Discoloration in Renaissance and Baroque Oil Paintings. Instructions for Painters, theoretical Concepts, and Scientific Data
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Painters’ Methods to Prevent Colour Changes Described in 16th to Early 18th Century Sources on Oil Painting Techniques *

'When colours change at all it must be somewhat in the manner following, for as they are made some of metal, some of earth, some of stone, and others of more perishable materials, time cannot operate on them otherwise than as by daily experience we find it doth, which is, that one changes darker, another lighter, one quite to a different colour, whilst another, as ultramarine, will keep its natural brightness even in the fire. Therefore how it is possible that such different materials, ever variously changing (visibly after a certain time) should accidentally coincide with the artist’s intention.'

William Hogarth, *The analysis of beauty*, 1753.1

Hogarth’s description of the discoloration of pigments, a problem that concerned him as a professional painter, was intended as a critical note to those painters and connoisseurs who maintained that an artwork’s beauty increases with age. However, there are many historical texts in which artists do express their concern about colour changes and where they explain how this influences their choice of materials and methods. In this chapter, historical documentary sources will be used to create an impression of the knowledge concerning colour changes in oil painting. That in the 15th century painters knew already that their oil paints could discolor, can be inferred from guild regulations prescribing a specific long-lasting material or technique. There are also letters by artists taking notice of the need for durable colours. Discussions concerning the proper or poor preservation of (oil) paintings are an important part of Giorgio Vasari’s *Vite* (1568), from which it appears that at the time - in any case in Italy - this was an important aspect in their consideration. The painters’ instructions in this period often transmitted in manuscripts rarely address the discoloration of oil paint. Rather these sources concentrate on the preparation of materials and pay less attention to these materials’ characteristics and methods of use. As described in the introduction, from the 17th century the properties of the various paint compositions are discussed in greater detail. Correspondingly, instructions on obtaining durable colours are now much more regularly mentioned. Therefore, with respect to the source material, the emphasis in this chapter will lie in the 17th century. In addition, research will be carried out into 18th century texts containing information that is clearly linked to 17th century techniques.2

*Historical terminology on discoloration*

Documentary sources employ a range of terms and descriptions to define the various changes of colour in paintings. Often, these are the same ones we use today. For instance, authors speak of the fading, lightening, or yellowing of paints. At other times, the meaning of an old description may be deduced from the context and our present knowledge of the changes of colour. For example, an author noting that the colour of a paint consisting of light-sensitive pigment will disappear, must mean that this paint fades.3 Sources regularly refer to the dying of paints (French: *meurer*, Dutch: *versterven*, German: *versterben*).

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* This chapter is an adjusted version of an article with the same title published in: Hermens (1998), pp. 91-132.
2. Information about discoloration in 18th and 19th British sources has been compiled by Carlyle (1990) and (2001).1.
3. See note 93.
The term was used in a very general way to signify the loss of original colour. This change could imply a lightening or darkening of the colour, as well as refer to a change of hue.  

I. Instructions to prevent discoloration caused by the oil binding medium

The oil binding medium’s tendency to turn yellow
In the course of time, the oil medium has a tendency to turn yellow. Degradation products are formed as the oil dries and ages; these include chromophores that impart colour. This process, which in particular occurs in the dark, lowers the tone of the paint-layer and also adds a yellow tinge. Light, and not just sunlight, can partially bleach a discoloured paint-layer. As they dry and age, not all oils will discoulour to the same extent. Linseed oil is particularly susceptible to discoloration while walnut oil and especially poppy oil are less so. Painters manipulated the properties of their oils, such as the oil’s colour, viscosity, and drying time. They exposed their oils to sunlight (sun-thickened) or heated the oil (boiled oil), often in conjunction with siccatives. The way in which the oil is prepared greatly determines the degree to which it turns yellow. Paints that contain a high proportion of oil to pigment are particularly liable to discoloration. The amount of oil needed to make a paste varies from pigment to pigment. Examples of pigments with high oil absorption include red lake, raw and burnt umber, all black pigments, some yellow ochres and the coarse-grained blue pigments azurite and smalt.

Painters’ knowledge about the discoloration of oil
Historical texts reveal that painters were well informed about the discoloration of oil and that they regarded this as an important problem. In the De Mayerne manuscript (1620-46), the painter Paulus van Somer (c.1576–1621) is quoted as saying: ‘It’s the oil that kills the colours’ (Fig. 1). It was known that exposing discoloured paintings to sunlight would reduce their discoloration. In one of his letters, Rubens (1577–1640) suggested that his paintings should be treated in this way if they discoloured during long journeys.

4. In an instruction noted down by De Mayerne, the term meurcrh as used as a synonym for darkening; see note 15. Eikelenberg pointed out that indigo oil paint is subject to dye pale (blebekrachtig is vertert); see note 77.


6. This is a familiar phenomenon in relatively fresh paint-layers. However, even paint on works more than a century old can still react to cycles of light and darkness; Carlyle (2001).2


8. Historical recipes on the preparation of oil media have been compiled and reconstructed by Keller (1973) and Carlyle (2000, 2001).1

9. This was evidenced from experiments carried out by Dr Leslie Carlyle, Canadian Conservation Institute (CCI), Ottawa, Carlyle (2000) and personal communication.


12. Mayerne (1620-46); see Graaf (1958), p. 185: ‘Ce qui met les couleurs c’est l’huile.’
Apparently Rubens knew that it was possible to bleach both fresh and older layers of paint. Rubens' suggestion must have been the standard method of that time; it is repeatedly recommended in painters' treatises. For instance, the Spanish painter and art theoretician Antonio Palomino y Velasco wrote in his treatise El museo pictorico y la escala optica (1715-24; Fig. 2): It is always important for an oil painting to be in the open air and the sun for a while, so that it loses the swolenness (abutagado) that tends to mortify the colours, especially the blues and the whites, and even more if the painting has stood some time turned to the wall.14

Problems with coarsely ground blue pigments

The discoloration of the oil can lead to disturbing results primarily in several blue pigments. Small and azurite can only be used coarsely ground because, if they are ground too finely, they will begin to lose their already limited intensity of colour. These pigments require a relatively large amount of oil to process them into paint. Although the painter may obtain a workable paint when he grinds the coarse particles long enough with the medium, the coarse pigment particles do not retain the oil effectively, so that this soon oozes out of the paste. It is still fairly easy to deal with the blue pigments when they are mixed with finely ground lead-white because this pigment requires little oil and also retains oil well. However using the blue unmixed, as is necessary, for example, for rendering the shadows of blue drapery, can create difficulties in the paint application that can lead to discoloration. De Mayern described the problem as follows:

Colours die when the oil floating on the surface dries and forms a skin which turns dark in the air. There are pigments, such as the smalts, that do not mix easily with oil, and therefore sink to the bottom and therefore die easily, i.e. darken.15

Paint reconstructions indicate that when small is mixed with (un-treated) linseed oil, because of the floating oil layer, the wet paint acquires a striking surface that looks like glass or enamel. As the paint dries, the layer of oil forms a skin that turns yellow and darkens. In a cross-section from such a paint the small particles that have sunk to the bottom are clearly visible (Fig. 3).

Palomino warned against another problem likely relating to small's large particle size: When painting with small, the oil can easily drip, particularly when the painter tries to apply a thick layer of paint or when the oil is fat.16 By fat oil Palomino was referring to an oil that had been thickened by exposure to either

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13. Rackham & Rossen (1887-1909), vol. 5, p. 156: 'Lo remiikpaurlunt, si ctla  est  arritv, ce sera de  tesposer  a  plusieurs  repmes  au  suleil,  dunt  les  rayons  went  compress  cette  superficult  de  l'huik  que  cause  le  changememt,  et  si  fut  moment  il  tornme  encore  brum,  il  faudra  de  nouveau  l'exposer  au  soleil. La  chaleur, valet la  remiik  unique  a  cette  grave  maladic.'

14. Palomino y Velasco (1715-24; 1795-97), vol. 2, p. 57: 'y siempre es importanrt a una pintura si el idio que gote el descubito de los ayres, y del oil algun tanto para que se la quiste le abutagado, que tende mortificar los colores, especialmente en azules y blancas, y mas si se truda algun tiempo vuelta a la pared.' The English translation is from Velázquez (1986), p. 157. The term abutagado, which literally means swollen and puffy, will refer here to the process of oil turning yellow. Palomino also used this term to describe a discoloration that occurred indoors when a fresco painting is coated with a layer of linseed oil. The explanation by Velázquez (1986), p. 215, that the term could describe the turbidity of colours that could result from an unsatisfactory mixture of pigments and oil seems less likely to me. See also the advice in the De Mayern manuscript, note 94. Smith (1676), p. 77, recommended exposing pictures each year in May or June a couple of hours to sunlight.

15. Mayern (1620-46); see Grauf (1958), pp. 190-91: 'La mort des couleurs: es quando l'huile naprente un dessus, e cachie & fais une peau, qui mort au luir. Il y a quelques couleurs, e les enmêlent entre autres qui ne se mouvent pas assezement avec l'huile, ans sont toujours a fond de laire, e sont meurent facilement, i.e. mortuisen.'

16. Palomino (1715-24; 1795-97), vol. 2, p. 67: '...con lo qual se mengura, y poro que se corte, y cherece, que le solle hacer con mucha grana, y mas si esrd carpaado, y el abutagado algun gran, y enantes es monocolor pintura tendido basa aburr, porque no resuba padre, hasta que se mengura, y asito le ponen en las orillas una papeles de cireza, mependoles la orilla para que freaque, y se remiikcheando el acyel, y si sola se esto bastante y no es monocolor pintura basa aburr.' Translation by Velázquez (1986), p. 166.
sunlight or heat. Also De la Fontaine in his *L'Académie de la peinture* (1679), warned for dripping of smalt paint. The difficulties described in treatises are regularly reflected in the actual paintings. One example is Mary's mantle in Maarten van Heemskerck's (1498-1574), *Drapers' altar* (1546) in the Frans Halsmuseum, Haarlem (Fig. 4a-c). This is one of the earliest known Netherlandish paintings in which smalt is used. In the shadow areas of the cloth the coarsely ground pigment has obviously been applied with plenty of binding medium. These passages have yellowed dramatically into their present brown and greasy appearance. Here, Van Heemskerck encountered precisely the problem mentioned by Palomino: where a thick layer of paint has been applied, the paint has dripped.

