Discoloration in Renaissance and Baroque Oil Paintings. Instructions for Painters, theoretical Concepts, and Scientific Data
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Introduction

Nowadays, Renaissance and Baroque oil paintings usually look different from the way the painters intended them. Past restorations, such as cleaning paintings with strong abrasives and solvents, have often contributed to the occurrence of optical changes. However, optical changes can also be due to the ageing of the materials used by the painter. This 'natural' ageing of the binding medium and the pigments is substantially accelerated by climate conditions, including (bright) sunlight, moisture and atmospheric pollution. In old paintings, the deterioration of the paint has resulted in varied colour and tonal changes. Areas may have become dark, or have faded. In certain instances, the colour of aged paint has even changed entirely. Because the alterations in the individual areas of the representation are anything but proportional, the present colour range can deviate greatly from what the painter intended. This also frequently affects the original modelling. For example, an even brown or red drapery could have initially displayed a rich play of folds. Obviously, this can also seriously disrupt the painter's intended suggestion of three-dimensionality.

Presently, the problem of the degradation of old oil paints is the research domain of conservation science, namely the science investigating the cause of ageing processes in works of art and developing methods of retarding or countering them. Researchers focus on uncovering the chemical and physical characteristics of oil binding media and pigments. The composition of paints in old paintings is painstakingly analysed to this effect. On the basis of the results, paint systems are made that approximate as closely as possible the original composition of the old paints in the aspects deemed relevant by the researchers. By exposing these reconstructions to artificial ageing, an attempt is made to accelerate the natural ageing processes. When chemical and optical changes are charted, useful information can be acquired about the degradation processes that have occurred in the old paints.

Ageing processes in the paint sometimes have far-reaching consequences for our interpretation of an artist's pictorial, illusionistic and aesthetic intentions. It is crucial that conservators are acutely aware of the optical changes that have occurred in the old paints. Obviously, insight in this field is equally important for art historians concerned with aspects of colour in old master paintings. The impact of the discoloration of paint on our interpretation of old paintings, however, has not received much attention either in the field of conservation or in art history. Within conservation science, research on ageing is conducted primarily by chemists and physicists, scientists whose own fields devote little or no attention to the visual consequences of chemical and physical changes in the painted image. Similarly, art historical research into colour, even in recent studies, usually takes little or no account of the fact that the paintings' appearance has changed in the course of time. This may be due to the fact that art historians resist consulting the — for them rather impenetrable - scientific literature. As Leslie Carlyle (1998) has shown, there is a long-standing tradition of a discrepancy in the art literature between stylistic and technical aspects of painting. While style and technique were still treated in connection with one another in the first half of the 19th century, in the course of the 19th and 20th century these approaches to works of art developed into two separate fields of study; each with specific questions and methods and a literature that is barely accessible to the other field. Only lately have a growing number of art historians begun to make use of the results obtained from the scientific investigation of painting techniques. Examples of this are the studies by Marcia Hall (1992) and John

1. Wettering (1999) and (2001)
Gage (1999) on old master painters’ use of colour. Knowledge gathered by conservation science on the ageing of old works of art, however, is hardly reflected in the art historical literature. This may be because answers to questions essential to research on colour, such as its original intensity and tonality, or the nature of the modelling applied by the painter are not found in the conservation literature, which is dominated by chemists and physicists.

This dissertation is the first extensive art historical study focusing on the phenomenon of the discoloration of paintings. Five independent studies present research on the original composition of the paint and the original appearance of the paint in Renaissance and Baroque oil paintings. The point of departure for this research are contemporary writings on the technique of oil painting and on the use of colour and chiaroscuro in paintings. By means of a broad approach and a multifaceted analysis of these historical art technical and art theoretical writings, a demonstration is given of this material’s potential for both scientific and art historical research.

The texts examined vary greatly. They were written by both professional and amateur painters, art lovers or connoisseurs, and range from succinct practical instructions, which have usually come down to us in manuscript form, to early published scholarly treatises which expound in detail the myriad aspects of the art of painting.

