see Appendix i), suggests that Nolan may also have been using nitrocellulose at this time (Reed 1942). In Nolan's letters to Reed, he notes he has lacquer for painting while in the Australian Army as early as July 1942 (Nolan 18 July 1942). The finding of two paintings in which this unusual media has been used, is a confirmation of the value of the correspondence in describing materials that may be identified with analysis.

The earlier paintings dated 1938-39, *Head of Rimbaud* and *Untitled-abstract* share a number of features, which makes them distinctively different from other Nolan paintings analysed. Comparison of the FTIR spectra from samples removed from *Untitled-Abstract* and from the verso of *Head of Rimbaud*, consistently give small carbonyl peaks in the range around 1740cm^{-1}. This suggests that there is very little binder present in comparison to the pigments, unlike the Ripolin enamels, alkyds and nitrocellulose resin paints. It is not possible to give a positive identification of the binder, but the low proportion of binder to solids is typical of artists' oil paints in which the consistency of the paint is formulated to be stiff and thick in order to hold the textural impressions of the brush. The pigments detected are typical for those used in artists' paints of the period, natural ochre, lead chromate with a gypsum component and French ultramarine. The presence of the coal tar colour PO5 is also an interesting finding and was not identified in other paintings examined analytically by Nolan. These paints are also typically matte in appearance, due to the low proportion of oil binder. It is likely that these two early paintings by Nolan were painted using standard artists' oil paints.

5.9 Are Nolan's paintings post-February 1943 exclusively Ripolin?

The series of paintings Nolan painted in 1946 and 1947 on the subject of the bushranger Ned Kelly have the clearest documented association with Ripolin paint. They were painted in the dining room at Heide. The twenty-seven Kelly paintings selected for the series, now in the collection of the National Gallery of Australia, were not examined as part of this study, but the Art Gallery of New South Wales has two paintings by Nolan dating from 1946 with Kelly subjects, *The camp* 1946 and *First-class marksman* 1946. *First-class marksman* was exhibited in 1948 as one of the 27 works in the original Ned Kelly series (*The 'Kelly' paintings of Sidney Nolan 1946-1947* 1948) and later separated out from that group. It was however painted separately to all the others Kelly paintings while Nolan was minding the house of Danila Vassillieff at Warrandyte (Pearce 2007).

These two paintings from 1946 share the use of matte paint features in the landscape, with gloss paint for figures, highlights and in particular for the black armour of Kelly. While *The camp* has been varnished with a synthetic AW2 (cyclohexanone type) varnish, *First-class marksman* retains its uncoated original surface.

5.9.1 Case study 11: *The camp* 1946

The camp 1946 was painted, along with the paintings which were to become the 'Kelly series', on the dining table at Heide and is representative therefore of that group of works (Figure 174). Catalogued as Ripolin enamel, it shares with those other paintings the use of a Masonite support and a white ground preparation applied to the smooth side of the board. Although now varnished, the use of matte paint in the landscape as compared to the high gloss surface of the cut out blue screen and Kelly's armour, is still apparent.

Figure 174. Sidney Nolan, *The camp* (1946), enamel on hardboard, 89.7 x 121.5 cm. Collection: Art Gallery of New South Wales, purchased 1978. © Trustees of the Sidney Nolan Trust

The white ground layer is a zinc oxide, barium sulphate and talc pigmented paint, as shown in the FTIR spectra of a sample taken from the white tent in which the ground layer has been used as image (Figure 175). A small peak at 2097cm^{-1} suggests that the white ground has been slightly adjusted in hue with a small addition of Prussian blue pigment. In addition to the broad carboxylate peak in the 1500-1600cm^{-1} area relating to the presence of zinc oxide and oil, a sharp peak at 1541cm^{-1} demonstrates that a significant proportion of zinc stearate soap has formed in this instance. This pigment analysis of the ground is confirmed by the PXRF, which gives peak assignment to the elements zinc, barium, sulphur and silicon. Magnesium is below the detection limit of loss mass elements. Although these pigments are all found in the flat Ripolin white 501, there is no titanium dioxide detected in the ground layer as found in the paint from the can.

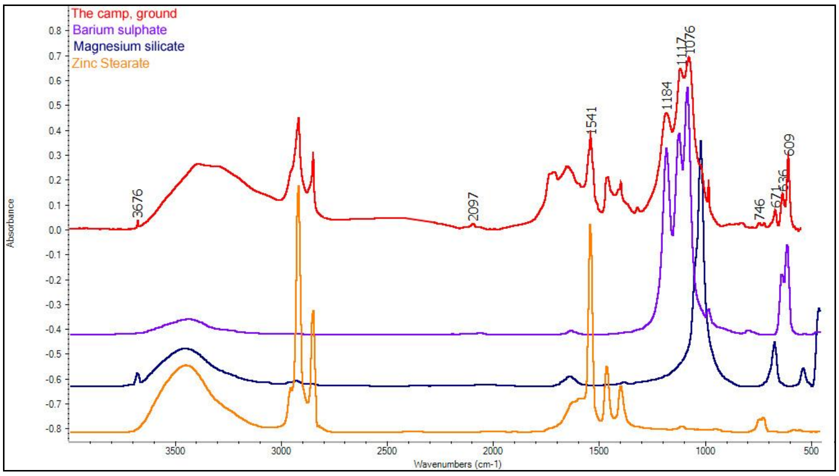


Figure 175. FTIR spectrum of ground layer sample from *The camp* 1946 with barium sulphate, magnesium silicate and zinc stearate (©Nicolet Instrument Corp., 1991-1994). Image: Paula Dredge

FTIR spectroscopy of the gloss white paint from the campfire smoke is consistent with Ripolin white 1, an oil-based paint. A large carboxylate peak in the area 1500-1600cm^{-1} suggests the presence of zinc oxide. No other white pigments are present in the FTIR spectrum. Comparison with a dry sample of Ripolin white 1 from the Wahroonga studio cans gives an excellent match between the two spectra (Figure 176).

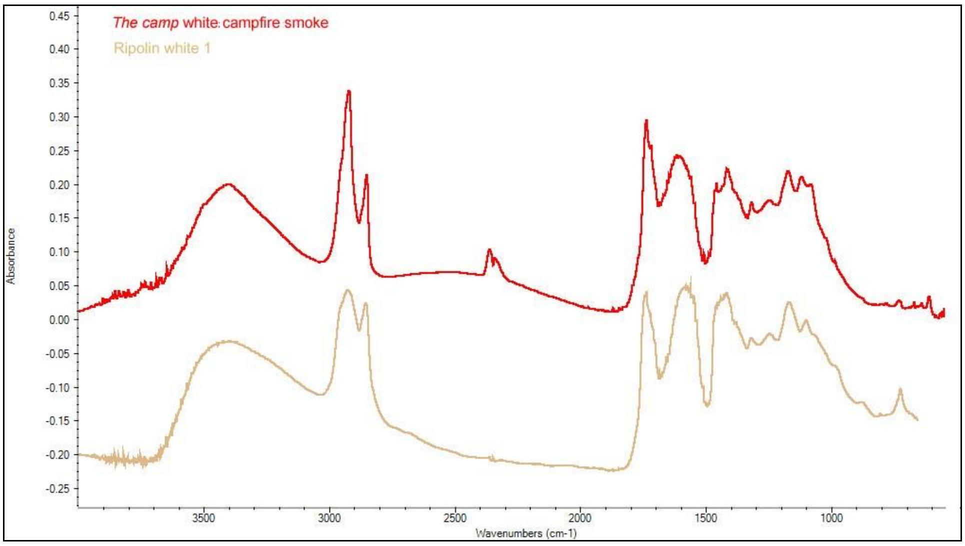


Figure 176. FTIR of white gloss sample from *The camp* 1946 and Ripolin white 1. Image: Paula Dredge

FTIR of the gloss blue ‘screen’ on the left side of the painting gave a positive result for oil and the pigments Prussian blue and zinc oxide. PXRF of the blue towards the top of the painting is consistent with the finding of these two pigments (iron and zinc). When tested in the lower part of the painting, lead and chrome were additionally found from the presence of lead chromate used in the landscape that exists below the blue ‘screen’. These results from the analysis of the coloured paint areas on *The camp* 1946 are consistent with the paint mediums and pigments analysed in the cans of Ripolin enamel.

When a sample of black paint on the Kelly armour was examined with FTIR spectroscopy, a surprising but strong analytical match with alkyd resin paint was found. A comparison of the FTIR spectrum from the Kelly figure with a FTIR absorbance spectrum from the contents from the can of black Dulux paint from Nolan’s studio illustrates their spectral similarities (Figure 177). FTIR peaks at 1265, 112, 1072, 742, 706cm^{-1} and the doublet at 1599 and 1579cm^{-1} are all typical of alkyd resin paints. The lack of any pigment spectral features suggests that the black pigment, in both the can of Dulux and on the painting, are carbon based.

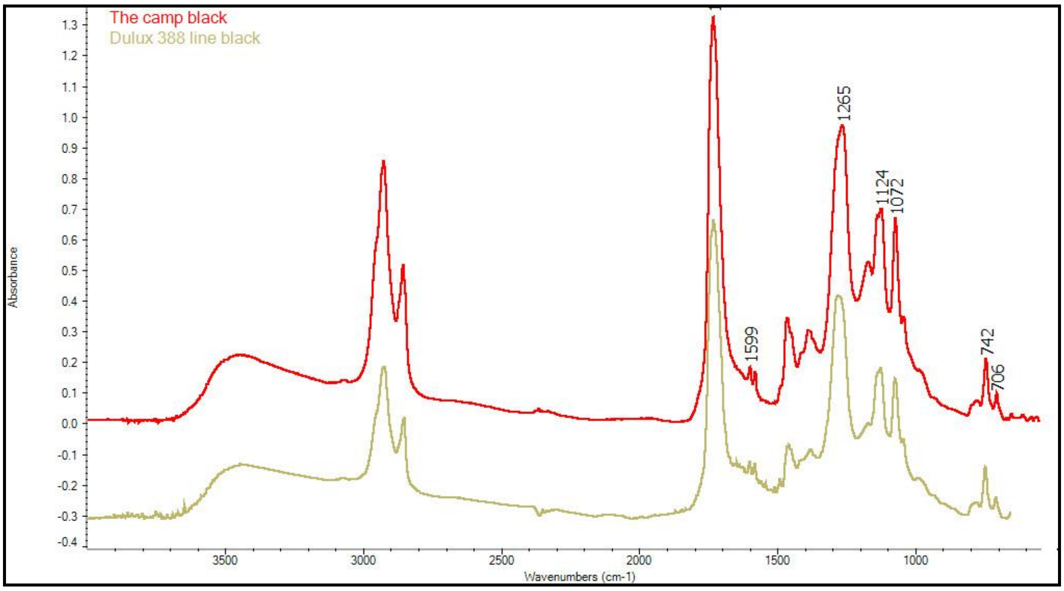


Figure 177. FTIR of black paint sample from Kelly armour at lower centre from *The Camp* 1946 and alkyd from black Dulux can. Image: Paula Dredge

This unexpected result for the black paint on the Kelly armour on the painting *The camp* 1946 demonstrates the effectiveness of the FTIR analytical technique in distinguishing between the oil-based paints and alkyd resins used by Nolan. However, a comparison of the FTIR spectrum taken from the top surface of the paint with the underneath of the same sample, is a salient example of the need for careful interpretation of results taken from surfaces. The underneath sample of black paint from the black Kelly armour conversely to the top gives a FTIR spectral result for oil-based paint, with a sharp zinc stearate peak at 1541cm^{-1} (Figure 178).

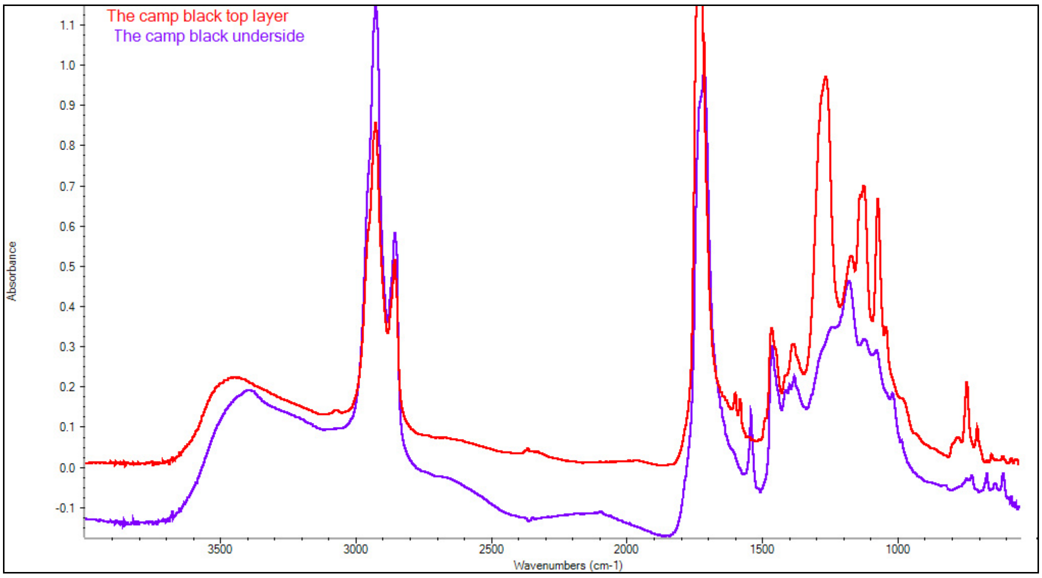


Figure 178. FTIR of black paint from Kelly armour on *The camp* 1946 top surface and underside. Image: Paula Dredge

A cross-section sample of the black Kelly armour taken from the bottom edge and mounted in polyester resin viewed in incident illumination under the microscope as shown in Figure 179, does not immediately demonstrate any difference between the black paint at top and bottom. Examination of the same sample in ultraviolet light (Figure 180) clearly shows that two different black paints are present. The oil-based paint at the bottom has a distinctively brighter fluorescence than the alkyd paint at the top. This is consistent with the finding from the can of Ripolin black 1105 that was found in Chapter 4 to have the natural resins colophony and copal in the paint. Natural resins typically demonstrate a bright fluorescence under ultraviolet light.

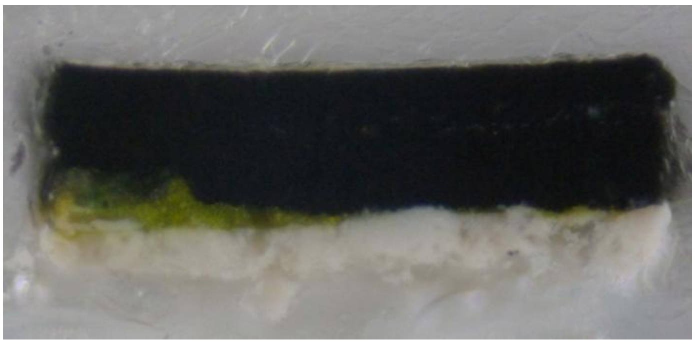


Figure 179. Mounted cross-section of black paint sample from Kelly armour at bottom edge of *The camp* 1946, shown in incident light at x200. Photo: Paula Dredge

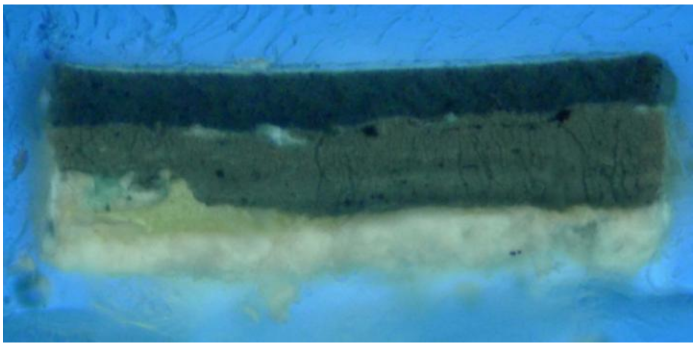


Figure 180. Mounted cross-section of black paint sample from Kelly armour at bottom edge of *The camp* 1946, shown in ultraviolet light at x200. Photo: Paula Drege

Table 5.12 *The camp* analytical results

The camp	**Binder (FTIR)**	**Pigment (FTIR)**
Ground	Obscured	Barium sulphate, magnesium silicate and zinc stearate
Gloss white	Oil	Zinc oxide
Gloss blue	Oil	Prussian blue, zinc oxide
Gloss black Kelly upper	Alkyd	Not detected (carbon black)
Black Kelly lower	Oil	Not detected (carbon black)

These results suggest that Nolan originally painted the Kelly figure in an oil-based paint (probably Ripolin black 1105) and then repainted it in an alkyd black paint. This finding has considerations for the cataloguing of the paint medium on this painting, and it suggests that Nolan made a critical adjustment to this figure in repainting it with a fast drying alkyd paint. Examination of another Kelly painting of the period provides a critical comparison to test the extent to which Nolan may have adjusted his paint mediums to suit specific needs.

5.9.2 Case study 12: *First-class marksman* 1946

The acquisition in 2010 by the Art Gallery of New South Wales of *First-class marksman* enabled a comparison with another painting by Nolan from 1946 on the Kelly subject. Five colour areas on the painting *First-class marksman* 1946 (Figure 6) were examined with FTIR spectroscopy. These were the blue sky, dark blue hill, a red spot from the gun, a bright yellow from Kelly's eye, the glossy white from the eye and the black paint of the armour.

This painting, which is painted on the smooth side of a piece of Masonite was prepared with a white ground layer. Comparison of the FTIR spectra from the ground layer of *First-class marksman* 1946 with the ground layer of *The camp* 1946 gives well matched spectra (Figure 181). Comparison of PXRF spectra also gives very similar results for both ground layers which are pigmented with barium sulphate, kaolin and zinc oxide. This suggests that the same paint was used for the priming of both these panels, but that it is unlikely to be a Ripolin product.