Using a binding medium that is less liable to discolor

Painters were well aware of the necessity to remove the mucilage in the oil in order to combat its discoloration. Almost every painters' manual describes one or several recipes for this process. Usually, the oil was washed with water wherein water soluble components dissolved. In order to absorb mucilaginous material painters used to add sawdust, snow, powdered chalk, breadcrumbs or alum to the water. Painters also tried to obtain more permanent colours by bleaching the oil in sunlight. The result was an oil with a much lighter colour.

Instructions suggest that blue and white paints that were particularly susceptible to yellowing should not be made with linseed oil but with a medium that did not discolor to the same extent. In the *De Mayerne manuscript*, the Amsterdam painter Abraham Latombe proposed: *Walnut oil is the best [oil] for white, smalt and azurite*, and Paulus Van Somer believed: *Poppy oil is good for painting white, and for blue.* Binding medium analyses of 15th to 17th-century oil paintings have revealed that white and blue areas were indeed regularly painted with walnut oil. Poppy oil was only seldomly found. However, the analyses show that blue and white passages were also often painted with linseed oil. The advantage of linseed oil is that it dries faster than nut or poppy oil and produces a more tough and flexible paint-layer. Sources indicate that some painters also considered the 'adjusting' of the linseed oil medium to be unnecessary for a durable blue. The Spanish painter and art theoretician Francesco Pacheco described in great detail his ideas concerning the right painting technique for the colour blue in his treatise *Arte de la pintura* (written before 1638; published in 1649). Pacheco used Santo Domingo blue as his pigment, by which he was probably referring to a naturally occurring blue copper pigment from the Spanish southern-American colonies. Pacheco applied the pigment with a purified linseed oil that had

17. This is evident from contemporaneous recipes for the preparation of 'fat' oils. These recipes will be considered in chapter IV, section III, *Oil media*.
18. Fontaine (1679), vol. 2, p. 16.
20. Many recipes on the purification and bleaching of oils were recorded by De Mayerne (1620-46); see Graaf (1958), pp. 68-72, 179-186. These and contemporary formulas have been compiled and reconstructed by Keller (1973).
21. Verbal communication: Leslie Carlyle (CCI) and Hayo de Boer (ICN).
been bleached for fifteen days in the sun. According to him, with this oil blue colours were equally, or even better, preserved as when nut oil were used.

At least the blues that I, as well as other painters, have executed in this way... remained brilliant and kept their colour. In the hands of other painters the blues die. Even when they use walnut oil and lavender oil, the blues die on them. Because of this, some Italians who have seen my blues have been persuaded that they were ultramarine, trying to see what secret I used. What is marvellous at most is that neither my blues nor my whites are mixed with the walnut oil so revered by all. But I never use walnut oil, or only a very few times. I have nothing against linseed oil, although there are those who say that blue and white must not have anything to do with it.  

Pacheco added, and that may have been his secret, that the blue paint should be applied thinly and that it should be allowed to dry slowly in a cool place.

Sources suggest that some painters tried a gum or glue medium for their blue and green colours. A gum or glue solution not overly diluted with water, has a viscous consistency in which coarse small or azure particles remain well distributed. In the De Mayerne manuscript Anthony van Dyck (1599-1641) is quoted: and he [Anthony Van Dyck] told me [De Mayerne] that on his paintings he very frequently applied these [green and blue] colours with gum water and that he covered them with his varnish once they had dried. Van Dyck would have used the varnish in order to imbue the colours that had been applied with gum water with the same gloss as the areas that had been painted in oil paint. To ensure that the paint with gum water would adhere, Van Dyck said that he first applied onion or garlic juice to the oil ground. During his visit to Italy from 1649 to 1651, the English antiquary Richard Symonds recorded in his notebook that in their oil paintings painters in Venice regularly applied the areas with small 'in gua gue', that is mixed with gum water (gouache).

Writing in the late 17th century, both Boschin i in his Rische minere della pittura (1674) and Baldinucci in his Notizie de'professori del disegno (1681) stated in their description of the life of Paolo Veronese (1528-88) that this painter used to temper his blue pigments with glue made from leather clippings.

To date, the repeated mention of aqueous media in sources has hardly been supported by analytical results. In paintings by Veronese and Van Dyck in the collection of the National Gallery in London no evidence was found for the presence of gum or other aqueous media.

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26. Pacheco (1649); see Sánchez Cántón (1956), vol. 2, pp. 85-86. 'Documento importante... a lo menos los que yo le gasto a por de otros: pinturas a rebolos y quandan hartos, y conservar un tono color, manteniendo a menos de los otros: aun son olos de nussas y espag q se les mueren. Y en eiva parte algúne estiaboes que duen vicis mis azules se hau preservados que son ultramarinos, preservando cer con cui secretos las gua gue, y, la que mas adueña que no ven mos acucles ni mis blancos el acet de nussas, tan reverenciado de todos, porque menos lo uo, o muy pocas veces; el que tiene no me gue el, aunque sus quien día que no ha de ver el azul ni el blanco este acet.' The translation of the sun-bleached oil is described p. 88. Translation by Véliz (1986), p. 74.

27. Pacheco (1649); see Sánchez Cántón (1956), vol. 2, p. 86.

28. Mayern e (1621-46); see Graaf (1958), p. 178: 'il m' a dit que bien souvent il souche ses tableaux lesdittes couleurs avec gua gue, & puis quittes axes passe son vernis par dessus. Mais que le secret consiste à faire que ledites couleurs à d'esteme proveno & s'attachent sur l'impression qui est à boilet. Ce qui se ferait certainement & fidèlement si au pase particulier l'impression le soe d'ignon (un d'ail), tel quel, en se renoue, & guardo de couleurs, a son &c.' De Mayerne recorded the same method in the margin of Abraham Latombe's recipe, which is mentioned in note 22.

29. Symonds (1650-52); see Beal (1984), pp. 229-30. Beal, p. 327, interpreted the term guazoo as 'A way of painting in colours made by tempering pigments with gum water: gouache.'


31. Beal (1984), p. 99, mentions that Joyce Plesters has not detected a glue medium in Veronese's paintings in the National Gallery, London. In recent studies by Penny & Spring (1995), and Penny et al. (1996), on Veronese's painting technique no reference is made to his use of binding media. For binding medium analysis of paintings by Van Dyck in the National Gallery London, White (1999), pp. 84-88. In two of the three Van Dyck's Italian-period paintings examined in the National Gallery Washington, the blues apparently were bound with egg yolk. Also traces of glue were found. However, it is not clear whether the glue was added by Van Dyck or migrated into the paint during the heated glue lining applied probably during the early part of the 20th century: Christensen et al. (1991), p. 50.
paintings by other artists, these binding media have only occasionally been identified in blue paint areas and than always as an addition to the oil medium.\textsuperscript{32} The discrepancy between the sources and the analytical results could be due to the fact that pure water-based areas may often have been repainted as a result of the original paint falling off. Even when the oil underpaint is rubbed in with garlic juice, it is unlikely that a pure gum or glue layer would have adhered permanently. Van Dyck and Veronese may also have soon discovered that their experiments were less than successful. Although the gum or glue solution itself will not turn yellow, when such a paint is varnished to make the gloss even yellowing of the end result will differ little from the end result should oil have been used.

Instructions to regulate the amount of oil in the paint-layer
Another important method to combat the discoloration caused by the oil medium, consisted of limiting as much as possible the amount of oil in the paint. Sources often advise against the excessive use of oil and suggest that the paint should be applied rich in pigment. The Parisian painter Pierre Le Brun asserted in his Recueil des essais des merveilles de la peinture (1635): Thick paints remain beautiful for a longer period of time and in Des principes de l'architecture de la sculpture de la peinture (1676), the French art theoretician André Félibien asserted: Those who wish their paintings to maintain their [colours]' freshness, use as little oil as they can and keep their colours as firm as possible.\textsuperscript{33}

For durable colours, sources regularly advise diluting the paint with a solvent, usually turpentine, lavender oil or spike oil. This makes it easier for the ground or underlying paint-layers to absorb the oil medium; as a result the upper paint-layer will be less liable to discolor because it will 'sink in' more. The Dutch painter Simon Eikelenberg (1663-1738) included the advice of the painter W. Witting in his Aantekeningen over schilderkunst as: careless mixing of oil with the pigment does not affect the paint's durability. Therefore one absolutely does not approve the practice of several painters, who have finished their paintings on the dead-colours, by applying little pigment and a lot of oil, just as if they were glaring, and sometimes even with oil of turpentine in place. For this reason, it was suggested that no more than a few drops of the tip of the brush of a solvent should be added.\textsuperscript{34} Especially late 17th century and 18th century authors warn against the excessive dilution with solvents. An example is the French painter, mathematician and art theorist Philippe de la Hire. In his Traité de la pratique de la peinture (published 1730) that originates from a lecture he gave at the Académie des Sciences in 1709, he warned:

Therefore one absolutely does not approve the practice of several painters, who have finished their paintings on the dead-colours, by applying little pigment and a lot of oil, just as if they were glaring, and sometimes even with oil of turpentine in order to make the paint flow more easily. This really severely spoils the work, for as a result these paintings are afterwards no more than a coloured mist without any liveliness, since too much oil and especially oil of turpentine kills the colours.\textsuperscript{35}

\textsuperscript{32} An addition of animal glue to the oil medium has been identified in an area containing smalt in Rembrandt's The syn rigad: the sampling officials (wards) of the Amsterdam drapers' guild. Rijksmuseum, Amsterdam: Groen (1997). Godfried Schalken used a mixture of oil and egg for paint containing smalt and indigo in his Self-Portrait. Fitzwilliam museum, Cambridge: Massing & Groen (1988), p. 106.