These varied writings enjoyed a widely diverging readership, though it must be noted that the specific target groups and the dissemination of these texts are usually not known. Concise, handwritten manuals appear to have circulated within painters’ workshops.7 Published scholarly treatises, in addition to a select group of professional painters, were probably chiefly read by art lovers who did not always paint themselves.4 Personal notes by painters and connoisseurs were intended primarily for their own use, though they may also sometimes have been collected with a view to publication. The material-technical information in printed ‘recipe books’ seems to have been read by both professional painters and art lovers.6 Furthermore, a large number of printed treatises obviously written for amateur painters were also published in the 17th century.7

Indeed, the diversity of the sources leads one to question just how much the information in the various texts is representative for actual studio practice and workshop teaching. In order to evaluate this, it is essential to become acquainted with the background of the author and his reading public. This, however, must be done with caution. One might, for example, suppose that the artist Wilhelm Beurs adjusted the information in his De groote waareld in ’t kleen geschildert (1697) - an instruction book, that according to the introduction was intended for amateur painters - in such a way for his reading public, that the information had little in common with the way a professional artist worked. Comparison of the advice in Beurs’ treatise with that in other 17th-century accounts however, proves that Beurs’ information is not at variance but in accordance with the texts of his contemporaries.

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5. Many of these instructions books, including those by Paulus van Somer (c. 1576-1621) and Abraham Latombe, were collated by De Meyerse (1621-46); see Graaf (1958).

6. See st example the introduction to the reader in Pierre LeBrun’s Recueil des essais de la peinture de Bruxelles manuscrit (1635). The object of LeBrun writing his treatise, which was intended for publication, was to inform art lovers about the material-technical aspects of the art of painting; see Merrifield (1849, 1967), vol. 2, pp. 795, 767-69.

7. Bruggheen (1616) and Beurs (1692) are examples of writings on painting techniques intended especially for amateur painters.
Concrete examples hereof will be addressed in this dissertation. That Beurs gives a representative account if the actual working methods used by his contemporaries was confirmed by recent technical research on still-lives from the Northern Netherlands.8

The nature of the technical information differs in the various sources. The texts from the early 15th century are mostly manuscripts with collections of instructions dealing with the making of oil media and concerning the pigments applied in oil painting. Information on the properties, or characteristics, of the oil paints are found only sporadically in these early texts. Not until the early 17th century do sources generally examine the drying time, colour-fastness, tinting strength, hiding power and application technique of the various paint compositions. This development was related to the increasing number of amateur painters and art lovers interested in the technical aspects of painting:9 This group required more detailed technical instructions than the professional painter, who learned his craft in the workshop. In the 17th century, authors gradually provide more indications as to how to render various objects true to life. Early instructions in this area describe solely which pigments should be used for the light, middle and dark tones. As of the middle of the 17th century, greater attention is given to the sequence in which the paint-layers should be applied and how specific textural effects can be realised.10 The additional technical information included in contemporary theoretical treatises also seems to be related to the increasing number of connoisseurs and amateur painters. The extent to which theoretical writings comprise technical information varies greatly. 17th century Dutch treatises, including works by Philip Angel (1642), Samuel van Hoogstraten (1678) and Gerard de Lairesse (1707), devote only sporadic attention to pure material and technical aspects. Some French authors, such as Charles Alphonse Dufresnoy (1668) and Henri Testelin (1680), are completely devoted to theory. In other French treatises of the period, and often in English and Spanish treatises, theory and practice are treated in relation to one another. Not only does the nature of the material-technical information in the sources change in the course of the centuries, but a shift can also be observed with respect to the theoretical information on colour and chiaroscuro. Early Renaissance treatises, such as Alberti’s *Della Pittura* (1436), cover aspects such as mathematical perspective and the rules of proportions.11 And, the application of chiaroscuro in the various discrete entities of a painting is also discussed. This aspect receives particular attention in the writings of Leonardo da Vinci.12 In theoretical disquisitions from the end of the 16th century, a painting is increasingly considered as a compositional unity rather than a constellation of separate parts.13 Ensuing from this is that authors began to take notice of the organisation of colour and the chiaroscuro in the painting as a whole and how these pictorial means could be deployed to create a convincing suggestion of three-dimensionality on the flat surface.

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8. Eikena Hommes *et al.* (1999), and various entries in Wallert (1999).