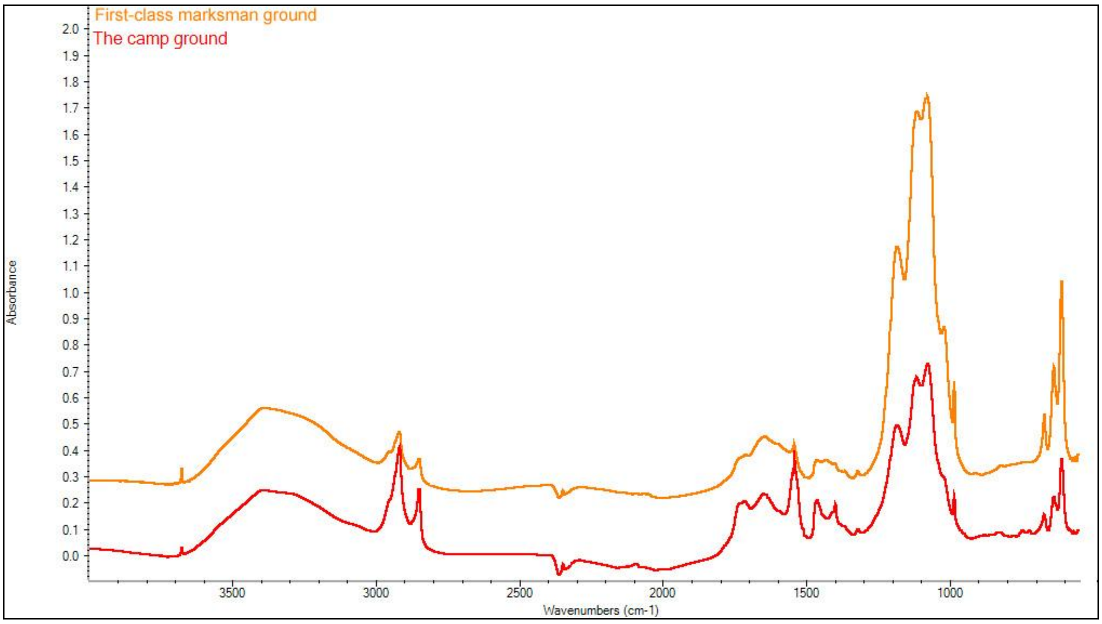


Figure 181. FTIR of the ground layers on *First-class marksman* 1946 and *The camp* 1946. Image: Paula Dredge

Coloured paint areas of *First-class marksman* 1946 give FTIR results consistent with the presence of oil-based paint, pigmented with zinc oxide, barium sulphate, lead chromate, Prussian blue and toluidine red. The FTIR spectrum, for example, of the bright spot of red paint at the end of the gun barrel is very similar to the spectrum for Ripolin red 16 (Figure 182). The differences noted between the two spectra are related to the greater oxidation of the paint on *First-class marksman*, exhibiting a broad peak effect in the 3400cm^{-1} region, and some evidence of zinc oxide and the formation of zinc stearate soaps in the area 1500-1600cm^{-1}. This consistency with the appearance of zinc carboxylates in the FTIR analysis from paintings in those colours which the Ripolin cans suggest zinc oxide is not present, such as red 16 and black 1105, suggests there may be a movement of these soap species into paint films sitting over zinc oxide-based ground or paint layers.

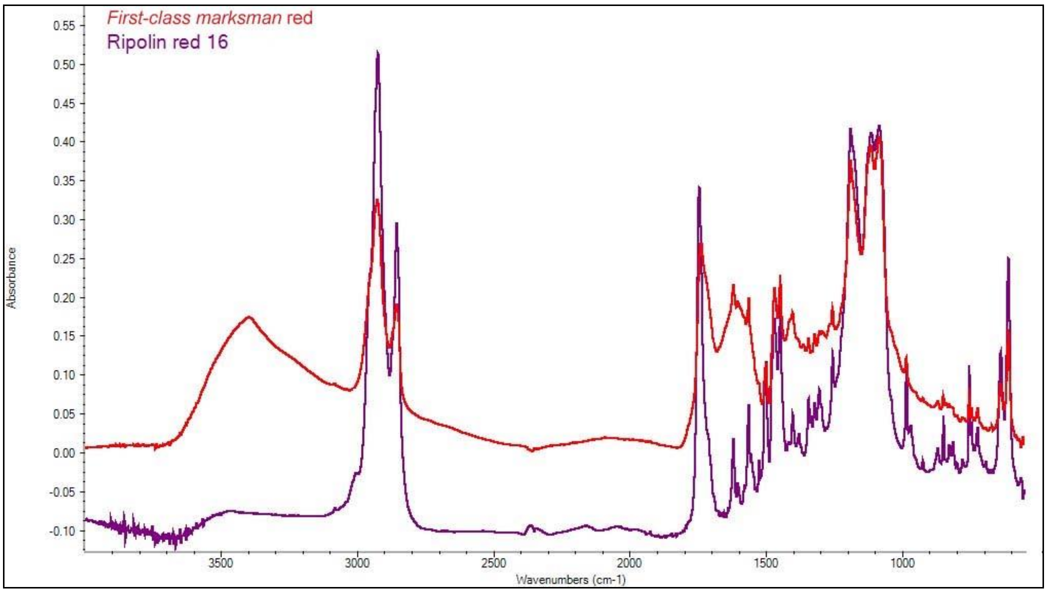


Figure 182. FTIR of red gloss paint from *First-class marksman* 1946 and Ripolin red 16. Image: Paula Dredge

Another important FTIR result from paint samples taken from *First-class marksman* 1946 is the blue paint from the mountains that provides good correlation with the Ripolin ultramarine 13 from the can (Figure 183). Differences between the spectra are again the result of the greater oxidation of the paint from the artwork compared to the paint from the can, but both samples give positive results for the presence of copper phthalocyanine, barium sulphate and zinc oxide. The useful match with the paint from the can of Ripolin ultramarine shows that copper phthalocyanine was present in Nolan's Ripolin paints as used in 1946, and suggests that this formulation was consistent with the paint as it was produced at that time or earlier. As it was likely that Nolan's Ripolin in 1946 was manufactured pre-war, Ripolin ultramarine was likely to be a copper phthalcyanine blue formulation dating prior to 1939.

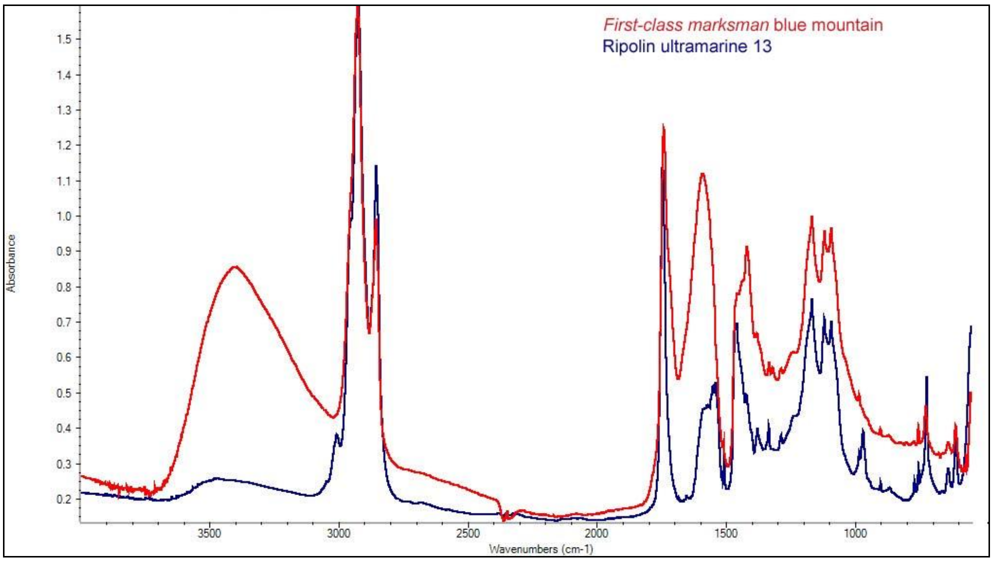


Figure 183. FTIR of sample of blue mountains in *First-class marksman* 1946 and Ripolin ultramarine 13. Image: Paula Dredge

FTIR spectroscopy of a sample taken from the surface of the black paint on the figure of Kelly on *First-class marksman* gave a similar result to that of *The camp* 1946 (Figure 184). Both black paints from the surface of Kelly figures are alkyd.

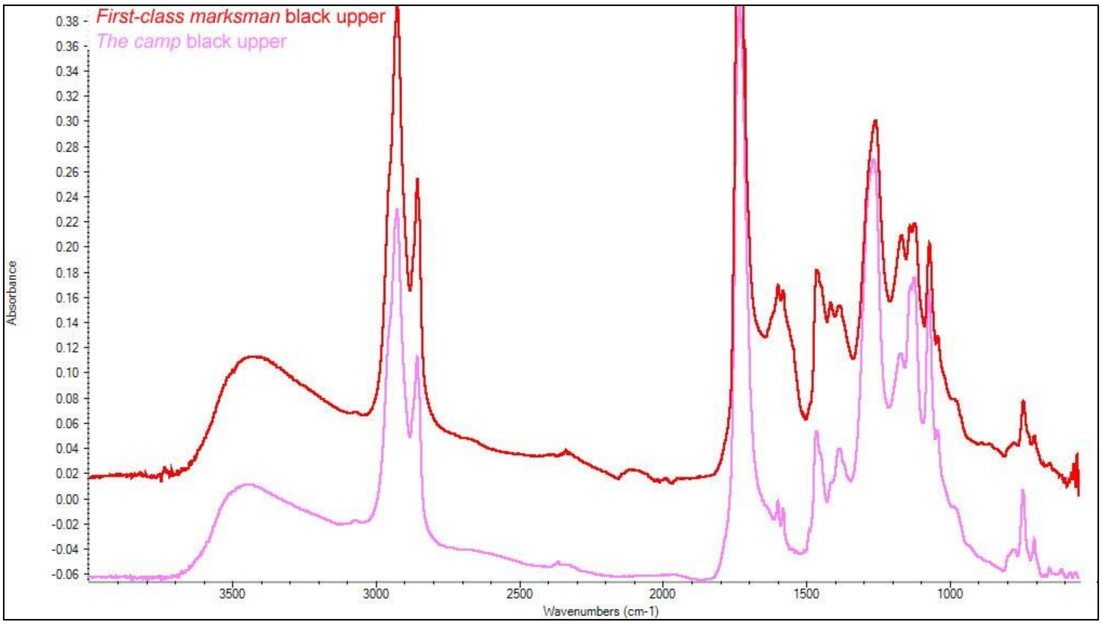


Figure 184. FTIR of black paint samples from *First-class marksman* 1946 and *The camp* 1946. Image: Paula Dredge

Samples of the black paints from *the camp* and *First-class marksman* were analysed at the Getty Conservation Institute with TMAH Py-GC/MS to identify the type of alkyd present. Both were found to contain pthalate (10.2 mins) and pentaerythritol (8.25 mins) (Figure 185). 1946 is a very early date for the use of PE alkyds. PE was only used in alkyds manufactured after the war and the historical survey offered in Chapter 3. suggests that Dulux was not widely available for the public until 1948. However, Joy Hester had written it was being manufactured in 1947 but could only be obtained by special arrangement (Hester 1947 cited in Burke 1995). Given Nolan's gift for seeking out the materials he needed, the idea that he obtained some of these early batches of PE alkyds is entirely possible perhaps it is more probable that this was in 1947 just before he left Heide rather than in 1946 when the paintings were painted and it was used to touch up the Kelly paintings to resolve issues with the black Ripolin paint. Examination of the paint layers in the black Kelly figure of *First-class marksman* reveals a similar overpainting with the alkyd over a oil-based black paint to that noted on *The camp*.

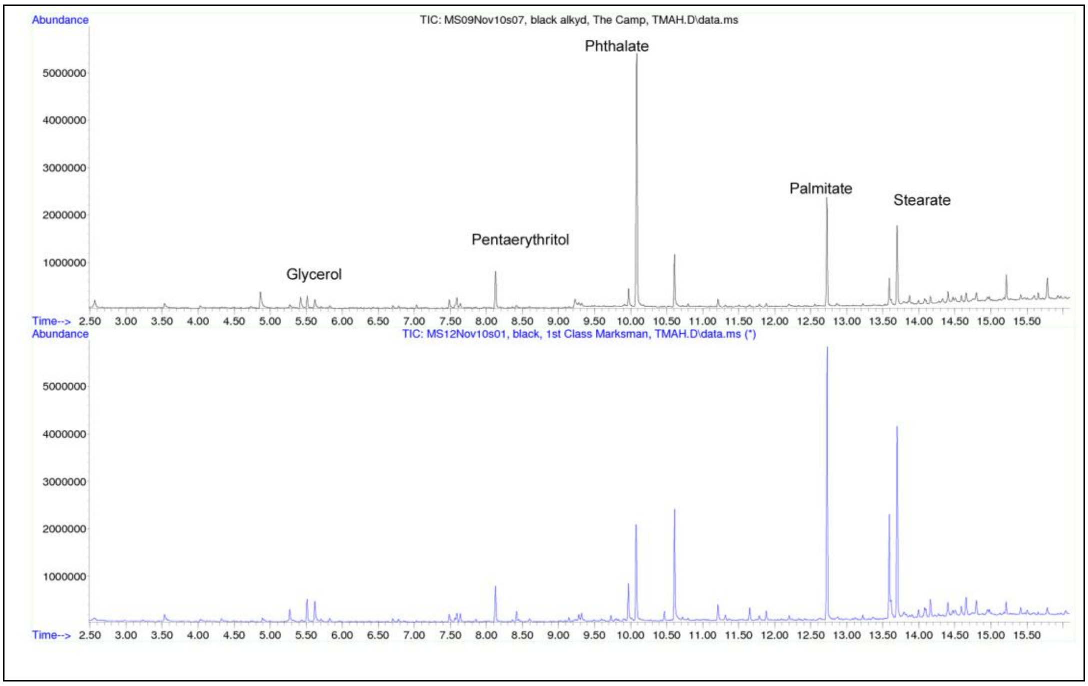


Figure 185. TMAH Py-GC of black paint samples from Kelly figures on *The camp* (top) and *First-class marksman* (bottom). Image: Michael Schilling and Getty Conservation Institute

A cross-section sample taken from the black paint of Kelly on *First-class marksman* 1946, when examined with ultraviolet fluorescence reveals a similar double layer of black paint to that of *The camp* 1946 (Figure 186 and 187). FTIR spectroscopy of the lower black layer also shows a typical oil paint spectrum similar to the spectrum for Ripolin black 1105. An additional ground layer was also observed with this cross-section when viewed under UV light. The ground layer retained with this sample has a specular fluorescence consistent with zinc oxide pigmented paint. A remnant of a lower ground layer is visible at the lowest right part of the sample. This ground layer has a diffuse fluorescence under UV light and is barium sulphate-based.

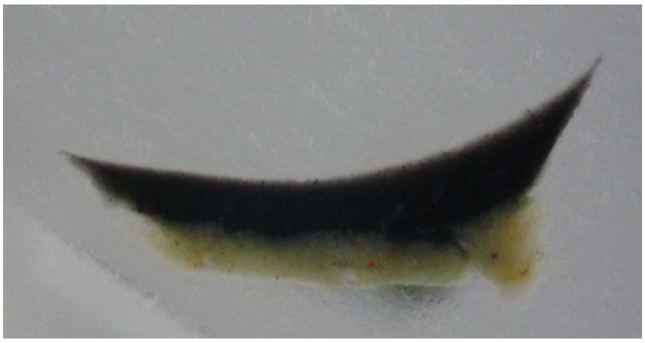


Figure 186. Mounted cross-section of black paint sample from Kelly armour at bottom edge of *First-class marksman* 1946, shown in incident light at x200. Photo: Paula Dredge

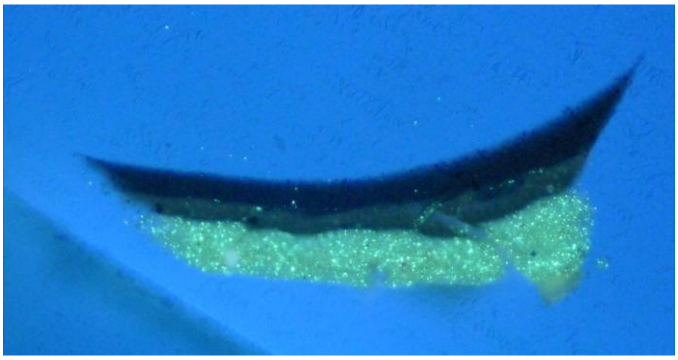


Figure 187. Mounted cross-section of black paint sample from Kelly armour at bottom edge of *First-class marksman* 1946, shown in ultraviolet light at x200. Photo: Paula Dredge

Both cross-section samples from the black painted Kelly figures were examined under a Scanning Electron Microscope (SEM) at the Microscopy and Microspectral Analysis Unit at the University of Technology, Sydney. Backscattered imaging of the sample from *First-class marksman* 1946 provides a grey scale of elemental mass the lowest mass elements are shown black and the highest mass white (Figure 188). The two black layers have very little high mass material and appear in this image almost completely black.