\textsuperscript{33} Respectively: LeBrun (1635); see Merrifield (1849; 1967), vol. 2, p. 815: 'Les couleurs grasse demeurent plus longtemps belles... il est faut employer grasse, et ne point esparger les couleurs en traçant.' Félibien (1676, 1966), p. 297: 'C'est pourquoi ceux qui veulent que leurs tableaux demeurent frais employent le moins d'huile qu'ils peuvent, & traitent leurs couleurs plus fermes.'

\textsuperscript{34} Eikelenberg (1679-1704), p. 694: 'Voor bet grijpje wisselciert in voor gewone zullen, en dat men daarom, deze be au dat ze niet liggend geen in zijn, met terpentine temp om dat dan meer invitce.'

\textsuperscript{35} For instance Mayencourt (1620-46); see Gervais (1958), p. 178: 'Pour le bleu faut ajouter un peu d'huile d'aspe, done on trois grutes, ainsi la couleur presque, on fait peint, & n'auront point de poux lumineux à la superficie, ne morissent jamais, ainsi demeurbe belle.'

\textsuperscript{36} Hire (1730), p. 719: 'C'est pourquoi on a l'habitude de peindre des quelques peintres, qui ont fait leurs tableaux, sur les étoffes, en y mettant peu de couleur & beaucoup d'huile, comme ils laissent, & même quelquefois avec l'huile de terpentine pour les faire couler plus facilement, ce qui à la vérité écarte fort l'ouvrage; car ces
Paints that are amply diluted with oil or a solvent flow more easily and therefore can be applied quickly and in very thin layers. The painter can thus complete his work swiftly and, moreover, economise on materials. After all, if he meticulously renders the modelling in an underpainting with inexpensive paints, he can complete his work, just as De La Hire described, with a thin 'glazed' colour layer that hardly contains any (expensive) pigment. This fast technique and the modest material costs would allow the cheap production of paintings. Presumably, this was more important to some painters than the durability of the colours they used.

The ground layer also plays a crucial role in the proper regulation of the binding medium in the paint layer. The ground layer of a painting primarily serves to conceal irregularities in the support such as pores, holes and wood grain. In addition, the ground must adhere well to both the support and the paint-layer to prevent the latter from flaking in the course of time. Finally, the ground can have an optical function.\(^{37}\) A good adherence of the paint-layer is achieved only if the ground is sufficiently capable of absorbing some of the paint-layer’s binding medium. Sources suggest that painters were aware that a ground’s capacity to make the upper paint-layers sink in contributed to the preservation of the colours. According to old instructions, the ground of a colourfast painting should certainly not contain too much oil.\(^{38}\) Naturally, the absorption of the ground should not be too strong. Possibly for this reason, Le Brun warned against using a ground with (much) umber: "Umber is of no use in the primings, for it absorbs the colours, which are laid on it, and this produces a bad effect."\(^{39}\) Indeed, due to its enormous high oil absorption, umber can even 'lap up' the oil from a paint-layer applied on top. Furthermore, umber paint contains a lot of oil so that it may darken severely. Eventually, this darker 'undertone' can have a disturbing effect on a painting, an effect amplified by oil paint-layers becoming more transparent in the course of time.\(^{40}\) To prevent a too strong sinking in of paint-layers, sources repeatedly warn to allow the ground layer enough time to dry before starting to paint. Richard Symonds described what had happened when the Roman painter Giovanni Canini (1617-62) was in a hurry to begin a portrait:

> 'When the next day after this face was done... The face & field were prosciugated [= dried out]... wh[ich] is a dryness that the colour is lost... and the next night more. He [Canini] said that [this problem had occurred because] the te[le] [= canvas] was not so thoroughly dry as it ought, clothes should be [perfectly dry]."\(^{41}\)

Instructions for using intermediary medium layers

Sources reveal that between the various painting sessions it was usual practise to 'oil out' or to 'wet out' the dried paint surface. Media of varying composition were suggested; linseed oil, nut oil and poppy oil

\(^{37}\) See section IV.

\(^{41}\) Symonds (1650-52); see Beal (1984), pp. 88, 242. According to Beal p. 327, the term 'prosciugated' is a corruption of prosiciugare, which means to dry out. Symonds uses the adjective to describe areas of oil paintings, which have dried dull and matt.
as well as resin containing media or turpentine. These oiling out or wetting out layers were used to re-saturate paint areas, which had become matt after drying, or to prevent a too strong sinking in of paint-layers applied on top. Another function frequently described in treatises was to provide a smooth surface for easy spreading of the paint using a fast technique. Sometimes painters worked into the wet medium layer but other times they waited until this layer had sufficiently dried. In either case, treatises recommend spreading the oil or varnish layer as thin as possible since any excess of medium caused the paint to discolour. The art of painting (1692) by the English art lover Marshall Smith provides a typical remark: ‘When a picture is dead coloured, we must avoid smearing it too much with oil, for the more speedy and easy finishing thence, which soon causeth the work to change.’ Paint cross-sections of 17th century paintings exhibit in between paint-layers regularly layers of medium. Examples include the blue sashes in Frans Hals’ (1581/85-1666) St. Adrian militia piece (1627) in the Frans Halsmuseum, Haarlem (See chapter Indigo; Fig. 16c, d) and an orange in the Festaon of fruits and flowers, by Jan Davidsz de Heem (1606-83/84), Rijksmuseum in Amsterdam (Fig. 6a-c). In both paintings these medium layers are very thin (less than 1 μm measured in samples). Presumably, when applying their wetting out layers, these masters took into account the same precautions as described by Smith a few decades later.

Instructions for mixing colours to a lighter shade
Another method to overcome the effect of the oil’s tendency to darken consisted of mixing the colours to a lighter shade. In other words: by adding extra lead-white. Sources mainly given this advice for pigments where the paint can darken dramatically because of the high percentage of binding medium, and for colours where a particular disturbing change occurs as the oil turns yellow. These problems are alleviated by adding lead-white because aside from lightening the colour, this pigment requires relatively little oil to be ground into paint. The Spanish artist Pacheco argued that painting in a lighter shade was necessary in order to create a durable blue out of his Santo Domingo blue pigment.

‘The reason I wish to counsel that the blues be light is that the blue darkens with time and turns black. This is seen in landscapes; and in my experience I have seen many draperies that were blue turn into a black blotch, so that the folds of the cloth no longer can be distinguished. But if the blue is painted light, it stays blue always and its highlights and shadows can be seen.’
Pacheco repeated his advice when discussing a blue consisting of smalt and lead-white. When mixed with a lot of lead-white, smalt is also much easier to process. Pacheco also suggested that the colours used for portraits should be mixed to a shade that was lighter than the natural one so as to achieve

43. Smith (1692), p. 83.
44. Described by respectively Eikema Hommes et al. (1999)2; Hendriks et al. (1998). Frans Hals’ use of intermediary varnish layers in indigo paint areas is considered in chapter V.
45. 100 grams of lead-white requires only 9-13 ml oil in order to be ground into a workable paste: Gertens et al., (1993), p. 70. This observation concerns machine ground paint. Hand grinding takes a little more oil.
46. Pacheco (1649); see Sánchez Cantón (1956), vol. 2, p. 85: ‘Nueva opinión. Yo soy de opinión que los azules se hacen claros... La causa que me movió a asistir a estos azules claros es, porque el azul con el tiempo avanza y se ve negro, como mostramos las pulseras, y uno por experiencia muchas ropas que fueron azules incluso en unas manchas negro sin que se determinen los trazos del pincel, y sienoz claro, siempre es azul y se ren son claros y oscuros.’ Translation by Velázquez (1966), p. 73-74.
47. Ibid., p. 128: ‘Poniendo bastante blanco, se hará una templa alegre, no oscurece antes se inclina más a clara, porque el tiempo la oscurece.’
paints that were more durable. Indeed, when the paint darkens, it detracts from the likeness.48 Other painters recommended mixing a lighter shade for the colour green.49 Some painters also applied the mixing of lighter and cooler shades to a wider range of pigments and colours. The Italian writer Carlo Cesare Malvasia noted in his Felina pittrice, vite de' pittori Bolognesi (1678) in the description of the life of Guido Reni (1575-1642), that Reni in his later works preferred to mix his paints with large quantities of white because he expected that the colours would be preserved more effectively:

And certainly one observes more and more clearly the truth of his prediction. While the paintings of others lose a great deal with time, his improve, the white becomes yellow and acquires a certain patina that reduces the colour so that it looks true and natural, whereas the other [paintings] are darkening too much, and equalise in this smoky obscurity, so that no longer the gradations, the half tones and the main light can be recognised nor to be distinguished.50

Reni's working method was not unanimously accepted at that time. It was rejected in Il micrososmo della pittura (1657), which was written by Francesco Scanelli. Scanelli argued that painters should depict the present reality as effectively as possible instead of concerning themselves with the future.31 In the 17th and 18th centuries, painting in a lighter shade seems also to have been applied to the copying of paintings. According to the notebook of Richard Symonds, Canini warned his assistant Antonio Maria when the latter was copying a landscape painting in which apparently mainly black and green earth pigments were used: Keep all colours lighter than those of the original because all blacks & terra verde turn blacker & darker afterward;52 Palomino gave the painter the following advice:

Important advice about tints for copies. Also be advised that in all cases the tints should be somewhat cooler or fairer than they appear in the original because the original colours have already degenerated with time, and because your colours will be subdued when they are blended and mixed. In addition, the colours will seem softer when they dry. Especially in blue or carmine cloths, the deterioration brought by time must not be imitated, because if these are made sombre from the start, and then time does its work, the colours will turn out far inferior to the original.53

Developments in methods to combat the discolouration of smalt oil paint

In the second half of the 16th century smalt began to be widely used in painting as a cheap substitute for azurite and ultramarine.34 Although smalt could not easily be used in oil, painters nevertheless continued

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48. Ibid., p. 150: 'Templandi el pintor sus colores algo mas claros que el natural, porque casi siempre oscurecen.'