9. This period witnessed the publication of all sorts of manuals for amateur painters, see note 7, and many art lovers kept notebooks with all manner of information they had received from painters. Possibly the most famous connoisseur who recorded painting technical information is the English court physician Théodore Turquet de Mayerne (1573-1655); see Graaf (1958). Another well-known example is the English philologist Dr. Thomas Marshall (1621-85) who recorded observations of Anthony van Dyck’s painting technique in his so-called commonplace-book; see Vey (1960).

10. Eikena Hommes *et al.* (1999).1


12. For the writing of Leonardo; see Richter (1883, 1979), McMahon (1956), Pedretti (1965) and (1977).

In the late 19th and early 20th century, when the technical aspects of painting were steadily disjoined from art criticism and art history in the art literature, a division was also made with respect to interest in the source material. While art historians concentrated on the biographical and art theoretical information, painters and conservators became increasingly concerned with the historical techniques. The extremely rapid deterioration of 19th-century paintings caused by the inferior materials delivered by the paint manufacturers and the painters' ignorance of the proper application of the paints, stimulated painters, conservators and chemists to rediscover the techniques of the old masters. The age-old paintings often proved to be better preserved than 19th-century works that were but a few years old. The 19th-century source publications and interpretations of Medieval, 15th-, 16th- and 17th-century technical writings by authors such as Sir Charles Eastlake, Mrs M. P. Merrifield and Ernst Berger are nowadays still much consulted, although usually no longer to learn how to paint better. In past decades the interest in the technical information has grown significantly. Even more books and manuscripts are being discovered in libraries and are being (re)published or otherwise disclosed. Other technical sources are also disclosed by, among others, the Netherlands Institute for Cultural Heritage in Amsterdam, via databases, microfilms scans, Xerox copies and photographs.

While the technical writings are readily available, the information they contain is still relatively unused in research on old painting techniques. Only recently, expanding interest in this area is evidenced by research conducted, for example, in the National Gallery in London on early northern European easel paintings (1997) and paintings by Van Dyck (1999), and in the Rijksmuseum in Amsterdam on 17th-century Dutch still-life paintings (1999). Especially in the research on symptoms of ageing in paintings there is a limited interest in the technical sources. Various reasons for this may be noted. First, the extremely fragmentary character of the historical information. The instructions consist of independent comments, which at times seem to lack any cohesion. Consulting one of these sources in which only mention is made that indigo must be stored underground for a few years because this improves the colour, or that small is best mixed quickly with varnish, the modern researcher will be unable to interpret these disparate bits of information adequately. An additional problem with the interpretation is that the authors of historic texts did not always provide a 'neutral' account of the techniques they and their colleagues used. For instance, in an attempt to elevate the status of painting, some 17th-century authors described precisely rare or highly complicated working methods or techniques that required expensive materials. And, they not infrequently adopted the formulas of older 'authoritative' writers, even though these techniques had become obsolete in their own time. These and other problems of interpretation related to making the source material accessible, have resulted in the old instructions not being taken seriously enough and technical painting investigation relying squarely on the supremacy of scientific research. Accordingly, when data obtained from scientific

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14. That this is the rationale behind the study of historical painting techniques in the second half of the 19th century is evident from numerous articles in the 1880's and 1890's in the German periodical Technische Mitteilungen für Malerei.


16. The few early studies combining research on source material with the scientific investigation of paintings include the study by Talley & Groen (1975) on the painting technique of the 16th-century painter Thomas Batewell, and McKam Smith (1988) on Velazquez' painting technique.

17. Respectively: Billings et al. (1997); Kirby (1999); Wallert et al. (1999).

18. This problem clearly emerged in a study of Velazquez' painting technique, in which technical information in Spanish painters' treatises was compared with results acquired through actual research on Velazquez' paintings; see McKam-Smith et al. (1988).
research on paintings conflicts with information in the sources, the information ultimately considered the most reliable is not usually that in the old writings. In many studies, the sources serve solely to illustrate the results of the scientific investigation of paintings: when the instructions contradict the analysis results, the old formulas are either ignored or dismissed as unreliable. Subsequently, art historians adopt the - in their view - 'solid' analytical results. Various examples of this practice are addressed in this dissertation.