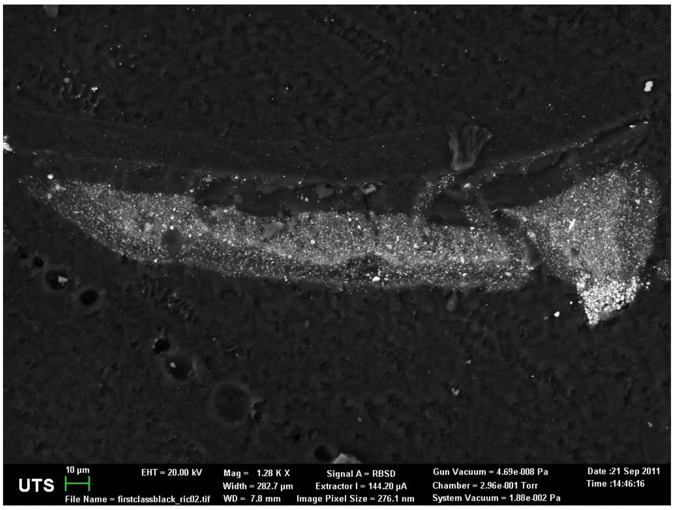


Figure 188. SEM in backscattered mode of black paint sample from Kelly figure taken from *First-class marksman* 1946. Photo: Richard Whurer

The two ground layers are seen clearly in SEM (Figure 184). When seen at higher magnification the very different pigment structures of the two layers are made more visible (Figure 189). SEM-XRF analysis of the two ground layers reveals that the upper layer is predominately zinc based (zinc oxide) with a small amount of lead and chrome (lead chromate), whereas the lower layer is dominated by the presence of barium and sulphur (barium sulphate) with some zinc (zinc oxide), silicon and magnesium (magnesium silicate). The FTIR ground sample analysed in Figure 178 is therefore the lower ground. *The Camp* in contrast only has a single ground layer, and this matches the pigments present in the lower ground layer of *First-class marksman* 1946.

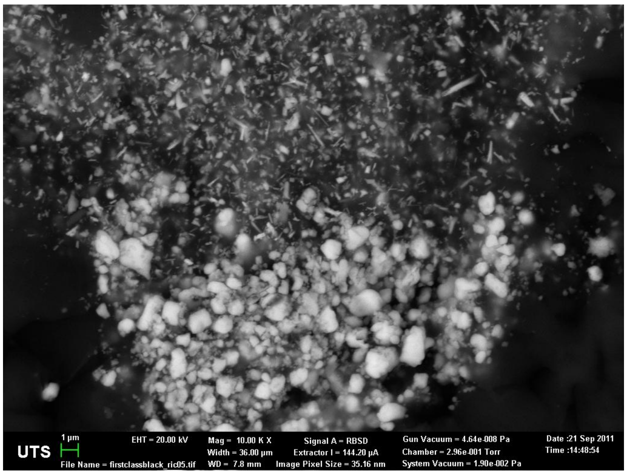


Figure 189. SEM backscattered image of cross-section of black paint on Kelly figure taken from *First-class marksman* 1946. Photo: Richard Whurer

Table 5.13 *First-class marksman* analytical results

First-class marksman	Binder (FTIR)	Pigment (FTIR and PXRF)
Lower ground	Obscured	Barium sulphate, zinc oxide, magnesium silicate
Upper ground	Not tested	Zinc oxide, lead chromate
Gloss white	Oil	Zinc oxide
Gloss blue sky	Oil	Prussian blue, zinc oxide
Gloss blue mountain	Obscured	Barium sulphate, zinc oxide copper phthalocyanine
Gloss red	Obscured	Barium sulphate, toluidine red
Gloss black Kelly upper	Alkyd	Not detected (carbon black)
Black Kelly lower	Oil	Not detected (carbon black)

5.9.3 Case study 13: *Colonial head* 1947

Colonial head is painted on a piece of laminated cardboard and inscribed by the artist 4 May 1947 (Figure 190). This painting dates prior to Nolan leaving Melbourne in July of 1947. The painting was prepared with several ground layers. The lowest ground layer is white but this was covered with a second grey coloured layer. Underneath the white ground is a dark blue paint in areas suggesting another image exists underneath. The paint layers have the appearance of gloss house paint with level surfaces and embedded dust and hairs, either from a disintegrating paint brush or a dirty space while painting. The level of gloss of the paint film is difficult to determine due to the presence of a varnish layer.

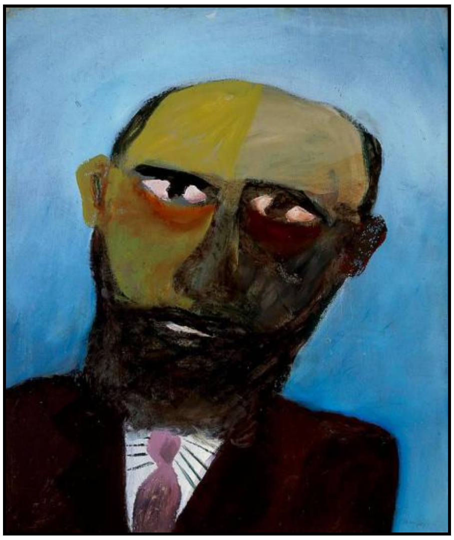


Figure 190. Sidney Nolan, *Colonial head*, 1947. Ripolin enamel on hardboard, 76.2 x 65.5 cm. Collection: Art Gallery of New South Wales, purchased with funds provided by the Art Gallery Society of New South Wales 2001. © Trustees of the Sidney Nolan Trust

The dark grey ground layer was left as part of the image in areas such as the right proper eye and gives a dark tonality to the pale blue background. The pale blue background has been modulated in tone and strength of blue throughout. The blue background has been applied over the edges of the face. The ears of the subject were applied last. There is a distinctive pattern of resist of the paint used on the ears over the blue background, suggesting the blue background may have been dry and formed a skin which did not key in the paint applied later. This resist effect is also present around the neck of the figure. This is a similar characteristic to the paint observed on *Self portrait* 1943 and suggests that the black in this instance may be Ripolin.

A paint sample taken from the centre of the right edge embedded in polyester resin, and polished as a cross-section clearly shows the presence of a dark lower paint layer followed by a white ground and grey ground, with the pale blue paint at the top (Figure 191). In ultraviolet light the specular fluorescence of zinc oxide is visible in the top blue paint layer and intermittently through the lower dark blue layers (Figure 192). The two ground layers give a more diffuse fluorescence.

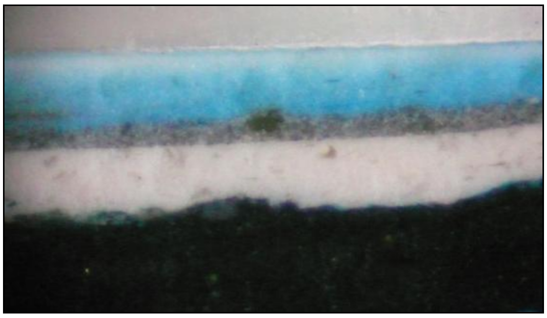


Figure 191. Mounted cross-section of paint from blue background at centre of right edge of *Colonial head* 1947, incident light x 200 . Photo: Paula Dredge

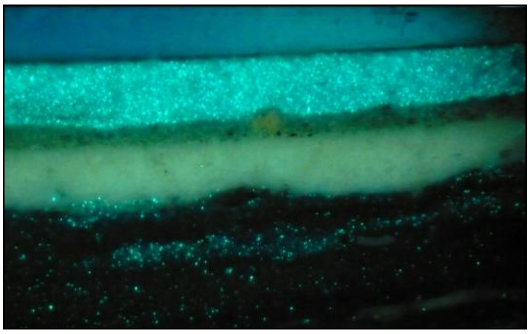


Figure 192. Mounted cross-section of paint sample from blue background at centre of right edge of *Colonial head* 1947, ultraviolet illumination x 200. Photo: Paula Dredge

Paint layers, including the dark blue lower underpainting all gave results consistent with the use of Ripolin paint when examined with FTIR (Table 5.14). The blue sky was identified as oil, Prussian blue and zinc oxide (Ripolin blue PE5), the red paint on the ear was consistent with toluidine red and barium sulphate (Ripolin red 16) and the transparent dark blue strips on the shirt was found to be oil, Prussian blue and zinc oxide.

The white ground when analysed with FTIR spectroscopy gave a result for the presence of barium sulphate and talc, very similar to the FTIR spectral results for the ground on *The camp* 1946 and the lower ground on *First-class marksman* 1946. The FTIR spectrum of the upper grey ground layer on *Colonial head* was dominated by the addition of calcium carbonate (chalk) seen in the FTIR spectrum as the large peak at 1420cm^{-1} with smaller peaks at 876, 1794 and 2513cm^{-1} (Figure 193).

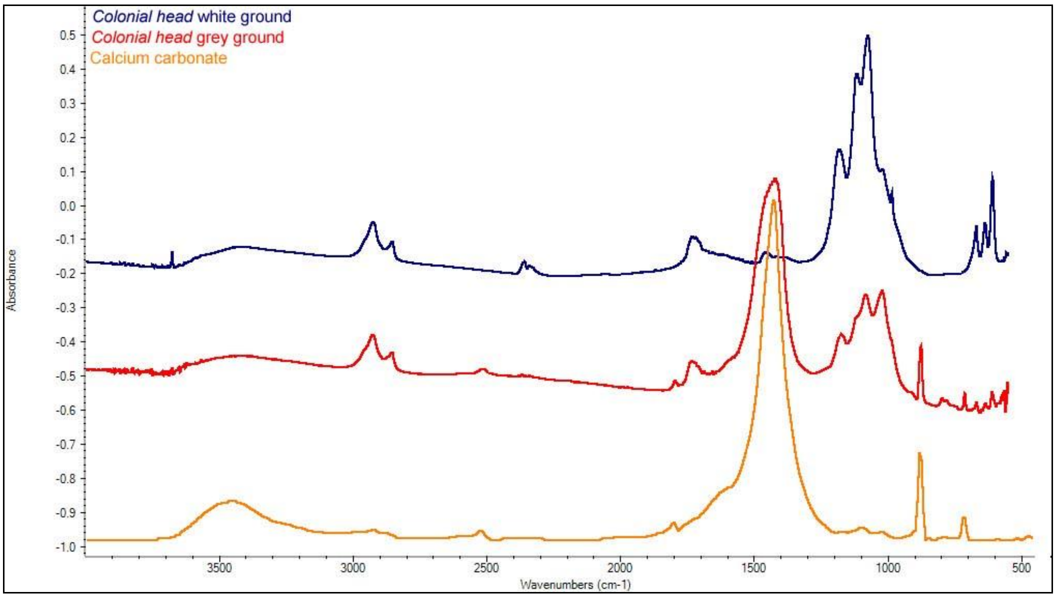


Figure 193. FTIR of white and grey ground layers from *Colonial head* 1947 and calcium carbonate (© Nicolet Instrument Corp., 1991-1994). Photo: Paula Dredge

Table 5.14 *Colonial head* analytical results

Colonial head	Binder (FTIR)	Pigment (FTIR and SEM-EDX)
Ground lower white	Obscured	Barium sulphate, magnesium silicate
Ground upper grey	Obscured	Calcium carbonate, barium sulphate
Gloss blue sky	Oil	Zinc oxide
Gloss red ear	Obscured	Barium sulphate, toluidine red
Dark blue stripes on tie	Oil	Prussian blue, zinc oxide
Dark blue underpainting	Oil	Prussian blue, zinc oxide

5.10 Summary of analytical findings from three paintings from 1946-1947

The results of the three case study paintings dating from 1946 and 1947 demonstrate the importance of noting the location of samples examined with FTIR; not only in a position across a painting but also within the layer structure. Paintings are multilayered structures and analysis of lower layers can be critically revealing of artist process. FTIR sampling from the surface of these paintings would have failed to recognise that the alkyd black paints on the Kelly figures were over a previously painted black figure in oil-based paint. Although we are unable to assign the two black paints used to Ripolin or Dulux specifically from the analysis of the black paints alone, it does appear that Nolan worked across both paintings in oil enamel that has pigments consistent with those found in the Ripolin cans. He then reworked both Kelly figures in an additional layer of alkyd-based paint. The reason for this probably lies in the different working properties of the two paints. The liquid, slow drying nature of the Ripolin would have been difficult to control within a sharply defined edge such as that of the Kelly armour. Additionally, when used over an already dry Ripolin paint film, the black Ripolin appeared to resist the surface pooling and separating as seen on *Colonial head* 1947 and *Self portrait* 1943. Paint-outs from the can of Ripolin black 1105 as shown in Figure 86 also formed wrinkling that would have been visually unsatisfactory in the depiction of the smooth high-gloss surface of the Kelly armour. In fact paint film wrinkling can be seen in the texture from the lower layers of the Kelly armour on both paintings suggesting that the black Ripolin did wrinkle. It seems therefore that Nolan retained an interest in black alkyd paint for these reasons long after he had taken up painting with Ripolin. This is also supported by the presence of a can of black Dulux paint found within the Wahroonga studio contents.

There are however some differences in the construction of the ground layers of the two 1946 paintings of the Kelly subject. *The camp* 1946 has a single priming layer dominated by the presence of barium sulphate, where as *First-class marksman* 1946 has two priming layers. The first ground is similar to *The camp* 1946, but the second is a zinc oxide-type. Analysis of ground layers might be a useful technique in potentially grouping works which were similarly prepared for painting however, in this instance, even within paintings from similar times, there is a significant difference.

5.11 Can ground layers provide useful information for grouping and dating of paintings?

While the paint layers on the works studied give strong FTIR spectral results for the characterisation of Ripolin paint, alkyd, and nitrocellulose, the analytical characterisation of ground preparations has the potential to offer additional information regarding Nolan's use of commercial paint products. As Nolan's preference was for recycled or adapted supports rather than commercially primed artists' canvases, the ground layers are not commercially applied by artists' colourmen. During Nolan's time in the Australian Army from 1942 to 1944 Sunday Reed was preparing supports with ground layers for Nolan and sending them to him on the train. Their correspondence also suggests they may have used zinc white and titanium white with egg ground layers in the period prior to 1942.

As the ground layers are often left unpainted in areas as image layers, the ground is exposed at the surface and vulnerable to light damage and potentially also to solvent damage during conservation treatment. This is particularly problematic if the ground layers were made from cheaper paints with greater potential for ageing issues than the coloured paint layers.

While white is Nolan's usual ground layer colour, he also used grey grounds such as those on *Dimboola* 1942 and *Colonial head* 1947. There are several cans of white paint from Nolan's Wahroonga studio in the National Gallery of Victoria collection which have been tinted grey, suggesting the use of grey grounds was of ongoing interest to Nolan. One of these cans is a Dulux white undercoat (Figure 123). The outside of the can is covered in paint drips and fingerprints in white, grey and black. FTIR analysis of a white paint sample from the outside of the can gave a spectral result for the presence of kaolin and titanium dioxide. A can of white Ripolin, (similar to the 'old white' can in the Art Gallery of New South Wales group), is also in the National Gallery of Victoria collection from the Wahroonga studio. It shows signs of being tinted to grey (Figure 194). The can's contents have not been analysed, but the similar can (untinted) from the Art Gallery of New South Wales group gave results for the presence of zinc oxide, calcium carbonate, barium sulphate, titanium dioxide and aluminium silicate.

Figure 194. Can of Ripolin white 1 tinted grey from Nolan's Wahroonga studio (National Gallery of Victoria). Photo: Paula Dredge

The strong FTIR spectral response from the white pigments in the ground layers typically obscures the response from the binder in the ground layers. Without undertaking GC/MS binder characterisation the grouping of ground types is dependent upon the identification of pigment combinations. There is potential for a more detailed analytical study of the ground layers on paintings by Nolan. However, initial results from this limited survey suggest a diverse use of materials for ground layers.

What is also noted in the examination of ground layers on paintings by Nolan is those that contain zinc oxide in a mixture with other white pigments, is the presence of FTIR spectral features with sharp side peaks at $1541 cm^{-1}$ suggesting the formation of mature zinc carboxylates.

5.12 Formation of zinc carboxylates

As discussed in Chapter 4, the combination of zinc based pigments and fatty acids from oil have the potential to form zinc carboxylates (soaps) within paint films. These reactions can continue to occur within oxidised paints well after they have dried, making them a concern for the stability of paintings that have zinc oxide paint layers. Zinc soaps within oil and alkyd-based paints have been associated with increased brittleness and movement of zinc carboxylates out of the paint film onto the surface of the painting (Osmond 2012). As Nolan’s preferred paint medium from the period 1943-1953 is Ripolin, which as demonstrated is a zinc oxide paint, the tendency for this paint to form zinc carboxylates is of critical interest. However, there has been little evidence of instability in Nolan’s Ripolin paintings to date, with no known cases of surface transformation by soap migration from the paint film.

Many of the Ripolin paints kept sealed and liquid in the cans and painted out for this study, showed signs of zinc carboxylate formation in the form of hard circular lumps within the paint. When examined with Synchrotron source FTIR, these aggregates were identified by the FTIR peaks at 1551 and 1533cm^{-1} and a shoulder at 1597cm^{-1} as zinc oleate (zinc 9-octadecenoic acid). As suggested by Corbeil, Helwig and Poulin (2011) oleaic fatty acids are usually consumed during oxidation and are not represented in well-dried and oxidised paint films. Therefore, the formation of zinc oleate is likely to be due, in the case of the paint in sealed cans, to the lack of oxidation. Samples of zinc oxide paint taken from actual paintings by Nolan, show a different result in the examination of the carboxylate region with FTIR analysis. Typically samples of Ripolin paints sampled from paintings by Nolan give a broad carboxylate region peak between 1550-1600cm^{-1} without sharp side peaks representing formation of specific species of zinc carboxylates (Figure 195). Osmond et al. (2012) describe these non-specific broad carboxylate peaks as carboxylic acid moieties. The correlation of Ripolin paint samples examined with FTIR spectroscopy with cross-sections suggest that in this form, the carboxylic moieties are broadly distributed within the paint film.