49. This was advised by the Roman painter Canini, Symonds (1650-52); see Beal (1984), pp. 5, 242, and Barnwell (1756), p. 40.

50. Malvasia (1678); see Zanotti (1841), vol. 2, p. 59: 'Egli alla per fine ha relate far osè, ed al coticcio de' buoni maestri passa, e' arrestato sopra considerevolmente la bianca a porre più una sola pennellata della quale, indù avvezzo Letterino non maestro, bisogna pensare un anno intiero; e certo che se avessi ogni di più avvanzata il suo progresso, che dove le pitture degli altri perdono tanto col tempo, la cui acquistiamo, inspiegabilmente quella bianca, e fuggendo una certa patina, che reducice il colore ad un vero, e buono naturale; ed l'altre annoverandosi troppo, ed in quella affamata scorté sabbiosa, non lasciamo avvenire e distinguer il piu e 'l meno, le mezze tinte e i buoni principali.' Although the extra lead-white would have overcome the effect of the oil's darkening, it would have been to the detriment of the colour-fastness of various paints. In fact, the degree to which light-sensitive paints, such as yellow and red lacs, discoulor is connected to the amount of lead-white that has been added: Saunders & Kirby (1994), pp. 90-91.

51. Scannelli (1657), p. 114: 'Ma lasciamo una tal ragione per insufficienza, perché dere chi opera dopo la detta preparazione malfare con ogni potere in ordine alla presente prima realità, e poi tradurre alla proroga causa del tutto fermo effetto del futuro.'

52. Symonds (1650-52); see Beal (1984), pp. 5, 242.

53. Palomino (1715-24, 1795-97), vol. 2, p. 59: 'Adestración importante para las tintas en las copias. También se advierte, que en todo caso las tintas con algunas mas frescas, é hermosas de lo que parecen en el original, usará por ello que en este lloso degenerado y a con el tiempo, como lo que estas se atajan a el sombras y muy claras unas con otras demas de lo que acústicos al incrustar; y especialmente en los paisos azules, y carmines no hay que desviar luar de lo determinado el tiempo porque a estas desde luego se manchan, despues el tiempo hace su efecto, y quedan muy inferiores a el original.' Translation by Veldz (1986), p. 160.

to seek ways to use this inexpensive and easily available blue pigment in oil paint. De veri precetti della pittura (1587), by the Italian painter and art theoretician Armenini, gives the first discussion of painting with the pigment in oil.

Then there is smalt, which even if the colour is very fine requires adroit handling and that its mixtures be well ordered. Since if what is worked does not come out at first painting [alla prima], to correct by repainting is laborious. Because the oil is seen to seep from every spot that is dabbled with the brush, this covers the brightness [of the colour] and blurring it so that, in short, it turns out yellowish.\(^{55}\)

Armenini believed that the formation of the oil skin could only be prevented by very careful handling of the smalt paint. De Mayerne noted down advice by Rubens that is in fact almost a repetition of Armenini's instructions.

To make smalt beautiful and bright, one should mix it quickly with the vernice and apply it carefully and don't tire yourself by stirring too much while the paint is wet, because this movement ruins the colour. But when dry, you can work on top just as you like.\(^{56}\)

Other texts suggest that 17th-century painters developed all kinds of techniques that facilitated painting with the pigment. The previously quoted instructions for applying smalt with water-based media or a lot of lead-white are examples of this. Painters also tried to ensure that for smalt (and other coarsely ground blue colours) the excess oil was effectively absorbed by the ground or underlying paint-layers. At the beginning of the 17th-century, painter and art-theoretician Karel van Mander described several tricks for encouraging the oil to 'sink in' when painting with smalt, in his Den grondt der edel vry schilder-const (1604; Fig. 7).\(^{57}\) He mentioned the use of poppy oil; this is a more fluid oil than linseed oil so it can penetrate the ground layer more effectively. He also mentioned prickling the priming layer with pins to create a porous surface that can be penetrated by the surplus binding medium. Paint reconstructions show that the paint's sinking in can indeed be facilitated by sticking pins into a chalk and glue ground on panel. However the trick only works when a thin fluid oil is used; the pin pricks have no effect with a tough, thickened oil. According to Van Mander, some painters also absorbed the surplus oil by carefully covering the paint with blotting paper.\(^{58}\) Finally he stated that others used an oil that was prepared according to experience. Van Mander did not reveal this oil's composition. It is quite possible he was referring to an oil diluted with a solvent since this medium was repeatedly recommended in later instructions for smalt.\(^{59}\) According to the De Mayerne manuscript, the painter Abraham Latombé added a

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55. Armenini (1587; 1971), p. 128: 'ci è poi il smalto, il qual colore se ben fari attizzare, ed ogni volta essere moneggiare con una avventa destrezza, e con le une mestecche bene ordinate perciocche se si lavora non riesce alla prima finta bene in quel modo che deve stare. E molto fatica poi a accompagnarlo col rinovarmi sopra, perciò che ogni poco che in si si pensi con le pennelle, si reca che l'oglio in superficienza, e riempie la sua vertigine, si doppia di modo che in breve diviene guida.'

56. Mayerne (1620–46); see Graaf (1958), p. 191: ‘Per far la smalti bella e chiaro, bisogna temperarla con vernice testo, & metter la piana & non affaticarsi, a mezzari troppo mentre il colore è lume, per che questa aggiustazione guasta il colore. Ma essendo seco di pane lustrar di sopra come in pane.’ In the 17th century, the term varnish (vernice) was used not only in its present sense but also to indicate an oil binding medium, which did not necessarily have to contain resin.

57. Mander (1604), f. 50r: ‘Smulden willen ingrijten weren, om minder is verterene. De smulden behoren wel in is slierten. Hieromtrent geschiedt met waddelen alsche ten penndren om van solce is gemaakt. Sommige haren claudepapier en leren de dar of byghen waar mette ry wadden d'oly dar niet. Ein regel[be] onder maclschen met landschi oly, onder van gyldchen ghebrukken oly ommareckt met praetischen.’

58. Various 17th-century writers mention charta bibula as an equivalent for claudpaper, which means blotting paper, Mederna (1973), vol. 1, p. 607.

59. It is conceivable that in Van Mander's day painters would have come up with the idea of adding a solvent to the small paint. Indeed, in the 16th century, many references were frequently used in the binding medium and were often added to varnishes. For instance, in his Idea del Tempi della Pittura (1590), the Italian painter and art theoretician Lomazzo (1590; 1965), p. 71 mentioned that in oil painting one used: ‘...i colori macinati con olio di most, & di giaia. & d'altre cose.’
few drops of lavender oil because: the paint penetrates, it absolutely does not shine and it absolutely does not acquire an oily skin on the surface and never dies, so it remains beautiful. The studio handbook entitled Pictoria, au nom de dios, anno 1622, part of a relatively unknown manuscript by De Mayerne, recommends a similar procedure and continues that for the deepest shadow areas: your may add there some drops of water. This makes it [the colour] even brighter. When some water is stirred into linseed oil, the viscosity of the binding medium increases considerably. This would assist coarse pigment particles to remain in place.

Van Mander’s advice to cover the wet small paint with blotting paper is described later in the 17th century by De la Fontaine in his L’Academie de la peinture (1679). Very small pieces of paper had to be thrown on the wet paint surface. After these papers had absorbed the oil, they could easily be removed by placing the painting upright when the paint was almost dry. About half a century later, Palomino mentioned that it was useful to apply absorbing paper to the edges of the areas where small was used.

Van Mander’s method of treating the priming layer with pinpricks is not mentioned in any other text. Thus far, analyses of paintings have also not yielded evidence of this working method. Here, Van Mander’s information may reflect a rarely used painters’ technique. Possibly he merely recorded the extremely time-consuming pinprick method so as to emphasise the craftsmanship that was needed to deal with small. The quest for better application techniques for small appears to have continued throughout the 17th century. It was De La Fontaine who in 1679 first allowed a painting to dry horizontally to prevent the disturbing dripping of the blue paint. Palomino also suggested that a painting with wet small paint should be left to dry horizontally. Surprisingly, he noted that the painting had to be turned face down. This was clever, for the grains of small would move to the surface of the painting thereby preventing the formation of an oil skin. Thus, the instructions show how the most effective methods for painting with small took shape during the 17th and early 18th centuries. Yet this did not mean that painting with small became ever easy. This is demonstrated by the tricks that Palomino was forced to resort to so as to apply the pigment to his painting in a satisfactory manner!