In this dissertation, the historical data and the results obtained from the chemical analysis of paintings, however, are considered as complimentary in an attempt to determine the relevance of the information obtained through both of these research methods. Naturally, using this approach means that a significant quantity of data has to be obtained from both research domains. With respect to the source research, a substantial group of writings must be investigated, including texts unrelated both chronologically and geographically. Only with such a broad comparative base can insight be gained into the significance of a formulated method for contemporary painting technique. As outlined in the chapter on verdigris, this prevents an instruction describing a little used technique from receiving undue attention at the expense of instructions reflecting prevailing painting techniques. It also allows chronological and regional differences in working methods to come to light.

A great amount of data culled from the chemical analysis of paintings is necessary to evaluate the currency of a technique. There are countless examples of instructions in the sources that initially seemed to contradict the contemporary working method of painters, but which when the number of analysis results increased, nevertheless, proved to reflect the customary technique. The chapter on indigo discusses how the ample attention in the sources on the use of this pigment in oil paint and the problem of the fading of these paints seemed unrealistic. After all, indigo was only sporadically encountered in oil paintings. Moreover, research in the textile industry had determined that indigo had excellent colourfastness. Only recently has a growing number of analyses demonstrated that indigo was, in fact, regularly used in oil - primarily by Dutch 17th-century painters - and that, quite to the contrary, such paint almost always has seriously faded.

The original composition of the paint
An aged painting is not always an unequivocal source of information for gaining insight into the degradation processes of oil paints, certainly when its history is unknown. The materials used by the painter may have radically altered, or been partly removed, while other substances may have been added to the paint-layer. The original composition of the paint is often difficult to reconstruct from the often seemingly incoherent information obtained from chemical analysis. More difficult still is determining how a passage must have been built up on the basis of a single analysed paint sample. Obviously, reconstructions founded on incorrect basic materials yield a distorted image of the degradation processes that have occurred in the paint-layer.

Ancient painting instructions afford extremely valuable information about the original composition of the aged paints. From these texts we can determine which pigments and which of their qualities were customary for the type of paint under investigation. The instructions indicate how - depending on the pigments used - various (oil) media were employed and that the choice of binding medium also hinged on the desired painterly effect - translucent or opaque, fluid or impasted etc. The recipes also explain when and for what reasons solvents, siccatives and fillers were added to paints. The old instructions mention which paint composition and build up of paint-layers was customary for suggesting the light, middle and shaded tones of the various coloured objects. The sources always evince how in their choice of material and technique, the painters weighed the advantages and disadvantages between the desired painterly effect on the one hand and aspects such as price, processability and colour-fastness of the materials on the other. Time and again, the sources provide an
understanding not only of the traditional procedures as such, but also the function of these working methods. This knowledge is crucial for the correct interpretation of the data obtained from the scientific analysis of paintings and contributes to a responsible formulation of paint reconstructions.

The paint's original appearance and the artist's original intention.

Recently, Ernst van de Wetering demonstrated how a 'mental reconstruction' can be made of the original appearance of a representation on the basis of contemporary art-theoretical writings and old drawn and painted copies.\(^{19}\) In fashioning a 'mental reconstruction' of the original colours and tones and of the modelling of the aged areas, equally valuable insights are afforded by the instructions for paint mixtures and the instructions for the build up of the paint-layers. For example, from the formulas we learn whether the lighter tones were painted with bright colours and whether black or otherwise muted pigments were added to the shadows, or whether intensely coloured pigments were used for shadows and lighter tints were achieved by the addition of a white pigment. From the sources can also be deduced whether for a specific passage a uniform layer of glaze was applied over the underpainting without differentiation, or whether the transparent paint was applied only on the shaded areas or the reflections. The theoretical instructions on the application of colour and chiaroscuro yield information on the desired strength and transition of the tonal contrast between the lit and shaded areas and the intensity of the colours there applied. Aspects such as the rendering of reflections or the atmospheric perspective are also often treated in detail in the old writings.