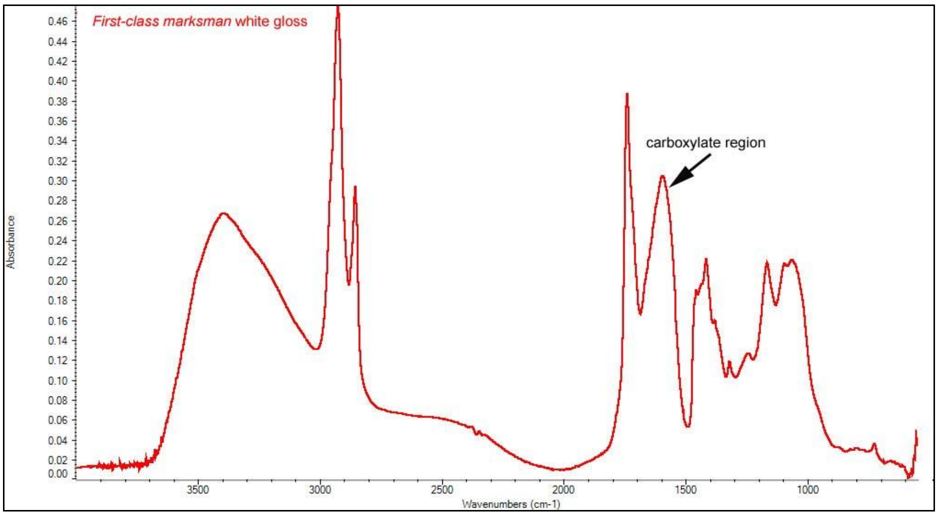


Figure 195. FTIR of sample of white gloss paint from *First-class marksman* 1946 showing broad carboxylate region. Image: Paula Dredge

It is when the more specific and mature form of zinc carboxylates are detected in FTIR spectroscopy by sharp peaks in the carboxylate region, specifically zinc stearate which is seen at 1541cm^{-1} , that the circular masses of low mass material is correspondingly seen in cross-section samples. The formation and movement of lumps within a dry and mature paint film has the potential to create problems in the surface texture of paintings either by cracking and breaking open the paint layers above, or by the migration of the soap aggregates through the structure of the painting.

Although these features have not been observed on the Nolan's paintings, when the lower ground layer from *First-class marksman* was examined with FTIR a sharp side peak was present in the spectrum in the carboxylate region at 1541cm^{-1} indicating the presence of zinc stearate (Figure 196). The FTIR spectrum is dominated by the presence of barium sulphate and magnesium silicate but a small carboxylate broad peak region is present with a sharp side peak at 1541cm^{-1} peak suggesting that zinc stearate has been formed in this paint. Studies suggest that specific zinc carboxylate species and aggregation within zinc oxide-based paint films occurs more readily in paint films that contain other metallic oxides in addition to zinc oxide (Osmond et al. 2012) such as those found in the ground layers of paintings by Nolan.

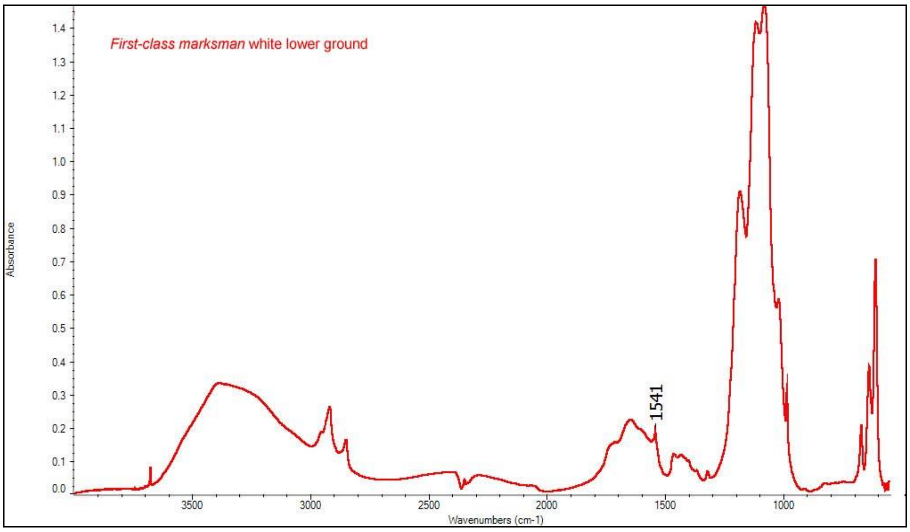


Figure 196. FTIR of lower ground layer sample from *First-class marksman* 1946. Image: Paula Dredge

An initial study to examine the mixed pigmented ground layer containing zinc oxide on a painting by Sidney Nolan was undertaken with Infrared Spectroscopy mapping on the Infrared Beam-line at the Australian Synchrotron.

5.12.1 Case study 14: *Burke and Wills expedition, 'Gray sick'* 1949

A painting by Nolan dating from 1949 provides a useful case study for the formation of zinc stearate in a ground layer. *Burke and Wills expedition, 'Gray sick'* 1949 (collection: Art Gallery of New South Wales) is painted on the smooth side of a sheet of Masonite (Figure 45). The medium description for this painting reflects the mistaken cataloguing of Ripolin paint as synthetic polymer paint. The coloured areas all match well with Ripolin paint apart from the red paint in the foreground, which was not identified with FTIR spectroscopy.

The Masonite was prepared with a white ground layer that consists of zinc oxide, barium sulphate, titanium dioxide and calcium carbonate. The binder could not be identified due to the dominance of peaks relating to barium sulphate in the fingerprint region. This FTIR pigment analysis matches that of the old can of Ripolin paint from the Wahroonga studio and may reflect Nolan's use of flat Ripolin paints for ground layers. The ground layer demonstrates the sharp peak in the carboxylate region at $1541 cm^{-1}$ suggesting that zinc stearate had formed within the ground layer (Figure 197).

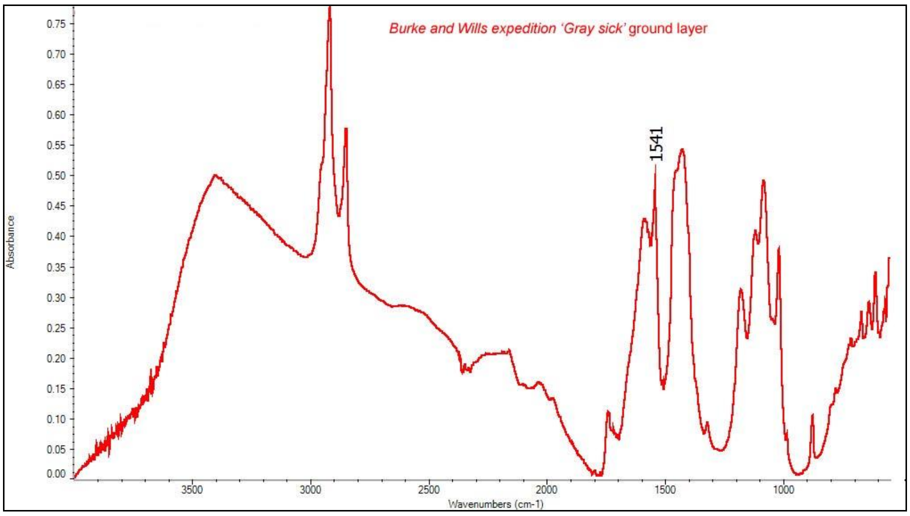


Figure 197. FTIR of ground from *Burke and Wills expedition, 'Gray sick'* 1949. Image: Paula Dredge

A cross-section example shows the white ground layer with the thin red paint layer from the foreground above and the Masonite panel below (Figure 198). Areas of clear spherical forms are evident throughout. Under SEM backscattered imaging of the cross-section these appear to be of low mass material, typically observed in zinc oxide paint films with soaps (Figure 199).

Figure 198. Incident light cross-section sample from foreground *Burke and Wills expedition, 'Gray sick'* 1949 x 400. Photo: Paula Dredge

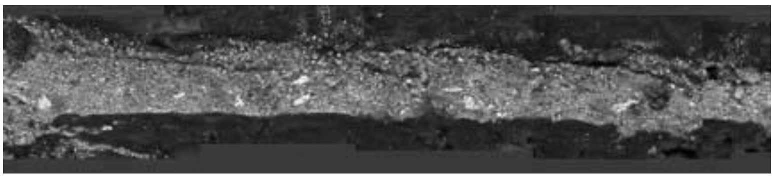


Figure 199. Cross-section sample viewed in backscatter mode in SEM from foreground *Burke and Wills expedition, 'Gray sick'* 1949. Photo: Richard Whurer

FTIR mapping of a thin section of this same sample with the Infrared Beam-line at the Australian Synchrotron confirms the association of the low mass areas visible under backscattered mode, with the 1541cm^{-1} zinc stearate peak (Figure 200).

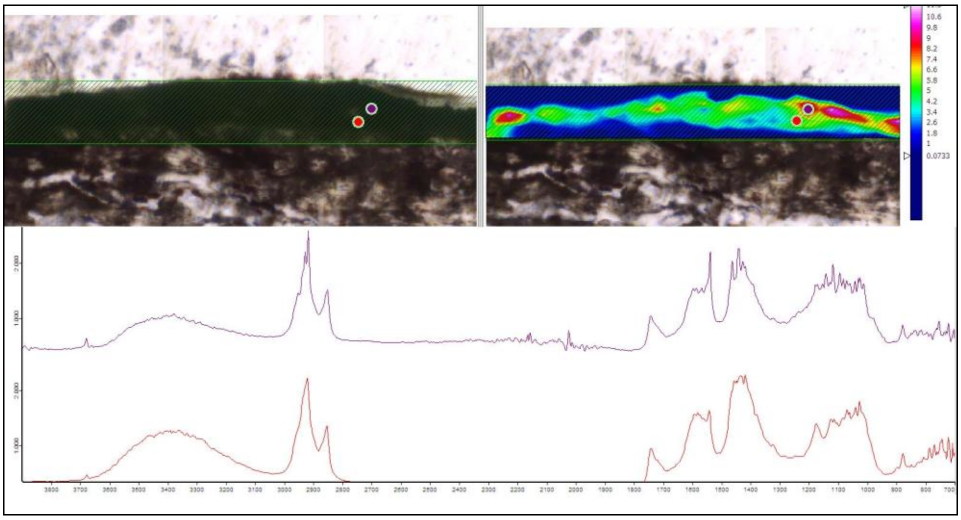


Figure 200. Australian Synchrotron Infrared spectral map of sample from *Burke and Wills, 'Gray sick'* thin section. Spectral peaks at 1550-1530 integrated in mapped area indicated upper left and showing relative peak heights at right (highest pink/ lowest blue) and two typical FTIR spectra from different areas of sample indicated at upper left. Image: Paula Dredge & Gillian Osmond

These IR maps suggest that it is the mixed white pigments present in the ground layers of paintings that form aggregates of zinc stearate associated with problems of brittleness and instability, rather than the more pure zinc white pigment in the gloss Ripolin paint layers.

5.13 Conclusion

The results of the analysis of paint samples from fourteen paintings by Nolan are given in Table 5.15. Those results that differ from the original medium descriptions as catalogued prior to the analysis, are outlined in bold.

Table 5.15 Media descriptions after analysis (changes from Table 5.1 noted in bold)

Painting title	**Inscribed date**	**Catalogued date**	**Medium description**	**Collection**
Head of Rimbaud		1938-9	Oil and boot polish and pencil on cardboard	Art Gallery of NSW
Untitled-abstract		c.1939-1940	Oil on photograph	Art Gallery of NSW
Luna Park		1941	**Nitrocellulose** on canvas	Art Gallery of NSW
Bird	Dec 1941		**Nitrocellulose** on cardboard on composition board	Heide Museum of Modern Art
Dimboola	5 Dec 1942		**Alkyd resin** on cardboard	Heide Museum of Modern Art
Waterwhee,l Luna Park		1942	**Alkyd resin** on composition board	Heide Museum of Modern Art
Wimmera landscape (landscape with train)		**1943**	Ripolin enamel on composition board	Heide Museum of Modern Art
Head Dimboola	4 Jan 1943		**[unknown]** on composition board	Heide Museum of Modern Art
Self portrait	March 1943		Ripolin enamel on hessian sacking	Art Gallery of NSW
Bathers	14 April 1943		Ripolin enamel on canvas	Heide Museum of Modern Art
First-class marksman	12 Dec 1946		Ripolin enamel **and alkyd resin** on hardboard	Art Gallery of NSW
The camp		1946	Ripolin enamel **and alkyd resin** on hardboard	Art Gallery of NSW
Colonial head	4 April 1947		Ripolin enamel on cardboard	Art Gallery of NSW
Burke and Wills expedition, 'Gray sick'	30 November 1949		**Ripolin enamel** and oil-based red ochre on hardboard	Art Gallery of NSW

The results show that the unusual medium of nitrocellulose was found on two paintings dating from 1941. Two works from 1942 were found to be alkyd resins; although the pigments detected suggest that they may not have been the same brand of alkyd paint. The work outlined in this chapter helps to broaden the picture of Nolan's use of alkyd paints and assists attempts to associate results with different pigments that may indicate brand. Investigation of a larger group of paintings by Nolan dating to 1942 would be a useful further study. As Nolan is the earliest artist yet identified to used alkyd paint, his paintings offer a unique dataset for early alkyd paint production. The finding of PE alkyds on several paintings dated 1946 is particularly surprising and suggests Nolan may have sought post war alkyds to resolve some of the difficulties he encountered in the use of black Ripolin for the figures of Kelly. Apart from this specific use of an alkyd on the Kelly paintings, after January 1943 the analysis is fairly consistent with a result for the presence of Ripolin oil enamel.

The analytical study of fourteen paintings by Nolan re-examines the question of medium descriptions. It does not offer a meticulous study of every paint type on each painting and it not intended as a complete description of the artist's working methodology and materials. It is hoped this study offers conservators the tools to be able to effectively assess the results of analysis of Nolan's paintings combining historical and instrumental types of analysis to the challenging issue of identifying Nolan's wide ranging and eclectic use of materials and techniques.

FTIR is demonstrated by this preliminary analytical study to be an effective tool for the identification of three commercial paint types; nitrocellulose, alkyd and oil based Ripolin enamel on paintings by Nolan. This is because, unlike artists' oil paints, commercial paints have a high proportion of binder which increases the response of the binder to FTIR spectroscopy. In addition, the primary use of zinc oxide in the Ripolin paint does not confuse the FTIR spectrum in the critical fingerprint region that is used to characterise the binder. The use of lead white and other types of fillers commonly found in artists' paint are more problematic in this regard.

There are a number of issues related to the use of FTIR as the primary analytical technique for identifying these commercial paints. Surface scrapings of paint films may not be representative of the paint film due to settling and layering of components. This is demonstrated by the finding of alkyd paint used on the two Kelly figures that were found to be painted over an earlier version in oil-based enamel (probably Ripolin). Cross-section samples are, therefore, a good partner technique to ensure the more complete mapping of the paint structure.

Cross-sections can be examined with SEM-EDS to effectively determine the inorganic metallic pigments. This is a better technique for the mapping of inorganic pigments present, particularly for non-Ripolin paints that may have a complex mixture of base white pigments and fillers. It also allows for comparison of morphology of pigments. The use of thin cross-sections on the infrared beam-line at the Australian Synchrotron is also a powerful tool to map the presence of different types of binders and the development of zinc soap aggregates within paint layer structures.

This chapter has demonstrated that Ripolin paint can be identified on paintings by Nolan by the presence of oil binders and the use of pigment combinations that are consistent with the analysis of pigments in the can of paint from the Wahroonga studio. Ripolin paint was detected on seven paintings all dating after February 1943. These results support the premise that the archival records of Nolan's correspondence and the diaries of Sunday Reed are true records of Nolan's use of Ripolin dating after January 1943. Alkyd paints were detected on two paintings from 1942. This is the earliest use of synthetic paint by any artist yet reported. Two paintings dating from the late 1930s have characteristics physically and analytically that suggest they were painted in typical artists' oil paints. This discounts the premise that Nolan was unfamiliar with the use of artists' paints.

The following chapter brings together the evidence of the analytical results from paintings studied in this chapter, with the historical information gathered in the previous chapters, to build an interdisciplinary understanding of Nolan's significant technical innovations in his choice and use of commercial paints.

Chapter 6. The final structure

> ***It is true that I have adopted, or been compelled, or made a decision to use a primitive technique but I do not know that I consider it a final technique. It has been the means of my painting education; no other, or so I believe, was open to me; but I still conceive of it as a scaffolding, part of the conception of the final structure, but not necessarily finally visible.***
> (Nolan 2 April 1952)

This thesis has made some significant new findings in regards to Nolan's use of commercial ready-made paints. Nolan's take up of nitrocellulose, alkyd and Ripolin enamel paint places him within a very small group of artists using these materials prior to the Second World War. While art historians and curators have been intensely curious about Nolan's use of commercial paint, particularly Ripolin, it has not previously been possible to unravel the complex terminology, historic records and results of analysis without the broad interdisciplinary approach offered in this thesis.

What emerges from the study is that this was a deliberate choice of materials made by Nolan. These were the types of paints that he preferred for their fast-drying, inherent glossiness and matteness and reduced textural features. This was not a strategy to avoid the technical by the use of ready-made materials. In fact Nolan was intensely engaged in the details of these paints and sought information directly from paint manufacturers and undertook experiments with additives. As outlined in Chapter 3 and 4, commercial paints were complex multi-component materials, and Nolan's understanding of these details is evidenced in his letters to Sunday Reed.

6.1 Scaffolding

This thesis began with the aim of addressing a number of problems in defining Sidney Nolan's use of commercial paints. These were in particular, the difficulty of cataloguing media descriptions of paintings dating from the early part of his life from

1938 up to his departure for England in 1953. As discussed in Chapter 2, Nolan's correspondence from the period 1942 to 1944 suggested that he may not have used Ripolin paint until 1943, although this is contradicted by an interview he gave in 1960 in which he stated he had been using it from at least 1942 and paintings have been catalogued as Ripolin from 1939. The Nolan correspondence further suggested that he may have been painting with Dulux, Dynamel and Duco prior to 1943. Diaries maintained by Sunday Reed in 1942 and 1943 supported the premise that Dulux was Nolan's principal medium for painting in 1942, prior to Nolan receiving a consignment of Ripolin from her at the end of January 1943. The question to be addressed was whether features of these different brands of paint could be found to assist with their identification on paintings by Nolan.