II. Methods to combat the paint’s discolouring as caused by the pigment’s discoloration

Discoloration of pigments

Most inorganic pigments have a good colour-fastness. However, a number can still cause problems. Under the influence of light, red lead can turn dark or even grow lighter. Vermilion, a red mercury sulphide, is generally durable. However, when the paint is lean and the pigment particles are poorly

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60. See note 35. A similar method for working with smalt is mentioned on pp. 180, 191.
61. Mayerne (1623-44), f. 108r: ‘Pour peindre du olimalt. Desmeslans avec longe troyer olimalaiw bien espais & avec du pétrole la rendais comme il doit etre. De cela avec vostre blanc en torre, vos couleurs, un plus brue troyer y pourez mettre du lac en vostre olimalt, y pourez mettre quelque goutte d’oue. Cela le rend haut plus frais.’ In almost similar terms, this procedure is recommended in a recipe for painting with azurite (f. 108v) that the advice to add some drops of water is here omitted. De Mayerne sometimes recommends spirit of petroleum for diluting blue and green paints; Mayerne (1620-46); see Graeff (1958), pp. 150, 156 and more commonly for diluting varnishes and dissolving resins: p. 74.
62. Fontaine (1679), vol. 2, pp. 16-17: ‘Pour empecher qu’elle ne souille. Quand vous aurez fait votre depeiner, vous pelures votre tableau sur terre, ou bien sur une table, après vous prendrez du papier mouillé, comme papier gros de marquand, le rempares par petits morceaux; & la bavure, tomber par dessus votre desserpe, principalement sur les ombres; après le papier terre tout l’oeil. & quand tout le bleu sera comme solide, que vous appellons Sainte ou estube, encore que la couleur ne sera seule, le papier empechera qu’a la couleur ne souille pas. Pour eire à la peuper, il faut faire tomber le tableau sur un osine, tout le papier tombera. Netté qu’il ne lay faut laisse sauter pour que vous ne l’en prenuerez plus ais. Il ne faut mettre de gros morceaux, parce qu’il manqueroit la deserte.’
63. See note 16.
64. See note 62.
bound, paint can blacken if exposed to atmospheric pollutants.\textsuperscript{66} Orpiment, a semi-opaque bright yellow, and realgar, an orange yellow, are both arsenic sulphides and are known to be affected by the action of light. It makes them change into arsenic oxides that have a transparent white colour.\textsuperscript{67} In many 16th and 17th century oil paintings, smallt particles have partially or completely discoloured. It is now proven that this is because the potassium in the potash glass of which smallt is made, has migrated into the oil medium. This process lowers the basicity of the glass to such a level that smallt’s colouring component cobalt looses its blue colour.\textsuperscript{68} In many paintings, the surfaces of verdigris glazes have turned an opaque brown. The precise cause of this discoloration has still not been established.\textsuperscript{69} Another group of pigments, including umber, lampblack and asphalt contain coloured components (i.e. tar and other hydrocarbon compounds) that can penetrate to both the top and the lower layers of paint. Optically, this ‘bleeding’ can be extremely disturbing.\textsuperscript{70}

Discoloration is most likely to occur with pigments that are made from organic colorants. So that they can be used in oil painting, most organic colorants are first made into lake pigments. This process involves allowing the colorant to form a precipitate onto a white substrate, commonly aluminium hydroxide.\textsuperscript{71} Other white substance such as chalk and other natural white earths were also used. The colour-fastness of the lake colours is extremely varied. Good carmine or madder lakes reasonably light resistant, while other red lakes, such as brazil wood lake, can fade rapidly.\textsuperscript{72} All yellow lakes have a mediocre to extremely poor colour-fastness; this includes schiegetel [in British sources also denoted as the pink], which can have yellow, yellow-brown and yellow-green nuances.\textsuperscript{73} Also the blue colorant indigo can rapidly fade in an oil medium when exposed to light.\textsuperscript{74}

The degree of colour-fastness greatly depends on the pigment’s quality. For instance, depending on the origin of the colorant, the colour-fastness of the various red lakes can vary tremendously. The way in which the pigment is manufactured plays a role too.\textsuperscript{75} In the past expensive pigments were regularly adulterated with cheaper but visually compatible pigments. This kind of tampering could greatly reduce a pigment’s durability.

\textit{Historical knowledge about the durability of pigments}

Literature sources reveal that painters were knowledgeable about durability of the various pigments. Hence, in \textit{De teekenkonst} (1636), the Dutch writer and poet Cornelis Biens praised the durability of

\textsuperscript{66} Spring & Groux (2001). Feller (1967) has studied the darkening of vermilion by light. See also Gettens \textit{et al.} (1993)\textsuperscript{1}.


\textsuperscript{69} The chemistry accompanying the colour changes of verdigris glazes has been discussed by Kuhn (1993)\textsuperscript{1}, and others but information from the literature is conflicting: Berg \textit{et al.} (2000), p. 19 suggest that this chemistry involves three important processes which are accelerated by dissolution of copper pigments in the medium. These processes are: initial partial formation of (reduced) copper (-I) complexes in the drying process, hydrolysis of the ester bonds of the polymerised triglycerides to form a copper-based ionomer and, in the possible case of discoloration to brown, formation of finely dispersed CuO.

\textsuperscript{70} Kietel (1960), p. 303.

\textsuperscript{71} Hermens & Wallert (1998), pp. 274, 292.

\textsuperscript{72} Saunders & Kirby (1994)\textsuperscript{1}, p. 86; Schreppe & Roosen-Range (1986).

\textsuperscript{73} Saunders & Kirby (1994)\textsuperscript{1}, p. 86. On the terminology of scint-yellow or seig-yellow: Goedings & Groen (1994)\textsuperscript{1}.

\textsuperscript{74} The fading of indigo in oil paintings will be considered in chapter V.

\textsuperscript{75} For example, the colour-fastness of red and yellow lake pigments is strongly influenced by the kind of metal salt onto which the dye has been precipitated: Saunders & Kirby (1994)\textsuperscript{1}, pp. 86-87.
ultramarine, writing that it can above all others be used beautifully and undyingly for skies, distant landscape and clothing. Red lead, verdigris, asphalt, lampblack, indigo, schietgeel and red lake were almost always regarded as problematic. The Dutch painter Eikelenberg stated that: Indigo, once it is used by the painters, is subject to decline, to die pale.77 Palomino commented on verdigris: When it begins to decline, however, it ends being an infamous dark brown.78

Usually painters are unanimous in their description of the type of discoloration that can occur when particular materials are used. Occasionally there are remarkable differences. For example, sources describe a variety of phenomena, which would occur during aging of paint containing lampblack. This black pigment, which consists mainly of soot (carbon), is made by incomplete combustion of oil, tar, pitch or resin.79 In his Vite (1568) Giorgio Vasari notes various times that lampblack always darkened severely. De Mayerne stated that paint made of this pigment could turn yellow and an English manuscript on portrait painting entitled The art of painting in oyle by the life (1664) mentioned: some will use no lampe blacks in there pictures in oyle... for say they it will fade in time. Eikelenberg observed that passages wherein lampblack had been mixed with lead-white, in time obtained a whitish appearance as though weather-stained.80 Since at the time the combustion process could not be precisely controlled, lampblack contained a high proportion of tar and other hydrocarbon compounds.81 Depending on the binding media and pigments used with the black, these impurities could possibly have resulted in different types of discoloration.

Sources frequently remark that a pigment’s colour will last for a long time if it is a high-quality pigment and that it will soon disappear if the pigment is of poor or mediocre quality. Painters detected major differences in the colour-fastness of the red lakes especially. For instance, as the Spanish painter Pacheco said: For painting in oyl, carmine [a cochineal lake] from Florence is better than that from the Indies, and it is more sure and durable, although the one from Honduras is not bad.82

Because painters knew that a good pigment was needed to ensure a durable colour, their manuals describe many methods of determining whether one was dealing with a good and unadulterated pigment. Hence, in De groote waereld in 't kiezen geschildert (1692) the Dutch painter Wilhem Beurs gave the following advice to the amateur painter: The best yellow schietgeel is [an] intense yellow; it dies the least after being hung in private or in other stinking places.83 Beurs stated that the quality of red lake could be determined in the same way. However, painters will by far not always have been in a position to adequately evaluate the durability of their pigments when they purchased them, and will have generally bought their materials on good faith. Typical of this is the above-quoted comment by Pacheco, who mentioned the place of origin as the only selection criteria for evaluating good carmine.

76. Barts (1636); see Klerk (1989), p. 56: ‘Ik verwijze hier het twijfelijk alternariumhaken, dat tot boetse, terre landschap en schilderen heven als andere sloozen en onbestrijdelyk geplaatst kan worden.’
77. Eikelenberg, (1679-1704), p. 741: ‘De indigo, na dat zij van de schittering gebrekteys rood onderwierpen is bloedstijf, te verduren.’
78. Palomino (1715-24; 1795-97), vol. 2, p. 76: ‘pero en comenando a deiscer, rama a punar en un pudo ohcuro infame.’
82. Pacheco (1649); see Sánchez Cámom (1956), vol. 2, p. 83: ‘El carmin para pintar a olo es mejor de Florencia que de India, y es mas segura y durable, aunque no es mucho el de Honduras.’ Translation by Veliz (1986), p. 73.
83. Beurs (1692), pp. 14-15: ‘De beste goede schietgeel is dic tooggeel is, en dan moet bestier, wanneer in privaat, of andere stikchende plaatsen gehangen heeft... Laat... Men kan ze ook bepermen even als de lige schietgeel.’
Painters did not only distinguish the different qualities of each pigment, they also separated the various pigments into better or poorer kinds. To them, a good pigment meant one with an intense colour that was also durable. A clear example of this is to be found in a survey of the various red pigments in Der Wohl anführende Mahler (1719; Fig. 8), by the German painter Joan Melchior Crocker: The red colours are very different, and the one is better than the other both in terms of beauty and durability. In fact, vermilion is almost the most beautiful and durable of all the red colours.84

Differences of opinion about pigments' colour-fastness

Sometimes the opinion of the old masters with regard to the colour-fastness of a particular pigment differs with what is presently known. For example, nothing in the sources indicates that anyone had noticed that paints with umber and realgar could fade and become transparent.85 We know now that the discoloration of small paint can be caused by both by a yellowed oil binding medium and by the diminution of the blue colour in the pigment particles. The colour change in the small particles will presumably become visible within 25 and 50 years.86 However, in the sources consulted, painters did not seem to have been aware of this type of discoloration. Only yellowing and turning black (i.e. the darkening) of small oil paint is mentioned in connection with a discoloration caused by the oil medium.87 As suggested in the previous paragraph, remarks that small discoloured or could die were also associated with this kind of discoloration. Possibly, the effect of the diminution of the blue colour went unnoticed because it was masked by the oil's yellowing and darkening.