A substantial number of texts on oil paint techniques from various European countries was analysed for this research. The earliest sources date from the late 14\(^{th}\) and early 15\(^{th}\) century, the period in which oil became commonly used for easel painting. A wide selection was made from 15\(^{th}\) through 18\(^{th}\) century sources. That both geographically and chronologically divergent texts could be cohesively analysed is defensible on the grounds that despite chronological and local differences in painting techniques, one can speak of a certain international uniformity in the period investigated. Research on paintings has proven that, although the local availability of materials was a determining factor, painters in Europe were working with a very limited number of virtually the same pigments until the beginning of the 18\(^{th}\) century. The characteristic features of the pigments required specific processing.\(^{20}\) The great mobility of painters in the period under investigation, certainly during the years of their training, also facilitated the rapid exchange of technical information.\(^{21}\) A comprehensive selection was made of published writings and manuscripts with respect to the Dutch material. In addition, Spanish, German, Italian, French and English texts were chosen from different periods. This resulted in an analysis of painting instructions and other data from approximately 200 written sources.

In the five studies constituting this dissertation, the possibilities of the old texts for research into the discoloration of oil paintings are illuminated from different angles.

The first chapter elucidates how a system of organisation can be introduced in the rather impenetrable technical source material on painting that contributes to the disclosure and interpretation of this information. By understanding the function of the recipes in the painting process, the fragmentary instructions can be connected to one another, complementing and elucidating one another.

\(^{19}\) Ibid., note 1.

\(^{20}\) Only when Prussian blue became available (introduced in the early 1700s) and the use of Naples yellow increased in the early 18\(^{th}\) century did drastic changes take place in the handling of materials and painting technique. They were followed in the 19\(^{th}\) century by the discovery of zinc, chrome, cadmium and cobalt pigments and oil paints, as well as the industrial production of paint in tubes.

With the method developed in chapter one, the references in the sources on discoloration are brought together in the second chapter. This gives rise to a coherent survey of the traditional knowledge on the ageing of oil paint and the painters' attitude toward this phenomenon. The sources reveal that numerous painters considered the changing of their colours a great problem and that many exercised constant care to guarantee the greatest possible colour-fastness of their paintings. The pursuit of permanence appears to have been an important criterion in the painters' choice of pigments and binding media. At the same time, they created a large number of often refined painting techniques that benefited the colour-fastness of their works.

The third chapter addresses the problems of interpretation concerning the use of colour in aged paintings. The complex historiography of Raphael's Transfiguration serves to demonstrate how throughout the centuries anachronistic notions played a crucial role in the interpretation of the use of colour in this influential painting. Also addressed is how the study of written technical and theoretical sources combined with the knowledge of the materials used by Raphael and how they age, as well as the examination of contemporary copies and preparatory studies afford understanding of the original appearance of the Transfiguration and Raphael's intentions with respect to colour and chiaroscuro.

Finally, the fourth and fifth chapters each concentrate on an important problem of discoloration in oil paintings in the period under investigation: the brown discoloration of verdigris glazes in 15th - through 17th-century paintings, and the fading of indigo paint in primarily 17th-century Northern Netherlandish paintings. The choice of these topics is associated with the areas of interest of the project Molecular Aspects of Ageing of Painted Art (MOLART), and allowed my analyses of the sources and of the painting surface to be combined with (chemical-analytical) paint research. It also made it possible to make paint reconstructions based on historical instructions and to subject these paints to artificially ageing systems. This integrated approach reveals that the degree and the nature of the discoloration of verdigris and indigo paints depend on a large number of material and technical variables, including the quality and purity of the pigments, the type of binding medium, the presence of additives and the painting technique (such as the thickness of the layers, pigment volume concentration, type of underpainting). The old instructions also appear to yield valuable insights into the original colour of the aged paints and the modelling they must have had. Old master painters had knowledge in the area of the ageing of their paints from which present-day researchers could learn much. For example, it is the sources that inform us that the light fastness of indigo varies enormously in different binding media. Finally, from the sources we can gather how the limitations and possibilities of the pigments (verdigris was extremely difficult to process while indigo was very easy) had impact on the use of colour, brushwork and the rendering of the modelling by painters from different centuries.

Except for the chapter on indigo, all of these studies have appeared earlier as articles in publications in the fields of conservation science and art history. The second chapter on the painters' knowledge of the ageing of their paints was rewritten for this dissertation. The other articles are mostly unaltered, though expanded in places and including recent literature. In the first two introductory chapters, several typical examples of the various recipe groups are given. In the last three chapters the referencing of the source material is more comprehensive.