Historical studies of Ripolin and Dulux as produced in France (Koussiaki 2003) and the USA (Standeven 2006) suggested that there was a critical difference between these brands of paint that Ripolin was oil-based enamel whereas Dulux was synthetic paint based on an oil-modified polyester resin called alkyd. Duco, properly called a semi-synthetic, was made from nitrocellulose (Standeven 2006). A study of the Australian paint industry in Chapter 3 alongside the analysis of a number of cans of both of these products in Chapter 4 demonstrated that both Dulux and Duco were manufactured under licence in Australia from the late 1920s and utilised the same binders as the products offered in the USA. Analysis undertaken on cans of Ripolin from Nolan's Wahroonga studio (Chapter 4), alongside the historical evidence of Nolan taking up Ripolin in 1943 (Chapter 2) and the finding that pure zinc oxide paints were unusual in Australia (Chapter 3), suggests that Ripolin can be confidently identified on his paintings, although it may not be sufficient in the study of the work of other artists without associated historical documentation.

Analytical examination of the cans of Ripolin paint confirmed that Nolan's English-made Ripolin was oil-based paint. Gas chromatography/mass spectroscopy analysis undertaken on the gloss Ripolin paints from Nolan's studio found that the oil in the white gloss Ripolin contained castor oil, but the lack of the castor oil markers in the other tints and the ratio of palmitic to stearic fatty acids suggest the inclusion instead of either linseed or tung oil, or possibly a mixture of the two. The oils and resins also exhibited signs of heat treatment, indicating that the oil was thickened by heating and that the resins were melted, and possibly modified, prior to addition to the oil. Cobalt and manganese driers were also detected by the presence of metal ions, particularly in dark colours. The use of heat-bodied oil and resins is typical for oil-based enamel paints of the period and is the secret to the high-gloss self-levelling features that Nolan admired. The pigments used in English Ripolin are high-tinting colours typical for commercial paints of the period, Prussian blue, copper phthalocyanine, toluidine red (PR3), carbon black, bone black, alizarin on calcium carbonate, and three types of chrome yellow; lead chromate, lead chromate modified with lead sulphate, and basic lead chromate. The white pigment was principally zinc oxide, although small amounts of titanium dioxide (anatase) were also detected in some colours. Barium sulphate was present in a number of colours offering body to the paint without lightening the tint. By the 1940s Ripolin was already an old fashioned type of paint that was rapidly being superseded by alkyds, an oil modified polyester that dried faster and gave a more durable finish. Ripolin nevertheless maintained its position as high-grade gloss paint because of the use of quality components and a larger colour range than was on offer from locally manufactured alternatives.

A study of fourteen painting by Nolan from the period 1938 to 1949, were analytically tested in Chapter 5 to see if the readily available techniques of FTIR and pXRF were sufficient to distinguish between Ripolin Dulux and Duco. It found that oil binders in paintings by Nolan after January 1943 were able to be detected, particularly in those colours without strong responses from the pigments. Black paints were good subjects for the identification of binders over pigments. Comparison with the pigments found in the cans of Ripolin paint from Nolan's studio, also gave good correlation with pigments identified on paintings. The presence of toluidine red (PR3) on a base of barium sulphate, or copper phthalocyanine and barium sulphate with a broad carboxylate FTIR spectral feature (zinc oxide), are two useful colours associated with the ingredients detected in the cans of Ripolin red 16 and ultramarine 13.

Alkyd binders were detected on several paintings by Nolan dated to 1942, supporting the diary entries by Sunday Reed, that these were painted with Dulux. Nolan's use of alkyd on paintings from at least 1942 is earlier than any recorded use by an artist. Previously the earliest identified use of alkyds was on a painting by Willem de Kooning dated 1948 (Lake & Schilling 2010). The pigments detected in similar colours on the two paintings did not however provide satisfactory matches with each other to confirm that the paints were the same formulation. It suggested that Nolan may have used more than one brand of alkyd paint in this period and that the brand Dulux cannot therefore be applied to all alkyd paints identified on works by Nolan. Without an identifying marker for Dulux, a larger study group of alkyd paintings is required to confirm the presence of different brands of alkyd paints. Alkyd was also detected on two paintings of the Ned Kelly subject dating from 1946. In both of these paintings the main body of the works were executed in paints matching the content of the Ripolin cans from the studio, but the black figures of Kelly were over-painted with black alkyd paint. This alkyd over paint must have been Nolan’s as in 1947 he left Heide and Melbourne and was not reunited with the paintings he made there. The repaint in alkyd, it was suggested by this research, was due to the less satisfactory features of the black gloss Ripolin 1105 that demonstrated a tendency to wrinkle, bleed across edges, and produce a distinctive resist pattern when applied over under-painting in Ripolin.

Two paintings by Nolan dated 1941 were identified by FTIR to be painted in nitrocellulose lacquer. The medium in these paintings are visually indistinguishable from the alkyd or Ripolin paints, although they do exhibit ageing characteristics that suggest the paints are brittle and friable. Nolan’s use of nitrocellulose as a medium applied by brush in a painterly style is unprecedented, although it may have been influenced by published accounts of the use of Duco by David Siqueiros’ who more typically poured and sprayed the fast setting medium (McGlinchy et al 2013).

Ground layers applied by Nolan, (and Sunday Reed in the period 1942-44), are a mixture of white pigments in a number of combinations. It is difficult to unravel groupings of similar priming layers and this is probably due to the large number of different types of white paint that Nolan may have used for preparing his supports. The Wahroonga studio contents include a number of different types of paints that may have been used for priming including, Ripolin white and the same paint that was tinted grey, Dulux surfacer, Euston white lead in oil, Kem-Tone and lead-based oil paint that was made by Nolan and is recorded in hand written recipes. Correspondence between Nolan and Sunday Reed also suggest that he was making his own egg-tempera priming at least prior to the Second World War. Many paintings have double priming in two different types of white paint indicating that considerable attention was given to preparation of supports for painting.

Finally, issues relating to the formation of unstable and movable metallic soaps within zinc oxide-based Ripolin paint were considered and investigated. While the Ripolin paint in cans was found to have these types of aggregates when first painted out, they tend to transform and dissipate in hard and dry paint films and were associated therefore with the lack of oxidation in the cans. Gloss Ripolin on paintings by Nolan examined with FTIR exhibit a broad carboxylate group, without the sharp side peak at $1541cm^{-1}$ associated with the formation of zinc stearate. Ground layers in which a number of different white pigments were associated with zinc oxide were more likely to form zinc stearate, and may consequently create issues with mobile aggregates moving through paint films. This is a complex area of analysis that warrants further investigation.

6.2 Technique

The successful outcomes from this research are a result of the application of an interdisciplinary approach to the question of Sidney Nolan's use of commercial paint. Nolan has proved a unique case study that has left a significant legacy for research in the form of correspondence from the period, a large body of paintings and a time capsule of the contents of his studio dating from the early 1950s. These are the primary resources that have provided this study with its strongest evidence. Historical research of Nolan's developing technical interests, alongside a history of the Australian paint-making industry, was also essential for providing historical context for the results.

The research has also been timely working parallel with the concurrent international project investigating French-made Ripolin and earlier research on the history of the development of synthetic paint binders in the USA and the UK The increasing availability of bench-top μ-FTIR and PXRF systems has impacted on the ability to analyse binders and pigments. These systems are well suited to the analysis of commercial paint products due to the high proportion of binders that makes the pigments less dominant in the analytical results compared to artists' paint. More expensive and dedicated instrumental systems such as gas chromatography/mass spectroscopy, Raman spectroscopy and SEM (Scanning Electron Microscopy) have been essential tools to unravel the complex formulations of the Ripolin and alkyd paints. These, however, require the expertise of dedicated conservation scientists and are beyond the resources of most conservators and curators wanting to test questions of paint media for cataloguing purposes.

Ripolin is particularly compatible with FTIR due to the use of zinc oxide that has a minimal response to infrared, reducing the problem of overlap of spectral features from pigments. It is important to note however that there are limitations to the use of surface scrapings of paint examined by FTIR. The principal limitation is the recognition that paintings are complex multilayered structures that do not necessarily reveal their structure at the surface. An additional problem may occur if paint films are very thin and cannot be separated from ground or varnish layers as occurred with the examination of one painting in this study. Cross section samples are valuable guides to ensure a full testing of the materials has been undertaken. The paintings by Nolan provide particularly good subjects for minimal sampling and testing, as he worked in a limited range of colours and did not build up complex multilayered structures.[13]

The study of the Australian commercial paint industry clarifies the distinction between the different brands of paint available in Australia and their binders. An analysis of the nomenclature used by paint companies to describe these binders has assisted in the interpretation of the terminology used by Nolan in his letters dating from the early 1940s. The associated study of Nolan’s correspondence alongside the scientific analysis has given support to the proposition that Nolan’s first use of Ripolin was in February 1943, not 1939 as previously recorded.

Nolan’s painting practice is an unusual technical case study, as when he took up a new medium he tended to abandon the old, rather than simply incorporate a new technique or material into his practice. In fact he enjoyed new media and having to adapt his practice. Nolan’s engagement with his materials and his love of a technical

[13] For example the paintings by Nolan’s contemporary, Ian Fairweather provide a very different type of analytical challenge due to the multi-layered structures of his paint films (Macnaughton 1996).

challenge is well described by Albert Tucker in an interview dating from 1979. Tucker recalls Nolan's take up of polyvinyl acetate in 1957.

> I put him onto the polyvinyl acetate. He dropped all the medium he was using, his ripolin and so on. When he went out—he is a more organised man than I am—he quickly tracked down one of these firms and got this in. He threw out all his other stuff...
> (Tucker 1979).

This tendency of Nolan's to abandon old techniques and materials in favour of new, provides this study with an unusual opportunity to date materials and their use by Nolan to specific time frames. The ability to distinguish different materials on his paintings is a useful technique for potentially providing date markers to his paintings, bearing in mind that there are anomalies, such as his continued use of black alkyd paint long after receiving the Ripolin in 1943.

A larger analytical study of Nolan's paintings dating from the early 1940s would provide a more secure dataset for the dates of use proposed by this thesis. The ability to unravel some of the contradictions outlined in Nolan's historical biography rests on a substantial analytical study of his paintings that is beyond the capabilities of this thesis. Ultimately the analysis of individual paintings is the necessary work that must be undertaken by the holders of Nolan's paintings to build an understanding of the artist's engagement with a broad range of materials. It is hoped that this thesis assists with identifying that need and the possibilities for understanding and interpreting results in the context of Nolan's practice and the availability of materials in Australia.

6.3 Conservation concerns

Ralph Mayer in *The artists' handbook of materials and technique* (1970) is clear in his warning to artists in the use of commercial materials for permanent painting.

> The experimental painter for whose special requirements none of the traditional painting materials seem to be ideal, longs to explore this field, and before such products were made expressly for artists, he sometimes turned to industrial paints on the market, such as the Duco-type lacquers, the bright household enamels, and the mat finish interior wall paints — excellent products, but all foredoomed to failure because they are not intended for artist's use.
> (Mayer 1970 p. 198)

Even though this warning was not present in the 1940 edition of the book where Nolan would have read it, it is unlikely that Mayer's warning would have been of interest to Nolan. An awareness of commercial paint products and their vulnerability to ageing was probably in fact their attraction to Nolan in the late 1930s when he enjoyed the idea of impermanence (Nolan & Smith 1962).

Nolan's interest in fugitive materials appeared to have undergone a change by 1942. It may indeed have been the influence of Sunday Reed who brought about this changed attitude in her vision for Nolan's paintings creating a permanent record of a modern landscape. Despite Nolan's own proclaimed interest in permanent materials, he does not appear to have fully subscribed to the new approach, as war shortage and the necessity for effect were contrary drivers. In the same letter as he speaks of his preference for Dulux as the most durable paint, he also asks for aniline dyes even though he acknowledges their potential vulnerability.

> An ounce of the dye goes a long way, amongst other things it works well in Nucraft, so it is a good investment in spite of being, so they tell, very fugitive.
> (Nolan 22nd October 1942, p. 3)

The long term permanence of commercial paints when used on paintings has not been fully researched. Paint companies undertook extensive testing of their products to ensure good outcomes when used for painting houses or cars (Figure 201), but permanence for that use is only seen in terms of ten years. However, neither is outside weathering and high ultraviolet light exposure the norm for artworks kept inside. These very different environmental exposures between paintings maintained in museum conditions compared to paints on the outside of buildings makes it inappropriate to compare the results of ageing tests from studies of paint companies to those of art works.

Figure 201. Wolfgang Seivers, *Pigment analysis and paint testing activities, Balm Paints Research Laboratories, MacNaughton Road, Clayton*, 1961, silver gelatine photograph, 19.8 x 24.5 cm. Collection: State Library of Victoria, H2000.195/209.

Without systems for measuring unaged paintings for comparison with the same works re-examined seventy year later, there is no objective measure for documenting how Nolan's paintings might have changed over time. A visual examination of his paintings in Ripolin oil enamel suggests they have aged extremely well. Although vulnerable to scratches that mar the surface of the painting, they have preserved their gloss. There is no evidence of zinc soaps emerging from the paint despite the presence of the two primary ingredients for this to occur; oil and zinc oxide. This study has demonstrated that zinc soaps are present in the gloss Ripolin colours, but that they retain their distributed form within the paint films. Aggregation of zinc soaps may be present in the ground layers and in the matte Ripolin paints, but these have not to date been identified as issues on the paintings. The identification of copal resin is also reassuring for future solvent treatment of Ripolin paintings as it is a hard and insoluble resin. The presence of colophony in some of the colours is more concerning as this has been identified as a cause of traction cracking which developed on paintings by Colin McCahon (Hillary et. al. 2007). However, colophony can be added to paint in a number of forms that have different properties. Harriet Standeven (2011) suggests that ester gum for instance is more stable than untreated colphony. Although it has not been established in which form the colophony is present in the Ripolin it does not appear to have caused issues with traction cracking on paintings by Nolan.

Whether the pigments in the Ripolin are permanent is less certain. Prussian blue, copper phthalocyanine and carbon and bone blacks are all used in artists' paints and are considered to have good permanence. Lead chromate is sometimes associated with blackening, and the toluidine red on the lids of the cans of Ripolin red 16 has darkened due to exposure to light and the environment. There are no examples of paintings in Ripolin by Nolan where darkening of the yellows or red appears to have occurred. In fact the Ripolin paintings have survived extremely well.

Alkyd paints were considered superior to oil enamels for durability, and these too on paintings by Nolan appear to be in excellent condition. Standeven (2011) suggests that alkyds may be vulnerable to highly alkaline water-based cleaning but are otherwise extremely stable materials. It is the paintings executed in nitrocellulose lacquers that are of greatest concern. Nitrocellulose is considered to be unstable when exposed to relatively low light levels and heat. Certainly the use by artists of nitrocellulose as a plastic solid has led to some spectacular changes in the medium; discolouration and brittle failure. As paint however it appears to have aged better. The two examples identified in this study, *Bird* 1940 and *Luna Park* 1940, are both in fair condition. Although they have brittle craquelure, they are remarkably well preserved with little apparent yellowing.

6.4 Visibility

Exploring the motivations for Nolan's use of these materials expands discussions regarding his developing iconography, not previously fully explored without this background research of technical understanding. While technology offers new readings on Nolan's aesthetic decisions in his painting process, the paintings themselves, as survivors of their period, offer subjects with precise dates for scientific analysis of paints for historians and conservators working in the area of decorative paint finishes. Similarly developing a history of the Australian paint making industry informs the scientific analysis of the paintings. The reading of Nolan's correspondence that describes these materials also offers an increased understanding of the limitations of material availability, particularly during the Second World War, and demonstrates how artists adapted to this limitation. There is a story embedded within Nolan's history that speaks of the developing influence of advertising and commercial art for artists from the 1920s, in which bright, glossy and sparkling paints were used to represent glamour and incite desire. An increasing number of artists came forward from a background in the commercial arts, bringing with them experience with non-artist type paints.

A history revealed through the study of Nolan's technical engagement with commercial paint is that of the technological advances in chemistry of paint-making occurring through the interwar decades. The movement away from naturally sourced paint binders and pigments and solvents to those synthetised in factories from coal and petroleum products was liberating for paint-makers and offered artists new possibilities for bright liquid paint. Synthetic materials were of controlled quality and could be sourced close to home, rather than leaving paint-makers dependent upon colonial exploitation and seasonal or political changes. This history of paint manufacture parallels in many ways Nolan's own experiences in 'making-do', adapting to the changing limitations of the time but forging a new identity in the wondrous world of plastics and synthetics. Nolan and Reed spoke during the war of 'reconstruction plans' and this is where Nolan saw it- in the bright world of plastics and new materials, not in traditional artists' oil paint.

The question as to whether Nolan really knew what was in his paints or simply chose materials that suited his painting method is difficult to answer. The paint industry did not promote their paints to consumers by their components. Although the terms nitrocellulose, alkyd and oleoresinous were used in the trade literature, they were more commonly described on their labels as either lacquer, synthetic or enamel. Nolan's background working in commercial art practices and his deliberate pursuit of information which is evidenced by his visit to the Reichhold plant in 1952 and the deliberate use of alkyd on the black Kelly figures, suggest that he had both the technical background and engagement with the properties of his paints to make the distinction between the three different types of gloss paint.

Why Nolan himself did not speak of his use of nitrocellulose in later discussions regarding his materials is also unclear. The highly volatile and powerful odour of the solvents used in nitrocellulose paints compared to turpentine used in enamels and alkyds, would have made the difference between the paints evident. Arthur Boyd, in writing about his painting materials that he used in the late 1930s and 1940s, was careful to note that he had painted with 'amyl acetate' on only one early bride painting[14] (Boyd c. 1980s). Boyd began to make his own oil paints grinding pigments into stand oil and wax in about 1940 in response to the non-availability of materials and a desire to control the properties of his paints. Although driven by similar pressures to Nolan, Boyd's response was different. Perhaps Boyd's anxiety about nitrocellulose paint driven by its reputed poor longevity, may also have been Nolan's reason for his silence on the subject when later discussing his materials.