Occasionally in sources we find very different opinions about a pigment's colour-fastness. Sometimes this is connected with the fact that the sources did not have a fixed terminology for the pigments' names. Hence, the term ash (sandrij, as, achen) was regularly used for azurite, for lesser qualities of ultramarine, as well as for blue verditer, an artificial blue copper pigment.88 Apparent differences of opinion of the various painters about the durability of ash may well have been due to this unclear terminology. In addition, differences in quality due to adulteration can be responsible for the contradictory judgements concerning durability. Painters almost always considered vermilion to be one of the better pigments for oil painting and valued it for its colour-fastness. However, De Mayerne recorded two remarks by the painter Van Somer where he warned that vermilion could die.89 Van Somer may have had this negative experience due to having mixed his vermilion paint so leanly that the pigment was left vulnerable to react with atmospheric pollutants. Another explanation may be that the vermilion he was dealing with was either of an extremely poor quality or was adulterated. Particularly the pre-ground and ready-made variety would have often been mixed with the non-durable red lead. Marshall Smith mentioned this fraudulent practice in The art of painting (1692): 'Vermilion if it have glittering specs in it; or of very light colour, it is not good as being mixt with red lead.'90 In Van Somer's days, vermilion was

84. Crotker (1719); see Schiefl (1982), p. 94: 'Die mühlen Farben sind sehr unterschiedlich, und an Lichthaltigkeit und Beständigkeit eine der andern überlegen, wie dem der Zinnroh der sicher die schönste und beständigste unter den mühlen Farben ist.'

85. Painters had only noticed that these yellow pigments, when mixed with other colours, spoiled the paint. See section III. Palomino (1715-24; 1795-97), vol. 2, p. 52, mentions the darkening of opiumt in oil.

86. According to Boon et al. (2001), p. 960, the onset of small's discoloration process would be a relatively rapid phenomenon, which would take 25-50 years to be noticeable to the viewer.


88. Mayerne (1620-46); see Graaf (1958), pp. 41, 169. See note 100.

89. Mayerne (1620-46); see Graaf (1958), p. 149: 'Ces couleurs mourent [éteignent, laisent, ne le poin, mine, vermillon, mauve, coalire, eamel et 'Vermillon mort c`te les autres couleurs.' Van de Graaf (1958), p. 55 suggests that these remarks referred to watercolour painting where vermilion has a less effective colour-fastness. However, this is not likely because all of Van Somer's other instructions refer to oil painting.

90. Smith (1692), p. 71. This fraudulent practice is also mentioned by Crotker (1719); see Schiefl (1982), p. 94.

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one of the most expensive pigments. De Mayerne included a price list of pigments that shows that vermilion was six times as expensive as red lead, which suggests that mixing with red lead must have been an extremely profitable business.

Sometimes we see in the sources that a particular discoloration of a pigment is initially unknown, while it is noted by later generations of painters. In other instances, the colour-fastness of a certain pigment is initially considered insufficient, while later, because painters had learned to process the material more effectively, a more positive opinion emerged. Examples of both developments are given in the chapters on verdigris and indigo.

Historical knowledge about the conditions that caused pigments to discolor
It was well known that sunlight accelerated the discoloration of specific pigments. Sources regularly contain warnings about not exposing light-sensitive pigments, such as red lead, indigo, schietgeel and red lake, to the sun. For instance, Cröker remarked in 1719: *Indigo is not durable when applied to objects that must stand in the sun, then it loses its colour.* Therefore, advices about bleaching yellowed paintings in the sun sometimes include a warning about light-sensitive paints. Palominó warned to approach the parts of the painting that were painted with indigo with caution: *because if it is much in the sun, it will disappear.* Areas that had been painted with light-sensitive pigments could be covered with paper to protect them against sunlight. De Mayerne recorded a method for cleaning an oil painting where the colours have been ruined. It includes the following recommendation:

[The painting is first cleaned with soap and water or just with water]. *It must then be left for an hour or two in the sun. This will lighten the sky and the landscapes in the distance that have been made with smalt, azurite, masticot and lead-white. However, the places with schietgreen and lake will be ruined by the sun and the water. For this reason, these parts of the painting are covered with glued paper. The same applies to the trees and other kinds of green that are made with [a mixture of] schitgegel and masticot.*

This remark also demonstrates that painters were aware that water could ruin paints made from particular pigments. According to the sources, red lake, schietgeel and schietgroen were especially vulnerable. De Mayerne recorded the following from the studio book of Abraham Latombé: *Schiëggeel... This colour is even less resistant to the air and rain than [red] lake; it fades, bleaches and decays.*

The choice between permanent and discolouring pigments
Cröker's warning about indigo shows that painters sometimes avoided certain pigments because of their limited permanence. In the *De Mayerne manuscript* we find the following advice against red lead: *Red lead dies and is not good for oil [painting]; in order to make orange you must mix vermilion with schietgel.* Apparently,

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92. Cröker (1719); see Schiefil (1982), p. 112. 'Indig is not besteadige Farbe auf 5achen, so in der sunnen stiten willen, dann er verliert seine Farbe.'
94. Canni criticised the practice of placing fresh paintings in the sun in order to speed up the drying of the paint, since this caused the fading of certain pigments: Symonds (1650-52); see Beal (1984), p. 233.
95. Mayerne (1620-46); see Berger, (1901; 1973), p. 126: '... puis soit mis au soleil pour une heure ou deux. Le Cadre & les peintures schiéggées faites avec Esmail, Cendre, Masticot, & Blanc de plomb, par se moyan s'edecresseint. Mais la on il falla de Sundegroen, & de la laque, de soleil & de Pian y nascent equidemment; par tant ces parties du tableau doivent etre couvertes de papier sale de jour. Les arbres & autres verdures qui se faut avec le Schiéggel & le Masticot sons de se nombre.'
96. Mayerne (1620-46); see Graaf (1958), p. 145: 'Schiegel... Ceste couleur, non plus que la laque n'endure e l'air ne la phleg, se paise, se blanchit, s'en ru.'
the painter who gave De Mayerne this information believed that even light sensitive yellow lake pigments made more durable orange oil colours than red lead. In his *Groot schilderboek* (1707), the Dutch painter and art theoretician Gerard de Laire suggested against non-durable verdigris:

_Not that one should use the verdigris in order to acquire a fine green: because, although it is the most beautiful, it is neither the most pleasant nor the most lovely to the eye especially as it dies dreadfully and changes colour._

Many organic colorants that were extremely sensitive to light were considered to be completely unsuitable for paintings in oils. These included juices of flowers and berries which painters frequently used for watercolours. These colorants were avoided because oil paintings were generally exposed to far more light than watercolours, which were used for book illustrations and for coloured prints.

Yet, pigments were frequently used that could easily discolour. *Schieggel*, indigo, red lake, smalt, and verdigris were often used in 16th and 17th century paintings. If a painter had decided only to use permanent pigments, he would have been left with a range that was far too restricted. Painters first and foremost wanted to achieve a certain colour or a particular illusionistic effect and would therefore opt for the materials that were the most suited for achieving this aim, even if this meant choosing materials that were not durable. For instance, it was important that painters had a yellow glazing pigment at their disposal. Because a colourfast version of this pigment did not exist, they were forced to resort to light-sensitive yellow lakes such as *schieggel*. The price also played a role. Earth pigments, which are very durable, were generally cheap. But various stable intense coloured red, green and blue pigments were very expensive. When it became too expensive to use exclusively permanent pigments, the painter opted for cheaper and less durable substitutes. For that reason, ultramarine, which was by far the most durable blue pigment, was by some painters rarely applied while they used the problematic smalt to a very large extent. Similarly, as will be discussed later, painters used not only durable and extremely expensive red lakes but also other, less effective ones. Along with the price, the painting’s function also influenced the use of materials. For instance, Palomino states *superfine Italian or French carmine, ultramarine and its ashes - these are not commonly used except for very exquisite things._

Another important factor in the selection of materials was whether the pigments were easy to work with. For example, indigo that was well-known to fade rapidly, was nonetheless regarded by painters as a serviceable pigment in oil painting, since it had good colour strength, it covered well and, because of its fine-grained consistency, it was easy to work with.

Orpiment, in sources often praised for its beautiful bright yellow colour, was rather cheap and was at the time generally considered to be durable. Nonetheless, the pigment was only used on a modest scale because it was extremely difficult to grind and its use required many precautions because of its extreme toxicity and limited compatibility with other pigments. In choosing their

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97. *Lairet* (1707), vol 1, p. 359: ‘*Niet dat men ook, om een schoon groen te hebben, het spaanschgroen moet gebruiken: want hoewel dit het schoonste *cy*, is het meest onaangenaam en dikkende te *t* oog niet, te meer doordien het *cy* geezeld versteert en van kleur verandert.’

98. Examples of light sensitive colorants used in book illuminations include: dragons blood, cornflowers, saffron. For these and other examples: Roonen-Rung (1984), pp. 75-90.


100. Palomino (1715-24; 1795-97), vol 2, p. 52. ‘*A reto no ay adicion por extraordinarios el carmine superfino de Italia, el Frances, y el ultramarino y sus cenizas, porque ellos no se grasan comunmente sino en cosas especiales.*’ Translation by Vela (1986), pp. 153-54. The French and Italian prefixes refer to the place where the carmine was manufactured: Vela (1986), p. 214. Scientific research into Velázquez' paintings has shown that dearer pigments were used for the more important paintings: McKim Smith (1989), pp. 51-69.

101. For instance: Cröker (1719); see Schiöfl (1982), p. 111: ‘*Indes... Es ist in den Oel-Farben eine sehr nöthliche Farbe.*’

102. About orpiment’s characteristics: West Fitzhugh (1997) 2; Wallert (1984). Many sources state that orpiment was only seldomly used due to its poisonous nature. For example Hure (1730), p. 667: ‘*On ne l'a en sort guéris dans la peinture, à cause que l'est une matière arénosale et dangereuse.*’ On the
materials, painters will have continuously weighed up various aspects. Different considerations will have been decisive for each painter and even each painting.

The 17th-century regulations of the Utrecht painters' guild includes an example of how painters selected pigments based on the destination of their work. In the 1630s the guild council decided that a *schilderkamer* or *toonkamer* would be established in Utrecht. This was an exhibition space for paintings, for which the members of the guild had to provide a work every six months. Should the painting sell, part of the proceeds were destined for the guild. Apparently, not all of the painters recognized the usefulness of this *schilderkamer*, for the required paintings were not always faithfully delivered. In 1644, the council found it necessary to impose a severe penalty on every member who did not comply and deliver a work made by himself to the above-mentioned chamber. From this may be deduced that sometimes the work of a pupil was handed in rather than a painting by the master himself. When after 1644, the painters could no longer avoid their half-yearly obligation, they attempted to produce the requisite painting as inexpensively as possible. In the decree of 1664, the earlier warning was expanded with the injunction that the painting had to be an original, entirely painted up with its usual colours, in an appropriate format. Painters probably had made a habit of sending copies to the *schilderkamer* and executing these works in an especially small size. In the painting up of this work painters did not use their normal colours, but pigments of inferior quality.

Methods for improving pigments in order to counter discoloration

Painters nevertheless attempted to give pigments that could discolor rapidly but which had great advantages, acceptable durability by pretreating them. In 1642, De Mayern recorded an excellent remedy to consolidate indigo, schietgeel and [red] lake in oil from the painter Fettz. An addition of burned alum stone would make the colours more intense and they never die when exposed to sun, rain or wind, which they normally do after a few hours in the sun. From the beginning of the 17th century, texts on painting techniques draw a link between the purity of lampblack and the durability of the paint. From that time onwards, there are various recipes for 'burning' lampblack to ensure a long-lasting result. The manuscript *The art of painting in oil by the life* (1664) advised leaving lampblack glowing in an open pan on hot coals until it stopped smoking then it will continue well in oil painting otherwise it will not. This process eliminated organic impurities resulting in a purer carbon.

other hand, ornament is recommended by the Netherlands painter Wilhelm Beurs for the rendering of yellow fruits and flowers in still-life paintings. Study of Netherlands 17th-century still-life paintings has revealed that in this aspect Beurs accurately described techniques used by his contemporaries: Baller (1999).

103. Muller (1888), pp. 29-33.
104. Ibid., p. 73: '... in de kamer Kamer is leeren een stuk werk; by leem gemaakt,'
105. Ibid., p. 81: '... in de voorslae de Kamer is leeren een stuk werk; by leem zyft gedaan, principaal getooflyf afgemaakt, met syn gewoneleyke kleuren, op een aangewesen format...'
106. Mayern (1620-46), see Graaf (1958) p. 173: 'Excellent moyen pour fixer l'indigo, le soude et le lacque à base... Les couleurs sont beaucoup plus orientales, et qu'elles sont exposées, au soleil, à la pluie et au vent, ne sont point mortes. Ce qu'il est tout ordinairement, et dans peu d'heures au soleil.'
107. *Art of painting* (1664), p. 108. Many instructions for burning of lampblack have been compiled by De Mayern (1620-46); see Graaf (1958), pp. 143, 148, 152, 164, 176-77.
108. It is striking that contemporary texts on (book) painting - the technique where lampblack found its main use - never mention these instructions. Recipes for 'burning' lampblack are only found in sources dating from the 18th century. Possibly, in printing technique a pure lampblack was considered less important. When using the deep black printing ink that contained an extremely quick drying varnish, the problems encountered by painters, will most probably not have taken place; Sijnman (1998); Verbal communication: Ad Sijnman (ICN).
Methods for constructing the paint-layer in order to counter discoloration

Sources show that painters expected that the discoloration of binding media and pigments could be combatted by composing the paint-layers systematically. As indicated in chapter one, the general practice was to divide the painting process into three phases: the underpainting or dead-colouring, then the painting up and finally the stage of retouching. 109 By deploying a particular system for the construction of the paint-layers, which involved applying the pigments in the right way to the right layer, the painter could exploit the advantages of the less colourfast pigments while reducing the risk of discoloration.

Instructions for limiting discolouring pigments to the underpainting

One method, which the sources frequently recommend, consisted of limiting the pigments that were liable to discolour to the underpainting. This advice concerns pigments, which because of their low price, great colour strength, or easy processibility, were useful for modelling or for the first layout before the final application of colour. In this case, a thin top layer of a colourfast yet expensive pigment afforded a durable result. Any discoloration of an underpaint-layer will not be particularly disturbing because its colour is more or less covered by another layer. By using them for underpainting, light sensitive paints are also protected from discoloration to a certain degree, since the top paint-layer functions as a filter so that the intensity of light to which the underlayer is exposed is reduced. As discussed in chapter one, Wilhelm Beurs (1692) and Marshall Smith (1692), advised restricting indigo to an undercolour for paints made of ultramarine or other permanent but expensive pigments. Paintings in which this technique has been identified will be discussed in chapter five. Some painters applied the ‘underpainting method’ to the pigment umber. In the manuscript entitled Secrets in the noble arts of miniatu miniatu (c.1653-57), the English graphic artist Daniel King wrote that, in his oil paintings, the painter Harry Bryan used umber in the dead-colour for the carnation. Bryan avoided using the pigment in the upper layers: ‘bycause it dames [= grows dim] too much.’ 110 This effect is connected with the fact that both raw and burnt umber have a considerable capacity to absorb oil. This makes the paint looks dull once it has dried and can also cause the paint to darken dramatically. Later in the 17th century the use of umber in an underlayer was also suggested by Marshall Smith: ‘Umber should be us’d only in dead-colouring, or in deep shadows, which you cannot obtain by brown-pink [dark yellow lake pigment], [red] lake, etc; but from its body, it is of great use in dead-colouring.’ 111 Smith, however, believed that umber could also be used in top paint-layers as long as it was restricted to the darkest shadows.

Painters sometimes followed a principle similar to restricting the less colourfast pigments to the underpainting when working with various grades of the same pigment in order to be able to apply expensive pigments economically. In his Traité sur la peinture (1699), Bernard Dupuy du Grez recommended confining the best quality ultramarine for the top paint-layer and using cheaper kinds for undercolours. 112 The practice is most frequently suggested in instructions for painting with red lake. This would have been due to the vast differences in price between the various red lakes. A price list in the De Mayerne manuscript shows that a high-quality red lake was 25 times dearer than the cheaper kinds. 113 In his

109. This working method, which has been confirmed by scientific research of paintings, is described in detail in many 17th and 18th century texts including Art of painting (1664), pp. 99-105; Dupuy du Grez (1699; 1972), pp. 245-55; Laurosse (1707), pp. 12-14. Nico van Hout will explore in detail the significance of the notions of dead-colouring and making up in his PhD. research on the dead-colouring stage in the work of Rubens.

110. King (c.1653-57), fol. 4r.

111. Smith (1692), p. 69.


113. Mayerne (1620-46); see Graaf (1958), p. 146; ‘Lacque, stelling 1, 2, 3. ou 25 s. lence la meilleure, meurt poë le bon.’

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There are two sorts of lake: the coarse and the fine. The coarse has a colour that is not permanent. Therefore it should be used as little as possible except for the dead-colouring of large draperies and for other areas that use a lot of paint. The good, fine lake comes from Venice. It is expensive but one uses it sparingly because it is only for the carnation. The ones that are the most red and the least violet are the best.114

Of course, De Piles did not restrict the ordinary 'coarse' red lake to the dead-colouring simply because of its limited durability. At least as important was the fact that the colour hue and intensity of this lake were clearly inferior to those of the 'fine' quality. Good red lake was also recommended for unmixed paint and for glazes. In Principios para estudiar el nobilisimo y real arte de la pintura (1693), which, according to the introduction, was intended for amateur painters, the Spanish artist José Hidalgo suggested this practice for painting red and crimson red drapery (Fig. 10).

Furthermore, red draperies are not to be glazed: the darks are made with good carmine made thin, and the lights are of vermilion and white, and the half-tints are of vermilion and carmine. If a crimson is desired, glaze it once or twice with good fine carmine and reinforce the darkest shadows with bone black.115

The use of different quality pigments described by De Piles and Hidalgo appears to have been applied fairly generally. A handbook named Le petit peintre de mr. de St. Jeban that is part of the De Mayerne manuscript contains similar instructions. Other descriptions include those of Beurs (1692), Dupuy du Grez (1699) and Palomino (1715-24).116

Discussion of differences in the working methods used to combat discoloration

There seems to have been a striking difference of opinion among painters with regard to the use of pigments of various qualities. Some authors advised restricting the discolouring pigments to the underpainting because they assumed that a colourfast upper layer was enough to guarantee durability. Others rejected this working method because they believed that durability would in fact be damaged by the underlying colour. De Mayerne recorded the following advice: It is necessary that the first layer (that one names the dead-colouring) should have colours as good as the last, otherwise the ones will kill the others, especially the beautiful ones like the azurs etc.117 The Spanish painter Pacheco shared the same view:

114. Piles (1684; 1973), p. 42: 'Il y a de deux sortes de laque, la grosse & la fine. La grosse laque est une couleur qui ne dure pas; c'est pourquoi il ne s'en faut servir que le moins que l'on peut, si ce n'est pour ébaucher de grandes draperies, ou d'autres choses dans lesquelles il en faut beaucoup. La bonne laque fine tient de Venise, elle est chère, mais l'on en ase bien peu quand ce n'est que pour les carnations. Celle qui est la plus violette en la moins violette est la meilleure.'

115. Hidalgo (1693; 1965), p. 8: 'Mas no admiten bulto, las ropas coloradas, los obscuros de buen carmin basto, y las claras de bermeillon, y blanco, y las medios tintas de bermeillon, y carmin. Y si se quiere carmesi, se baha una, o dos veces con buen carmin fino.' Translation by Veliz (1986), p. 135.


117. Mayerne (1620-46); see Graaf (1958), p. 143: 'N.B. Il faudit que la premiere couche [que on appelle le Todtfarben] soit de couleurs aussi bonnes: qu[on] la dernièrem, autrement les ones tuent les autres, spécialement les belles comme les azurs &c.'
Some are also accustomed to working curtains or cloth with red earth of Levante or with haematite and white before shading and glazing with carmine. But I am of the opinion that even those things that will be glazed should be worked with good colours because in that way it [the colour] is permanent and more durable.\textsuperscript{118}

These contradictory working methods may be due to the fact that painters made different demands of their paintings’ durability. Pacheco’s information was part of a learned discourse on painting in which he expounded upon the conditions that a painter had to fulfil both on a theoretical and technical level. He had the ideal of an erudite and skilful painter in mind, an ideal that was also accepted by the humanist circles that Pacheco frequented.\textsuperscript{119} Within this context, it is not surprising that Pacheco rejected pragmatic painting techniques and emphasised the image of a competent painter who built up all the layers of a painting using only the best and most durable paints.