Commercial gloss paints created paintings with very particular surfaces and effects that could not be achieved by the use of standard artists' materials. It gave rise to artworks with specific visual effects which were unlike any that had come before and they were greatly admired (and criticised) for these. Nolan became a virtuoso in his medium of choice and performed tricks that few could match, in painterly effects of colour and gloss and liquid effects, but all with incredibly flat and textually subtle surfaces.

[14] Amyl acetate was the solvent commonly used in nitrocellulose paints and Boyd uses the name of the solvent to describe nitrocellulose paint.

At the heart of these concurrent histories and scientific studies is the relationship of an artist with the process of painting. As described by David Bomford (2008) in the introduction to this thesis, this is the core we seek in undertaking technical art history. We are attempting to recover that moment that the artist picked up their brush. This is of course a richly rewarding endeavour and one that has shown itself in this thesis to illustrate new ways of understanding Nolan's motivations and intentions in making his paintings. It is an invitation to an intimate and private moment, but one eventually that we can only hope to come within striking distance of unravelling. The creative process remains a mystery. As Nolan himself wrote 'the final structure — but not necessarily finally visible' (Nolan 1952)

Figure 202. Sidney Nolan in the Wahroonga studio 1949. Photo courtesy Jinx Nolan

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Appendix i. List of works received by Sunday Reed 1942-1943 (diary record)

Sunday Reed diary entries

Sunday Reed diary title	**Sunday Reed diary date**	**Sunday Reed diary medium description**	**Sunday Reed diary dimensions (w x h) imperial [metric][15]**
Lightning	31 Oct 1942	Lacquer	
Going to school	10 Nov 1942	Painting. different treatment	
Little Desert evening	13 Nov 1942	Lacquer	Tiny
Dream of Cahius Sitlu	Received 5 Dec 1942	Masonite	
Boat (called factory)	9 Dec 1942	Dulux painting	
Latrine sitter	9 Dec 1942	Dulux painting	
Bathers	9 Dec 1942	Dulux painting	
Dimboola	9 Dec 1942	Dulux painting	
Head	9 Dec 1942	Dulux painting	

Suggested related work

Catalogued title	**Collection**	**Catalogued date**	**Catalogued medium description**	**Catalogued dimensions (h x w) cm**
Lightning Dimboola	Heide Museum of Modern Art	1942 (inscribed 31 Oct 42)	Synthetic polymer on paper	
Going to school	National Gallery of Victoria	Inscribed 10 Nov 42	Enamel on tissue paper on cardboard	42 x 57.7
Factory	Heide Museum of Modern Art	Inscribed 4 Dec 42	Synthetic polymer paint on cardboard	
Latrine sitters	Private collection	Inscribed 5/12/42	Ripolin enamel on pulpboard	
Bathers	National Gallery of Victoria	1942	Enamel paint on cardboard	64 x 76.2
Head of soldier	Australian National Gallery	Inscribed 6/12/42	Enamel on cardboard	

[15] Diary records by Sunday Reed describe works in imperial measurements [converted to metric]. Reed also describes works width x height, but cataloguing conventions give height x width

Factory	9 Dec 1942	Dulux painting	smaller
Landscape Dimboola (un named undated see letter 'red heart)	Received 22 Dec 1942		
Tattooed man (undated)	Received 22 Dec 1942		
Glad morning (undated) with Wail on other side	Received 22 Dec 1942		
Railway bridge	Received 22 Dec 1942. Dated 23rd	Dulux Masonite	3'x2' (61 x 92 cm)
Farmer's wife	26 Dec 1942	Dulux Masonite	3'x2' (61 x 92 cm)
Head Dimboola (other side Water wheel)	4 Jan 1943	Dulux Masonite	3'x2' (61 x 92 cm)
Waterwheel-Luna Park	5 Jan 1943	Dulux Masonite	3'x2' (61 x 92 cm)
Dimboola	5 Jan 1943	Dulux board	30' x 25' (75 x 63)
Nhill	Received 8 Jan 1943[16] Dated '43	First Ripolin canvas	23' x 19'
Head (destroyed) (First dissonance	6 Feb 1943	Ripolin	

Farmer's wife, Dimboola	Heide Museum of Modern Art	Inscribed 26/12/42	Enamel on composition board	
Head Dimboola (red man)	Heide Museum of Modern Art	Inscribed 4/1/43	Enamel on composition board	
Water Wheel Luna Park	Heide Museum of Modern Art	1942	Synthetic polymer on composition board	61 x 92
Dimboola	Heide Museum of Modern Art	Inscribed 5/12/42	Synthetic polymer on cardboard	62 x 75

[16] **Problem date. Should be Feb not Jan. Second 1943 diary noted first Ripolin painting received 5th Feb 1943**

worker)			
Troop train [at Nhill]	9 Feb 1943	Ripolin Masonite	3’ x 2’ (61 x 92 cm)
Kyata	9 Feb 1943	Ripolin Masonite	3’ x 2’ (61 x 92 cm)
Head- (Post office man)	10 Feb 1943	Ripolin board	30’ x 25’ (75 x 63)
Mirage	Received 6 Mar 1943 (undated)	Ripolin canvas	30’ x 25’ (75 x 63)
Dimboola street (other side Evening dated Feb 22)	Received 6 Mar 1943 (undated un named)	Ripolin Masonite (board crossed out)	3’ x 2 (61 x 92) (30 x 25 crossed out)
Nhill (Flour man)	18 Mar 1943	Ripolin board	14’ x 10$^1/_2$’ (35.6 x 26.6 cm)
Railway yards	Received 22-24 Mar 1943 (dated 17/3/43)	Ripolin canvas	30’ x 25’ (75 x 63)
Engine driver	Received 22-24 Mar 1943 (dated 15/3/43)	Ripolin canvas	30’ x 25’ (75 x 63)
Head Nhill	Received 22-24 Mar 1943	Ripolin hessian	25’ x 22$^1/_2$’ (63.5 x 56 cm)
Flour worker	Received 22-24 Mar 1943 (dated 15/3/43)	Ripolin board	30’ x 25’ (75 x 63 cm)
Morning mass	Received 22-24	Ripolin board	30’ x 25’ (75 x 63

Wimmera landscape (Landscape with train)	Heide Museum of Modern Art	Circa 1942	Ripolin enamel on composition board	61 x 91
Kiata	National Gallery of Australia	Circa 1943	Enamel on composition board	60.9 x 91.7 cm
Railway yards, Dimboola	National Gallery of Victoria	1943	Enamel paint on canvas	77 x 63.9 cm
Railway guard, Dimboola **[?]**	National Gallery of Victoria	1943	Enamel paint on canvas	77 x 64 cm
Self portrait	Art Gallery of NSW	Inscribed March 43	Ripolin enamel on hessian sacking on hardboard[17]	61 x 52 cm (cat)
Flour lumper, Dimboola	National Gallery of Victoria	1943	Enamel paint on cardboard	75.5 x 63.5 cm
Morning	Heide	Inscribed 43	Synthetic	

[17] Incorrect cataloguing. Not on hardboard

	Mar 1943 (dated Feb 43)		cm)
Head	Received 22-24 Mar 1943 (dated Mar 43)	Ripolin canvas	24’ x 28’ (61 x 71.1cm)
Landscape (other side Head)	Written in 25 Mar but continued from received 22-24 Mar 1943 (dated Mar 43) Other side dated Feb	Ripolin board	24’ x 19’ (61 x 48.3 cm)
Bathers	Received 17 Apr 1943 (dated April 43)	Ripolin canvas	30 x 25 (75 x 63 cm)
Nhill	Received 17 Apr 1943	Ripolin canvas	30 x 25 (75 x 63 cm)
Head	Received 17 Apr 1943	Ripolin board	30 x 25 (75 x 63 cm)
Head	Received 17 Apr 1943	Ripolin board	30 x 25 (75 x 63 cm)
Landscape-Little Sorrento	Received 17 Apr 1943	Ripolin maroflage linen	

mass	Museum of Modern Art		polymer on cardboard	
Bathers	Heide Museum of Modern Art	Inscribed April 43 and 12/4/43 (verso)	Ripolin enamel on canvas	64 x 76.5cm

Appendix ii. List of Nolan studio material, Artists' Materials Archive, Conservation Department, Art Gallery of New South Wales

Item no **SID** **Manufacturer** **Type** **Physical description** **Size/volume** **Condition** **Notes**	
1. 44138 Ripolin (London) Paint. White. 1 pint Used Contents used with residual material at bottom	
2. 43213 Ripolin (London) Paint. Red 16 ½ Pint Unused Contents liquid	
3. 43218 Ripolin (London) Paint. Red 16 ½ Pint Unused Contents liquid	
4. 43201 Ripolin (London) Paint. Quality BLT. White No. 1 ¼ gallon Used Contents liquid	
5. 43220 Ripolin (London) Paint. Quality BLT. White No. 1 ¼ gallon Unused Contents liquid	

6. 43195 Ripolin (London) Paint. Black No. 1105 1 pint Unused Contents liquid	
7. 43199 Ripolin (London) Paint. Quality BLT. Ultramarine No. 13 1 pint Unused. Damaged label Contents solid	
8. 43200 Ripolin (London) Paint. Quality BLT. Blue, Deep No. 40 RD 1 pint Used. Label damaged Contents liquid	
9. 43216 Ripolin (London) Paint. Quality BLT. PE5 Blue 25975 1 pint Unused	
10. 43230 Ripolin (London) Paint. Quality BLT. (PE5 Blue) 1 pint Used. No label Contents liquid	
11. 43226 Ripolin (London) Paint. Quality BLT. No. 3056 (ochre) 1 pint Unused Contents solid	
12. 43212 Ripolin (London) Paint. Flat. White No. 501 ½ Gallon Used Contents liquid	

13. 43229 Ripolin (London) Paint. Flat. White No. 501 ½ gallon Used Contents liquid	
14. 43205 Ripolin (London) Paint. Flat. Red No. 516 1 pint Unused Contents solid	
15. 43222 Ripolin (London) Paint. Flat. Red No. 516 1 pint Unused Contents solid	
16. 43206 Ripolin (London) Paint. Flat. Red No. 516 1 pint Unused Contents solid	
17. 43207 Ripolin (London) Paint. Flat. Red No. 516 1 pint Unused Contents solid	
18. 43211 Ripolin (London) Paint. Flat. Red 516 1 pint Used Contents solid	
19. 43202 Ripolin (London) Paint. Flat. Black No. 505 1 pint Unused Contents liquid	

20. 43210 Ripolin (London) Paint. Flat. Black No. 505 1 pint Used Contents liquid	
21. 43215 Ripolin (London) Paint. Flat. Black No. 505 1 pint Unused Contents liquid	
22. 43203 Ripolin (London) Paint. Flat. Canary No. 504 (yellow) 1 pint Unused Contents liquid	
23. 43204 Ripolin (London) Paint. Flat. Canary No. 504 (yellow) 1 pint Unused Contents liquid	
24. 43219 Ripolin (London) Paint. Flat. Canary No. 504 (yellow) 1 pint Unused Contents liquid	
25. 43214 Ripolin (London) Paint. Flat. Canary No. 504 (yellow) 1 pint Unused Contents liquid	
26. No 44225 Ripolin (London) Paint. Flat. Lemon no 514 1 pint Unused Contents liquid	

27. 43208 Ripolin (London) Paint. Flat. Blue, deep No. 540 RD 1 pint Unused Contents liquid	
28. 43227 Ripolin (London) Paint. Flat. Blue, Deep No. 540 RD 1 pint Unused Contents liquid	
29. 43209 Ripolin (London) Paint. Flat. Blue, deep No. 540 RD 1 pint Used Contents liquid	
30. 43217 Ripolin (London) Paint. Flat. Green No. 573 1 pint Unused Contents liquid	
31. 43221 Ripolin (London) Paint. Flat. Green, dark yellowish No. 590 1 pint Unused Contents liquid	
32. 43223 Ripolin (London) Paint. Flat. Peacock green No. 582 1 pint Unused Contents liquid	
33. 43225 Ripolin (London) Paint. Flat. Peacock green No. 582 1 pint Unused Contents liquid	

34. 43224 Ripolin (London) Paint. Flat. Pink, very light No. 565 1 pint Unused Contents liquid	
35. 43228 Ripolin (London) Paint. Flat. Maroon Lake to shade No. 1167 (red) 1 pint Unused Contents solid.	
36. 43390 Ripolin (London) Thinners. 1 pint unused Contents liquid	
37. 43388 Ripolin (London) Paste Filler 4lb Used	
38. 43385 Euston Lead Company (Aust) Ltd White lead in oil 7lb Used	
39. 43386 Euston Lead Company (Aust) Ltd White lead in oil 7lb Used	
40. 43389 T. S. Reely (North Sydney) Bitumen Paint 1 Gallon Used	

41. 43391 Lewis Berger & Sons (Aust) Pty Ltd Kem-Tone paint 1 quart Used can	
42. 43637 Lewis Berger & Sons (Aust) Pty Ltd Kem-Tone paint 1 Gallon Pierced lid No contents.	
43. 44146 B.A.L.M. (Aust) Pty Ltd DULUX paint. Black. ½ pint Used and dried contents	
44. 44152 Winsor & Newton (London) Transparent colour Clear glass jar with cork 6.5 x 4.0 (diameter) cm Used Dried contents appear blue	
45. 44175 Berger & Son Liquid stain. Pale chrome ½ pint Used Dried contents	
46. 44181 Lewis Berger & Sons (Aust) Pty Ltd Kem-Tone paint 1 Gallon Used. Pierced lid	
47. 44182 Unknown Paint. White. 23.0 x 55.0 x 23.0 Unlabelled used. Brush and dried residue	
48. 43387 Taylors Glazene putty 7lb Used	

49. 44140 Cushman & Denison (LONDON & NEW YORK) Ink. Transparent black Glass bottle with stopper. 23.0 x 7.0 (diameter) Used, ½ full	
50. 44187 Parker Pen Company Ltd (London) Ink. Quink. Permanent blue black Glass jar with plastic screw lid 6.5 cm x 6.5 cm x 4.2 cm Used with dried residue on bottom.	
51. 44188 Ricchie & Co Pty Ltd (AUST) Printing ink Metal can with lid 4.7 cm x 7.0 (diameter) cm Used with lid (loose) and died contents 1/2 full.	
52. 44189 F.T.Wimble & Co Ltd (AUST) Printing ink Metal can with lid 7.5 cm x 7.8 (diameter) cm Used can, but lid firm.	
53. 44139 Unknown Leather satchel with 12 metal pannikins filled with paint Used. Contents dried	
54. 44141 Unknown Paint. White. 11.5 x 8.0 x 4.0 cm Rectangular can with screw lid used as paint carrier with dried residue (white)	
55. 44142 Unknown Paint. yellow 11.5 x 8.0 x 4.0 cm Rectangular can with screw lid used as paint carrier with dried residue (yellow)	
56. 44151 Unknown Paint White glass jar with can screw lid 7.0 x 5.5 (diameter) cm Reused Vegemite container with unknown contents.	
57. 44157 Unknown Unknown Brown glass bottle with cork 8.4 x 2 (diameter) cm Dried contents in bottom of bottle. No label.	

58. 44158 Unknown Unknown Brown glass bottle with cork 6.4 x 2.5 (diameter) cm Dried contents in bottom of bottle. No label.	
59. 44159 Unknown Unknown Clear glass bottle with cork 8.4 x 2.0 (diameter) cm Dried contents in bottom of bottle. No label.	
60. 44160 Unknown Unknown Clear glass bottle with cork 9.0 x 2.5 (diameter) cm Dried contents in bottom of bottle. No label.	
61. 44161 Unknown Unknown Clear glass bottle 8.0 x 2.0 (diameter) cm Dried contents in bottom of bottle. No label.	
62. 44164 Unknown Unknown Brown glass bottle with cork 26 cm x 6 x 10 cm Reused Anslie's whisky bottle with 4 cm of liquid. Strong aroma of turpentine.	
63. 44163 Unknown Unknown Brown glass bottle with cork 30 cm x 7.5 (diameter) cm Penfolds wine bottle with clear liquid contents. $^{1}/_{3}$ full	
64. 44167 Unknown Unknown Clear glass bottle with cork 16 cm x 5 (diameter) cm Unlabelled bottle with 5cm of transparent brown liquid	
65. 44168 Unknown Unknown Clear glass bottle with plastic screw lid 15.5 cm x 5.5 (diameter) cm Unlabelled bottle with 3.5cm of transparent green liquid	

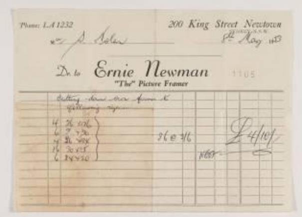
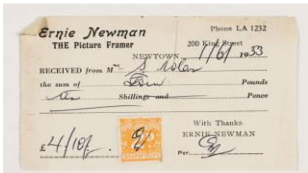
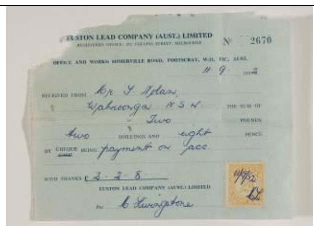
66. 44171 Unknown Unknown Clear glass jar with faceted side and metal screw lid 17.5 cm x 7.5 (diameter) cm Recycled and unlabelled jar with residue of brown material in bottom. Glass embossed with; ‘SANITARIUM HEALTH FOOD Co’	
67. 44172 Unknown Unknown Clear glass jar with faceted side and metal screw lid 17.5 cm x 7.5 (diameter) cm Recycled and unlabelled jar with residue of white paint on inside walls. No liquid. Glass embossed with; ‘SANITARIUM HEALTH FOOD Co’	
68. 44173 Unknown Lead white paint Clear glass jar with faceted side and metal screw lid 17.5 cm x 7.5 (diameter) cm Recycled and unlabelled jar with white and brown solids.	
69. 44174 Unknown Unknown Brown glass bottle with cork 8.4 x 2 (diameter) cm Dried contents in bottom of bottle. No label.	
70. 44176 Unknown Unknown White glass jar with can screw lid 8.5 x 6.5 (diameter) cm Reused Vegemite container	
71. 44177 Unknown Unknown White glass jar with can screw lid 8.5 x 6.5 (diameter) cm Reused Vegemite container with unknown contents	
72. 44178 Unknown Unknown Marble slab with broken edge and 4 attached reused Vegemite jars with unknown contents. Two other Vegemite jars appear to belong to this group.	
73. 44179 Unknown Unknown Reused Vegemite container with unknown contents. Appears to have been part of group of reused Vegemite jars on marble slab SID 44178 and 4151	
74. 44191 Unknown Paint	

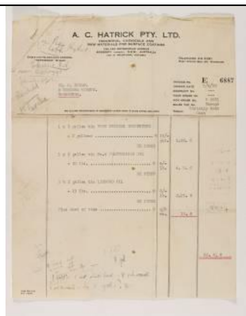
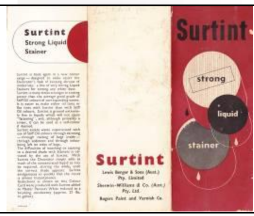
Blue cup with paint residue 7.0 cm x 8.0 (diameter) cm	
75. 44192 Unknown Paint Reused tobacco can containing dried white paint (heavy). No label. Embossed lid reads; ‘C. FRYDER & SONS LTD/ESTD. 1803’	
76. 44193 Unknown Empty recycled container Empty tobacco can. Label reads; ‘ Fryer's/Special/FINE CUT/ Tobacco/ MADE IN ENGLAND/ C. FRYER & SONS/ (Overseas) LTD/ LONDON’ Embossed lid reads; ‘C. FRYDER & SONS LTD/ESTD. 1803’	
77. 44194 Unknown Paint. Red. Reused tobacco can with dry red paint. Label reads; ‘ Fryer's/Special/FINE CUT/ Tobacco/ MADE IN ENGLAND/ C. FRYER & SONS/ (Overseas) LTD/ LONDON’ Embossed lid reads; ‘C. FRYDER & SONS LTD/ESTD. 1803’	
78. 44195 Unknown Paint Empty tobacco can with dried white & red paint on lid. Embossed lid reads; ‘C. FRYDER & SONS LTD/ESTD. 1803’	
79. 44196 Unknown Paint. Black Reused tobacco can with dried black paint Label reads; MEDIUM STRENGTH/CAPSTAN/Navy Cut/ W.D. & H. O. WILLS/BRISTOL & LONDON Embossed lid reads; ‘W.D. & H.O. WILLS. BRISTOL & LONDON/TRADE MARK’	
80. 44197 Unknown Paint. Blue Reused tobacco can with dried blue paint Label reads; MEDIUM STRENGTH/CAPSTAN/Navy Cut/ W.D. & H. O. WILLS/BRISTOL & LONDON Embossed lid reads; ‘W.D. & H.O. WILLS. BRISTOL & LONDON/TRADE MARK’	
81. 44198 Unknown Empty recycled container Empty can Embossed lid reads; ‘VAN HOUTEN'S/COCOA/NETT WEIGHT/ 4 OZ’	
82. 44199 Nestles Nescafe. Soluble coffee Empty can	

83. 44200 Unknown Empty recycled container Empty can Embossed lid reads; ‘REMOVE BEFORE/LOADING/ 11/41/CPP(in triangle)’ Base reads; ‘TOP’	
84. 44143 S. C. Johnson & Sons Pty Ltd (Rosebery) Wax polish 1 pound Circular can with dried contents Extensive notes on how to use and uses for wax polish on back of label.	
85. 44144 Kiwi Polish Co. Pty. Ltd (Melb) Kiwi glint 13 fluid ozs Rectangular can with dried contents	
86. 44148 W.Y. Rhind, Artists’ Colourman, 69 Gloucester Road, Regents Park London Varnish. Drying stopping varnish Black glass bottle with lead seal and cork 11.5 cm x 4.0 (diameter) cm Appears to have been used. Liquid half full.	
87. 44149 Winsor & Newton Ltd (London) Varnish. Winton picture varnish Glass bottle with black screw lid 11.5 cm x 4.5 x 2.5 cm This colourless Varnish, a solution of Synthetic Resin in Petroleum Spirit	
88. 44185 JOHN HADDON & Co Salisbury Square (London) Dry paint varnish Clear glass jar 1/3 full of translucent yellow resin (thick liquid).	
89. 44145 Winsor & Newton Ltd (London) Distilled turpentine Dried residue in bottom of glass bottle	
90. 44150 Fox Bros. Pty. Ltd. 276-8 Pitt st, Sydney Pure turpentine Clear glass bottle with cork 11.5 cm x 4.3 x 2.8 cm Appears unused. Liquid full to top.	

91. 44155 Anthony Hordern & Sons, Brickfield Hill, Sydney Mineral turpentine Brown glass bottle 30 x 9 (diameter) cm Bottle used, no cap, no contents. Outside covered in white paint finger prints.	
92. 44156 J.McCarthy & Co Pty Ltd, 133-135 Regent St, Sydney Distilled water Brown glass bottle 1 quart No contents	
93. 44162 Bruce Payne, 270 Pacific Highway, Hornsby Methylated spirits Crossed out in pencil and inscribed mineral turps	
94. 44166 E. Wills, paint & hardward store, 11 Railway ave, Wahroonga Methylated spirits Used bottle with 1.5 cm clear liquid. AGENT FOR Berger's Paint ‘Keeps on keeping on!’’	
95. 44153 N.V. Talens & Zoon, Apeldoorn, Holland Stand oil. Linseed Clearglass jar with screw lid 5.4 x 4.3 (diameter) cm Appears unused. Contents liquid and full.	
96. 44154 N.V. Talens & Zoon, Apeldoorn, Holland Stand oil. Linseed Clearglass jar with screw lid 5.4 x 4.3 (diameter) cm Appears unused. Contents liquid and full.	
97. 44180 N.V. Talens & Zoon, Apeldoorn, Holland Stand oil. Linseed Clearglass jar with screw lid 5.4 x 4.3 (diameter) cm Appears unused. Contents liquid and full.	
98. 44186 Winsor & Newton Ltd. (London) Unknown Clear glass jar with no label embossed on base. 1/3 contents, dried	

99. 44165 A.C. Hatrick & Co (AUST)? Drier. Cobalt asphaltum Reused bottle with small amount of liquid residue in bottom. Hand written label; ‘8 ozs cobalt asphaltum (?)/ 2 1/2 ozs turps’	
100. 44169 Unknown Insecticide 4 fluid oz. Used bottle with 7cm of clear liquid. Label reads; ‘MOSQUITO/ REPELLENT/LOTION....’	
101. 44190 Unknown Powder? Glass jar containing pink powder. Label has a picture of a rose.	
102. 44184 Fox Bros. (Sydney) Dry pigment. Yellow ochre Handwritten label’ Yellow Ochre/FOX’	
103. 44202 Unknown Hardboard 15 cm x 12.5 cm Paint-out on hardboard panel with red followed by white paint layers	
104. 44203 Unknown Hardboard 20.5 cm x 15 cm Paint-out on hardboard panel with white paint layer	
105. 44204 Unknown Hardboard 25 cm x 14.7 cm Paint-out on hardboard panel with pale blue and pink gloss paint layers	
106. 44205 Unknown Hardboard 23 cm x 14.5 cm Hardboard panel with paint remnants	

107. 44206 Unknown Hardboard 21 cm x 15 cm Hardboard panel with white ground and swatches of thick white paint	
108. 44207 Unknown Cardboard palette 35.5 cm x 27.5 cm Recycled cardboard backboard from a framed work used as a palette. Remnants of a S.A. Parker label and inscribed; 'SAILOR/ 3 gns/Sidney Nolan/ 8 Woniora Avenue/ Wahroonga/ N.S.W.' on verso	
109. 44208 Unknown Paper Painted cropped edges from an artwork (monotype?) with brown and blue paint layers	
110. Unknown sid Ernie Newman, The Picture Framer, 200 King Street Newtown Invoice 14.8 x 20.3 cm 8th May 1953 for cutting down frames.	 200 King Street Newtown Ernie Newman "The" Picture Framer
111. 44210 Ernie Newman, The Picture Framer, 200 King Street Newtown Receipt 7.8 x 12.3 cm 1st June 1953	 Ernie Newman THE Picture Framer Phone LA 1232 With Thanks ERNIE NEWMAN
112. 44211 Euston Lead Company Invoice 16.4 x 23.0 cm Invoice from Euston Lead Company for 4 cans (7lbs each) Euston White Lead in Oil dated 9th Sept 1952	
113. 44212 Euston Lead Company Recepit 12.0 x 15.0 cm Receipt from Euston Lead Company for 4 cans (7lbs each) Euston White Lead in Oil dated 11th Sept 1952	

114. 44213 A.C. Hatrick, Rosebery NSW Invoice 26.0 x 20.6 cm 9th Sept 1952 for Pure Swedish turpentine (2 x 2 gallon cans), Polymerised oil (1 x 2 gallon can) & Linseed oil (1 x 2 gallon can), with pencil inscriptions calculating white lead to oil and turps percentages.	
115. 44214 A.C. Hatrick, Rosebery NSW Receipt 16.2 x 7.3 cm 10th Sept 1952 (part payment of invoice dated 9th Sept 1952)	
116. 44215 A.C. Hatrick, Rosebery NSW Receipt 16.2 x 7.3 cm 10th Sept 1952 (part payment of invoice dated 9th Sept 1952)	
117. 44216 A.C. Hatrick, Rosebery NSW Venice turpentine 36.5 x 23.5 x 12 cm Large can with screw lid and remnants of Hatrick label. Aroma suggests contents are turpentine.	
118. 44209 Lewis Berger & Sons (Aust.)/Sherwin-Williams & Co. (Aust.)/Rogers Paint & Varnish Co. Surtint colour chart inscription in Nolan’s hand verso; Ring Hatrick for English firm	

Appendix iii. List of paintings included in analytical study

Paintings by Sidney Nolan included in study from collection of Art Gallery of New South Wales

[Medium descriptions as recorded on Art Gallery NSW Collection database 3rd May 2010]

1. *Untitled-abstract* c. 1939-1940 oil on photograph Art Gallery of New South Wales Bequest of Gwen Frolich 2006 132.2006	
2. *Luna Park* 1941 Enamel on canvas 67 x 84 cm Inscribed and dated lower left; LUNA PARK/41 Purchased with funds provided by the Nelson Meers Foundation 2003 35.2003 © Sidney Nolan Estate	
4. *Self portrait* 1943 Ripolin enamel on hessian sacking on hardboard 61 x 52 cm Inscribed and dated lower left ['N' backwards]/ March 1943 Purchased with funds provided by the Art Gallery Society of New South Wales 1997 412.1997 © Trustees of the Sidney Nolan Estate	
5. *The camp* (1946) Ripolin enamel on hardboard Not signed or dated Purchased 1978 207.1978 © Trustees of the Sidney Nolan Estate	

7. *First-class marksman* 1946 Ripolin enamel on hardboard 90.2 x 121.2 cm Signed and dated lower right corner ‘12.12.46/N’ Purchased with funds provided by the Gleeson O’Keefe Foundation, 2010 © Trustees of the Sidney Nolan Trust	
8. *Colonial head* 1947 Ripolin enamel on hardboard [sic cardboard] 76.2 x 65.5 cm Inscribed and dated lower right ‘Nolan 1947’ Inscribed and dated verso lower left ‘4.4.47/nolan’ Purchased with funds provided by the Art Gallery Society of New South Wales 2001 7.2001 © Sidney Nolan Estate	
14. *Burke and Wills expedition, ‘Gray sick’* 1949 Synthetic polymer paint and oil-based red ochre on hardboard Signed and dated lower right ‘Nolan 30.11.9’ Gift of Edron Pty Ltd-1995 through the auspices of Alistair McAlpine 445.1995 © Sidney Nolan Estate	

Paintings by Sidney Nolan included in study from collection of Heide Museum of Modern Art

1. *Head of Rimbaud* 1938-39 Oil and boot polish and pencil on cardboard Heide Museum of Modern Art Collection, Melbourne Purchased from John and Sunday Reed 1980 © Trustees of the Sidney Nolan Estate	
2. *Bird* 1941 Synthetic polymer on cardboard on composition board (inscribed lower right Dec 4th) Heide Museum of Modern Art 341 © Trustees of the Sidney Nolan Estate	

3. *Waterwheel, Luna Park* 1942 Dated: 1942 Synthetic polymer paint on composition board 61 x 92cm Heide Museum of Modern Art 1992.112 © Trustees of the Sidney Nolan Estate	
4. *Wimmera landscape (Landscape with train)* Circa 1942 ‘Ripolin enamel on composition board’ 61 x 91 cm Heide Museum of Modern Art 1980.70 © Trustees of the Sidney Nolan Estate	
5. *Dimboola* Date: 5/12/42 (?) inscribed lower centre ‘synthetic polymer on cardboard’ Heide Museum of Modern Art 1982.232 © Trustees of the Sidney Nolan Estate	
6. *Head Dimboola* Date: 4/1/43 (dated by artist lower left of centre) ‘Enamel on composition board’ 91.7 x 60.9 cm Heide Museum of Modern Art 1980.71 © Trustees of the Sidney Nolan Estate	
7. *Bathers* Date: April 1943 (inscribed on front lower right). Inscription on canvas fold over at verso top 12/4/43? ‘Ripolin enamel on canvas’ 64 x 76.5 cm Heide Museum of Modern Art 1982.247 © Trustees of the Sidney Nolan Estate	

Appendix iv. Instrumentation

Fourier Transform Infrared Spectroscopy (FTIR)

Fourier Transform Infrared Spectroscopy (FTIR) was performed on articles from the Sidney Nolan Wahroonga studio contents and painting by Nolan using a Thermo Nicolet Nexus Spectrometer. Samples were studied using the Continuum IR Microscope attachment and MCT-A Detector with KBr window (11,700-400cm^{-1}). A micro compression cell with diamond window was used as a sample platform.

Use of the Continuum IR microscope (x10 objective) and diamond window allows for absorbance spectroscopy of an extremely small sample, giving highly resolved spectra. Samples were generally taken by scraping the surface of the material with a sharp clean scalpel blade and pressing this material directly onto the clean diamond surface. The sample was then rolled with an FTIR roller to give thin and even sample distribution. Samples are between 100 and 200 microns (0.1-0.2mm) in diameter and approximately 1 micron (0.001 mm) thick using this technique. Spectra were gathered in the range from 4000-550cm^{-1} and are the sum of a 100 scans with a resolution of 4cm^{-1}.

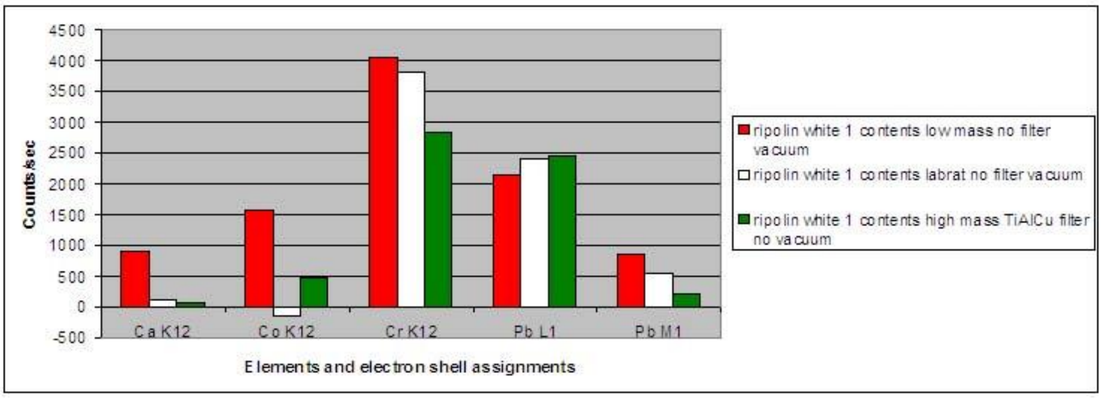
Attenuated Total Reflectance (ATR) FTIR was used when examining the Ripolin paint colour chart from the State Library of South Australia. The instrument made available by Artlab Australia for this analysis was a Thermo Scientific Nicolet iS10 with a germanium ATR crystal. Spectra were gathered in the range 4000-650cm^{-1} and are the sum of 32 scans.

Portable X-Ray Fluorescence (PXRF)

Energy Dispersive X-ray Fluorescence was undertaken with a Bruker AXS handheld Tracer III-V. During the research period the PXRF was updated to a Tracer III-V+ which increased its sensitivity. The instrument has a Si-Pin detector and a Rhodium target x-ray tube with a 13µm beryllium (Be) detector window. When the Tracer head is in direct contact with the sample, the x-ray beam spot is 3 x 4mm. The software used to operate the instrument and examine the spectra is S1PXRF 3.8.27 (Bruker

AXS). An additional software program was also used, Artax 7.1.0.2 (Bruker AXS) which allowed for comparison of multiple spectra. The additional use of filters, vacuum and changes to kV and µA allow for emphasis of certain parts of the energy dispersive spectrum. Four different measurement protocols were undertaken. The first was a general setting called lab rat mode (40kV, 1.1 µA, no filter vacuum 0.4 torr) allowing for the best gathering of information on the full spectra of elements. While the major inorganic components are readily identified with PXRF running in a lab rat mode, analysis of the trace elements is more difficult and requires adjustment of the Tracer settings and the use of filters and vacuum in some modes. In order to identify trace elements additional protocols were undertaken; low mass with filter [15kV, 2-15µA, Ti filter, vacuum 0.4 torr], low mass without filter [15kV, 15µA, vacuum 0.4 torr] and a high mass mode[40kV, 1.1-24 µA, Ti/Al or Ti/Al/Cu filter, no vacuum].

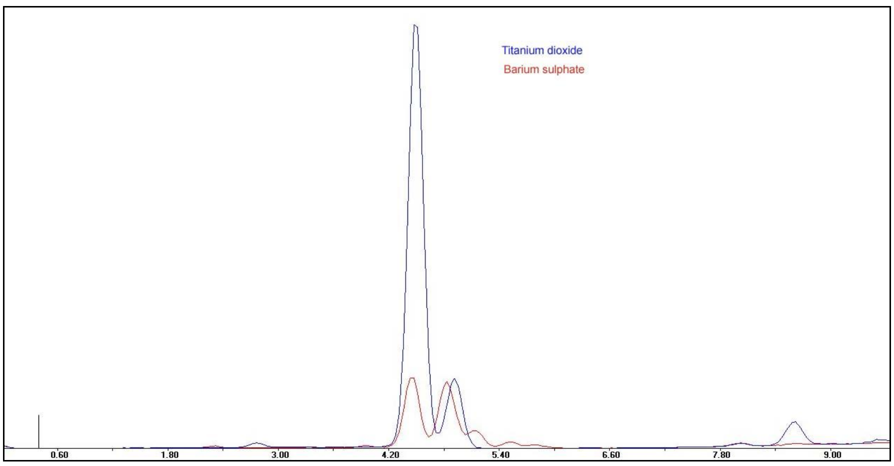
A comparison of the results with the PXRF counts, detected per second, using three different protocols, lab rat, high mass and low mass with Ti filter mode on a sample of Ripolin white 1 paint, (excluding the large counts for zinc), shows good general peak comparisons between fluorescence energies (Figure below). Elements with low fluorescence energies such as calcium require the use of low mass mode to be adequately detected when in trace concentrations. This comparison of the count rates detected from trace elements in Ripolin white 1 suggest that PXRF used in standard lab rat mode may be ineffective at identifying small amounts of cobalt that is present probably as a drier.



Comparison of PXRF low mass mode [15kV 15uA 400 sec vacuum], lab rat mode [40kV 1.1uA 400 sec vacuum] and high mass mode [40kV 1.1uA 200 sec Ti/Al/Cu filter] on sample of Ripolin white 1 excluding result for zinc

As PXRF identifies only the metallic elements and not the compounds present as pigments in paint, some additional analysis may be required to assign the metallic ions to specific pigment types. Some common pigments cannot be distinguished from each other by PXRF alone, such as lead sulphate and lead white. Others might be distinguished by the presence of partner elements such as lead and chromate commonly found in paint as lead chromate, but this could also be a mixture of lead white and chrome oxide. In simple paint mixtures these two variations would be readily distinguished by the colour of the paint itself, yellow for lead chromate and pale green in the case of mixing lead white and chrome oxide, but ready-made commercial paints may incorporate many different pigments to make such colours. Chrome yellow is commonly found in green house paint for example where it is combined with Prussian blue. In these instances, additional analysis with FTIR or examination with polarising microscopy may sort out elemental overlaps.

An additional limitation with PXRF analysis is the coincidental overlap of fluorescent energy assignments from different elements. The most difficult of these to resolve in this study is the correspondence between the fluorescence energy emitted by the K shell of titanium and the L shell of barium. Both of these are in the region of 4.5 Kev (Figure below). There are features of these spectral fingerprints which can be used to distinguish each of these elements when they are not both in the same paint film, but when mixed they can be extremely difficult to differentiate except as a possible amalgam of both spectral forms. Fortunately both barium sulphate and titanium dioxide have strong spectra differences in FTIR analysis.



Comparison of XRF typical spectra from barium sulphate and titanium dioxide pigments

Polarising Microscopy (PM) and Cross-section (X-section) Reflected and Ultraviolet Light (UV) Microscopy

These two microscopy methods are commonly used for examining samples from paintings. They require small samples and can yield information on pigments present and layering structures of organic materials. With PM the different groups of pigments within a paint film can be distinguished by colour, shape, size, refractive index in comparison to the Meltmount®, and the presence of a crystal structure which is identified by visibility under crossed polar filters. This technique is most useful for naturally sourced pigments which are larger and more variable in size and shape compared to synthetically produced pigments more common in the twentieth century. Organic pigments such as coal tar colours appear only as a stain in PM without any visible structure. This is however one of the few techniques that can identify the presence of ultramarine pigment by its colour, size and visibility under crossed poles.

Cross-section samples, similarly to PM, can assist with the identification of the different types of pigments present based on colour, shape, size and fluorescence under ultraviolet light. Zinc oxide in particular displays a distinctive brilliant pin point-like spots of green and purple fluorescence under ultraviolet microscopic examination. Cross-sections also provide information on the organic materials and their position within the paint film. The settling of heavier pigments towards the bottom of the paint film may be noted, with the corresponding movement towards the surface of lighter organic material. Metallic soaps which may have formed and aggregated into distinctive circular shapes can also be postulated based on their appearance under both reflected and ultraviolet light in cross-sections.

An Olympus Transmission and Reflectance microscope BX51 with polarising filters was used to examine the paint samples. Samples were examined at x100, x 200 and x400 magnification. Ultraviolet light source was provided by an Olympus reflected fluorescence system U-RFL-T with ultra high vacuum mercury burner lamp. Samples were prepared for microscopic examination in two forms. The first was a small scraping of the sample similar in size to the FTIR absorbance samples, which were pressed and spread onto a glass slide. A coverslip (1mm) was then attached using Cargille Meltmount adhesive with a refractive index of 1.662. These samples were examined with a microscope in transmission mode using a polarising filter, polarising microscopy (PM).

A second set of samples were prepared of paint chips embedded in epoxy resin (Struers Epofix). Samples after curing were turned 90 degrees and ground on a rotating grinder with silicon carbide papers until the sample was exposed on the surface, giving a cross-sectional view through the paint film. These samples were placed under the microscope and examined in reflected light mode with both visible and ultraviolet light.

Scanning Electron Microscopy (SEM)

Analysis on a number of Ripolin paint samples taken from the paint-outs of the Wahroonga studio contents were examined at the Microstructural Analysis Unit at the University of Technology. Viewing samples in the SEM in backscattered mode distinguishes elements by mass. Lowest mass elements appear darker and higher mass whiter in the grey scale of black to white. In this mode pigment morphology and dispersion are also made easily visible.

While EDS is similar to the use of PXRF in the identification of metallic species, this analysis under the SEM can be targeted to individual particles, rather than a generalised area of a paint film. Elemental mapping of cross-sections is also a useful technique to look at distribution of pigments within paint films.

Samples prepared as cross-section in polyester resin were placed uncoated into the Zeiss Supra 55VP Scanning Electron Microscope at 20kV accelerating voltage in variable pressure mode. Energy dispersive x-ray spectroscopy (EDX) was performed using the Oxford Instruments INCA x-sight microanalysis system. Pressure was maintained at 0.3 torr to minimise skirt x-rays.

Raman Spectroscopy (Raman)

RS is one of the few analytical techniques which can distinguish the two commonly used forms of titanium dioxide pigment, anatase and rutile, from each other. This is a critical identification in regard to dating paints with titanium whites. Anatase was the earliest type of commercially available titanium dioxide produced from 1913, whereas rutile was developed after the Second World War (Laver, 1997). The differences between the two types are that anatase has RS bands at 143, 396, 516 and 639cm^{-1} and rutile at 143, 232, 446 and 609cm^{-1} as documented by Gautier et. al (2009).

RS is also very useful as a partner technique to confirm the identification of many other pigments particularly organic types. Unfortunately only limited RS was possible during this research

Raman spectroscopy was undertaken with a Renishaw inVia Raman Microscope Spectrometer with a Near Infrared enhanced, deep depletion charge-couple device (CCD) array detector with 576 x 384 pixels and Peltier cooling and Renishaw near infrared diode laser at 785nm with 300mW nominal power at the source.. This was fitted with 785 nm Rayleigh edge filters and a 1200 lines per mm dispersive grating. The microscope was a Leica DM2500M microscope with 50X reflected light illuminated objectives. Laser power at the sample was reduced to 10% using neutral density filters and pinhole inserted to improve beam. Data was collected with an extended scan and 10 second dwell time.

Gas Chromatography-Mass Spectroscopy (GC/MS)

While the identification of the organic binder present in a paint film may be detected by FTIR as oil, alkyd or nitrocellulose, the type of oil or alkyd cannot be distinguished. Oils used in house paint in the twentieth century may be linseed, (most common), tung (sometimes called China nut), soya bean, perilla, safflower or dehydrated castor oil. There are many other oil types which are less common. Likewise alkyds used as paint binders have a significant oil component and will form part of a typical FTIR spectra along with the polyester resin component. The polyester resin itself is formed from a polybasic acid, usually phthalic anhydride or polyhydric alcohol (either glycerol or pentaeryrithol). The identification of the type of polyhydric alcohol present in the alkyd is useful in the examination of paint as it may provide information regarding dating and resistance to solvents. Glycerol based alkyds were the primary alkyd type prior to the end of the Second World War. After that time pentaeryrithol was found to form a more water resistant tougher alkyd film and it was substituted fairly broadly for glycerol based alkyds. The exact date that this occurred has not been well documented. Nitrocellulose lacquers were also plasticised with a number of different materials at different times such as natural resins, oils and alkyds, some of which may be distinguished with FTIR but more clearly with GC/MS.

Gas chromatography is a technique in which complex molecules can be separated from each other by type. Each molecule type is grouped and identified by the time it took to elute from the column. When coupled with a mass spectrometer, these separated molecules are each exposed to vapouring heat and their mass energies recorded which offers a second confirmatory identification system. GC/MS spectra are therefore three dimensional, in the x and y planes are the time and volume of each separated type of molecule from the gas chromatograph, and in the z or third axis is the mass spectra of the molecule as vaporised. Each mass spectrum is distinctive for each molecule. Different gas chromatograph protocols are used depending upon the types of materials expected in the sample and extensive reference sample libraries are necessary to be run at each of these settings to ensure the column is working effectively and as a cross reference for confirmation.

As oils and binders are extremely large molecules, some initial breaking down of their structure is usually required prior to offering them to the gas chromatograph, which prefers smaller more simple molecules to move efficiently through the column. This can be either done chemically or by subjecting the sample to heat, pyrolysis, (Py) or heat and chemical break down, thermally assisted hydrolysis and methylation. For each of these protocols there is a need to understand how the materials will break apart, and what types of molecules will be formed. For these reasons, the setup and running of a GC/MS system to identify paint components is complex and requires extensive work with reference materials.

Two different types of GC/MS were undertaken on the samples of paints from the Wahroonga studio by the Getty Conservation Institute. The GC/MS protocol run on samples of alkyds by Michael R. Schilling included derivatisation with tetramethyl ammonium hydroxide (TMAH) followed by pyrolysis (Py) prior to GC/MS. This is a useful technique in the study of alkyds as the TMAH-Py breaks the large polyester polymer into its polyol and polybasic acid allowing for identification of these components in the GC chromatogram. A second GC/MS protocol called Meth-Prep was undertaken on a larger group of Ripolin paint samples by Joy Mazurek. This technique is particularly suited to the identification of all the different fatty acid groups present in oil based paints.

Identification of the polyhydric alcohols in alkyd resins by Py-GC/MS is fairly straight forward, as either pentaeryrtithrol is either present (PE alkyd) or not (glycerol alkyd). Glycerol is present in both PE and glycerol based alkyds as a result of the oil.

Identification of oil type is far more difficult. There are two techniques which may yield results. The first is the presence of a particular type of fatty acid which is present in only one type of oil; an analytical tag. Some of these fatty acid tags are identified by Schilling, Mazurek and Learner (2007) and provide a useful guide. Castor oil for example contains ricinoleic acid and is an identifying acid for the presence of this oil. Unfortunately linseed oil, safflower, sunflower or soya bean do not have a distinctive fatty acid and cannot therefore be identified in this way. Fresh Tung oil contains eleostearic acid but this is not present in dried films.

The other methodology for oil type identification is a comparison of the proportions of two fatty acids, palmitic and stearic acids which appears to be a reproducible proportion for each oil type. Michael Schilling (in Lake 2010) suggests the usual proportion of palmitic to stearic (P/S) in linseed oil is 1.7, whereas tung is 1.1. Rapeseed oil has similar P/S proportions to tung, as does dehydrated castor (Schilling, Mazurek & Learner 2007). Soybean (2.8), safflower (2.9) and sunflower (1.4) all have higher amount of palmitic acid to stearic acid. No P/S ratios for candlenut oil which may be of interest in the analysis of post-war Australian made paints is consistently given in the literature, although a number of studies suggest that the palmitic acid is in smaller proportion to the stearic acid giving P/S ratio less than 1 (Siddique et. al 2011). However the use of the P/S ratio to identify oil type is problematic when a mixture of oils is present as this changes the ratio of fatty acids.

In the identification of plant resins which may be present, some analytical markers have been identified. The identity and relative abundance of diterpenoids for the three fossil resins called copals; Manila, Kauri and Congo along with those in sandarac are given by K.J. van den Berg, van der Horst and J. Boon (1999). All four resins contain methyl ester and methyl ether. In Manila, Kauri and sandarac these are in the form of communic acid (methyl ester) with mass to charge ratios (m/z): 81, 119, 175, 241, 257, 316, and communal (methyl ether) [m/z 81, 257, 270, 302]. Manila Copal (resin from *Agathis dammara*) has been identified by Cartoni et. al. (2004) as having two distinctive acids; patchoulane (MW 206) and agathic acid dimethyl ester (MW 362). Congo copal however is distinguished by the presence of ozic acid (methyl ester) [m/z 121, 241, 257, 301, 316] and ozol (methyl ether) and enantio-biformene (van den Berg, Ossebaar & van Keulen 2002, pg. 3). The most useful marker for distinguishing Congo copal from the other three resins is however another pyrolysis product of the derivatisation process, a small dicyclic reaction product from ozic acid described by Berg as having a molecular weight of 236 and m/z 161, 177, 236. Unfortunately this shares molecular weight and m/z features with a similar by pyrolysis product of communic acid and is distinguished only by differences in elution time compared to standards.

GC/MS Oils, Meth Prep procedure: 100 µl of a solution of Meth Prep II reagent (0.2M TMTFTH in methanol) in toluene (1:2) were added to the vials. The vials were warmed on a hotplate at 60°C for 1 hour. After cooling, the vials were centrifuged, and the contents were ready for injection into the GC/MS. An INNOWAX (25 M x 0.2 mm x 0.2µm) capillary column was used for the separation. Helium carrier gas was set to a linear velocity of 44 cm/sec. Splitless injection was used with a 60 sec purge off time, and was set to 260°C. The MS transfer line was set to 260°C. The GC oven temperature program was: 80°C for 2 min; 10°C/min to 260°C; isothermal for 15 min; 20°C/min to 260°C; isothermal for 2 min. Total run time is 38 min. The mass spectrometer was used in SCAN mode as it permitted unknown peaks to be identified on the basis of their mass spectra using a spectral library NIST. Fatty acids were quantified with calibration curves and the amounts of fatty acids are reported as % fatty acids (mg fatty acids/mg paint).

Derivatized pyrolysis-gas chromatography–mass spectroscopy was undertaken with a Frontier Lab PY-2020D double-shot pyrolyzer system equipped with a CGS-1050E carrier gas selector, SS-1010E selective sampler, and MJT-1030E microjet cryo-trap. The pyrolysis interface was maintained at 320°C. The pyrolyzer was interfaced to an

Agilent Technologies 5975C inert MSD/7890A gas chromatograph–mass spectrometer. A J&W DB-5MS-UI capillary column was used for separation (30 m x 0.25 mm x 0.25 µm), with helium carrier gas set to 1 ml/minute. The split injector was set to 320°C with a split ratio of 50:1 and no solvent delay. The GC oven temperature program was 40°C for 2 minutes, then ramped to 320°C at 20°C /minute, followed by a 9 minute isothermal period. The MS transfer line was at 320°C, the source at 230°C, and the MS quad at 150°C. The mass spectrometer was scanned from 33-600 amu at a rate of 2.59 scans per second. The electron multiplier was set to the autotune value. Samples were placed into a 50 µl stainless steel Eco-cup fitted with an Eco-stick, and three microliters of a 25% methanolic solution of tetramethyl ammonium hydroxide (TMAH) were introduced for derivatization. After three minutes, the cup was placed into the pyrolysis interface where it was purged with helium for three minutes. Samples were pyrolyzed using a single-shot method at 550°C for 6 seconds.

Australian Synchrotron Infrared Beam-line

The use of the Australian Synchrotron Infrared Beaml-ine, offers additional benefits to the standard FTIR bench top system. The Synchrotron provides the source of infrared light of far greater intensity allowing for a smaller beam. The Synchrotron IR sample area is usually set at 5 microns, whereas the area sampled in the Art Gallery of New South Wales FTIR transmitted microscope mode is 100 microns square. In addition the Synchrotron IR microscope is fitted with OPUS software which allows for gathering of spectra from multiple sample sites giving a maximum of 100x 5 um sites along each axis of a sample area, creating an IR mapping of a sample area up to 500 microns square.

There are two ways in which this detailed organic mapping of a paint sample might be useful. The first is that for a complex mixture of materials (which is the case in most paint films particularly in the twentieth century) standard FTIR spectra obtained from a 100 micron sized area which give a multi-peaked spectrum of all components, are difficult to interpret as separate components. However even finely dispersed modern paints demonstrate a lack of homogeneity at 5 micron level and may allow for detection of areas which have higher concentrations, or even exclusive concentration of a single material. This gives the potential to see materials in the mix, as separate spectra giving more potential for analysis of all components of the paint film. Secondly, mapping an area of paint, in particular cross-sections of paint films which maintain the integrity of the dried film, allow for imaging of the distribution of detectable materials through the sample area. This can visually demonstrate relationships between materials in the paint.

Samples were prepared for the Infrared Beam-line at the Australian Synchrotron by embedding paint samples in polyester resin and cutting 10 micron thin cross-sections. Sections were supported on a 1mm diamond window and flattened using a stainless steel roller. IR were collected in transmission mode with 5 x 5 micron aperture at 5 micron steps following custom defined grid positions. Spectra are the sum of 32 scans at a resolution of $4cm^{-1}$.