Sometimes sources mention painting techniques for durable colours that may at first seem contradictory. Along with the advice that indigo should be restricted to the underpainting, there are also instructions in which the pigment was to be applied to the top layer. This is a working method that has been observed in various 17th century paintings including works by Frans Hals (1581-1666), Judith Leyster (1609-60) and Johannes Verspronck (1597-1662).\textsuperscript{120} However, the authors that recorded the last method were well aware that this pigment could discolour and tried to prevent this from occurring. Difference in practice seems to have been due to the fact that painters had different ways of combating the same kind of discoloration. One of the methods used by authors recommending indigo in top layers consisted of applying the blue with only little lead white. Palomino warned: “that the lights not be made too light because the indigo colour easily weakens; therefore it must always be worked high in colour.”\textsuperscript{121} Apparently Palomino tried to overcome indigo’s tendency to fade by using a lot of indigo in the paint and therefore opting for a dark and intensely blue colour. This advice contradicts the recommendations for mixing colours to a lighter shade as discussed in the previous paragraph. However, those instructions were aimed at countering the oil medium’s tendency to darken. Palomino was referring to a very different type of discoloration; fading of indigo that is caused by light.

Instructions for a durable application of unstable pigments in the top paint-layer

In many cases painters would not have wanted to restrict the less colourfast pigments to their undercolours as these were particularly suitable for the upper layers because of their working properties, beautiful and intense colours or qualities as glazes. Sources describe various ways of applying unstable pigments to top layers in such a way that the risk of change was reduced. Palomino’s suggestion to mix indigo with a touch of lead-white is an examples of this.

Historical texts describe several methods to combat the discoloration of verdigris glazes. They advise that in order to preserve the green colour a little bit of varnish should be added to the oil medium. An artist’s manual known as Pictoria, collected by De Mayerne, recommended: “To preserve the colour of verdigris well, a little varnish should be mixed on the palette.”\textsuperscript{122} Other instructions warn that the green

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\textsuperscript{118} Pacheco (1649); see Sánchez Cántón (1956), vol. 2, p. 84: “También algunos acostumbran labrar cortinas o paños que lean de ser bautizados con alumbría de Levante, o con alba y blanco, cocinándolos con carmín y un poco de negro, pero soy de opinion que las cosas, aunque bautizadas de ser bautizadas, se labren con buenos colores, porque es más perpetuo y durable.” Translation by Veliz (1986), p. 73.

\textsuperscript{119} Veliz (1988), (1986), pp. 31-33.

\textsuperscript{120} The use of indigo by these painters and the historical painting recipes for indigo are dealt with in chapter V.

\textsuperscript{121} Palomino (1715-24, 1795-97), vol. 2, p. 67: “y es bellísimo color y muy dable de labrar, pero tiene también sus condiciones; y la primera es que los clares no sean demasiado claros, porque fácilmente se florecen, y así se ha de labrar siempre cabo de color.” Translation by Veliz (1986), p. 166.

\textsuperscript{122} Mayerne (1623-44), fol. 80r: “Drene vert. Dehaut premiersment estre echaudé de blanc & de noir charbon de fumée, puis glace pour la 2. fois de vertât, relevés de musique. Pour bien faire tenir la couleur un vertât fait second & melater un peu de vernis sur la palette.” Recipes that describe methods to prevent verdigris glaze from turning brown will be dealt with in chapter IV.
glaze needed to be varnished afterwards. In 1691, the still-life painter Jacob Bogdani (c.1660-1724), who worked at the English court, believed that: ‘Green leaves, of a light green, & in some places where the light shine thro'glaze then places with distilled verdigris ground in oil, & as soon as dry — varnish them places over with coppell varnish or else it will turn black.’123 Bogdani emphasised that only those areas that were glazed with verdigris were varnished, and that this varnish needed to be applied as soon as the glaze was dry; that is the moment that the varnish can be spread without mixing with the verdigris glaze. Paint reconstructions have demonstrated that both a varnish that covers the verdigris glaze and an addition of varnish to the oil medium provide (at least some short-term) protection against discoloration.124 Applying a varnish locally in order to prevent the paint in the passage concerned from discoloring was sometimes recommended for light sensitive pigments. In the De Mayerne manuscript we find the practice described for orange colours made of schieten and for paint made of indigo and lead-white. Palomino advised varnishing ornamental paint-layers as soon as they were dry so as to preserve their yellow colour.125 Most likely, a varnish layer inhibited to some extent the penetration of (UV) light that contributed to the degradation of the schieten. Indigo and ornament pigments.

Pacheco tried to preserve a paint made of light-sensitive carmine and lead-white by means of the underpainting. He suggested: If some rose-coloured drapery must be worked, it is more permanent if the underpainting is painted with vermilion. Then work the drapery with carmine and white and it can be glazed or left unglaed.126 Indeed, in the course of time, the vermilion’s intense red could still glow through the discoloured carmine layer.127 Other sources also recommended the same or similar construction of layers. Yet, only Pacheco linked the technique with the colour’s preservation. Most painters may have applied this combination of layers simply to achieve the special colour effect.


124. These reconstructions were carried out by the author and Dr K.J. van den Berg (ICN). A publication on this research is in preparation. Paint reconstructions were made with verdigris in 1. punished linseed oil, 2. punished linseed oil with an addition of colophony/spirit varnish, 3. pure colophony/spirit varnish, 4. punished linseed oil, covered after days, with a thin layer of colophony spirit varnish. The reconstructions were left to dry in daylight for three months (protected from direct sunlight). One series of samples was naturally aged and one series was subjected to two alternating ageing environments at the ICN: 1. Xenotest 150 S (8 days), and 2. dark-ageing in a climate chamber (7 days) at 50°C, in cycles of 75% RH (three hours) and 25% RH (three hours). The samples were acclimatized for at least 24 hours (at 23°C, 50% RH) after every ageing period before colour measurements (spectrophotometer Minolta CM 300-8). During ageing, paint 1 showed after a few days a strong colour shift from a bluish green towards a warmer green. In contrast, paint 2 did not exhibit the colour shift during the first week. From the second week onwards the colour became a warmer green. This change, however, was much less pronounced than was observed in the samples with the pure oil paints. Remarkably, paint 3 did not exhibit a colour change. Even after two years of natural ageing, the colour has preserved its bluish-green tint. Paint 4 exhibited similar colour changes to paint 2 during natural ageing. After artificial ageing all paints had become more yellow and darker. However, cross-sections indicate that in the case of paint 4, this colour change is only due to severe darkening and browning of the varnish layer. Under the varnish the verdigris paint appears un-altered and still has its vivid green colour. These observations demonstrate that an addition of varnish to the oil medium provides some short-term protection against discoloration. A varnish that covers the verdigris glaze prevents the glaze from discoloring over a longer period of time. However, the varnish itself does discolour. This means that the final colour effect would be little different from an unvarnished verdigris glaze. However, whenever one would remove the varnish the green would still be preserved.

125. The instruction for varnishing paint made of schieten is from the handbook of Le petit peintre. The instruction for varnishing paint made of indigo and lead-white is by Paulus van Somer. Mayerne (1620-46); see Graaf (1958), pp. 156, 148; Palomino (1715-24; 1795-97), p. 66.

126. Pacheco (1649); see Sánchez Cántón (1956), vol. 2, p. 83: "Y si se ha de labrar alguna ropa de rosaldo con el blanco y carmín, será más perpetuo su color si se besague debecho con hirondel y luego, a labrar con el carmín y blanco, se para quedar sin baldear, o para hacerlo." Translation by Velásquez (1968), p. 73.

127. Today, we know that, when compared to a white underlayer, an underpainting of vermilion will also absorb more light so that the amount of reflected light the paint-layer with carmine is exposed to will diminish.
III. Instructions to combat the discoloration caused by the mixing of incompatible pigments.

Knowledge about the incompatibility of pigments

Apart from the damage caused by sunlight, darkness and damp, the sources also provide much information about the discoloration that can occur when particular pigments are mixed together. The detailed instructions about the specific mixtures that can cause discoloration suggest that painters were extremely careful when dealing with this. There are numerous warnings about mixing with verdigris or orpiment. De Mayerne recorded: Verdigris (which one only applies for glazing) is so much an enemy of the other colours, that it will kill them all, especially the umber d'azur.\(^{129}\) The art of painting in oil by the Life (1664) warns the portrait painter about orpiment: 'Wee seldom use orpiment either red or yeallow, except only for gold lace or the like, because it is of a poysoneable nature, and will starwe other colours.'\(^{130}\) Several authors argued that mixing with vermillion could lead to discoloration. Marshall Smith wrote: 'Vermilion is apt to change somewhat black when compounded, but us'd simple in draperys etc. is of a lasting nature.'\(^{131}\) In addition, there are regular warnings about the discoloration that occurred through mixing with umber or lamplblack.\(^{131}\) Generally, the reason that was given for why discoloration occurred with these pigments was that the particular pigment in question damaged the other colours. Like for example in the above-mentioned warning in the *The art of painting in oil by the life.*\(^{132}\)

As mentioned in chapter I, when mixed together in a binding medium, certain pigments can cause a chemical reaction that could discolour the paint. Sulphur-containing pigments such as verdigris and orpiment can react with pigments consisting of either lead compounds (including lead-white and lead-tin-yellow) or copper compounds (such as verdigris and azurite). Studies of paintings have shown that some of these reactions may easily occur in an aqueous medium. However, in old oil paintings there is very little evidence of compatibility problems where less compatible pigments had been mixed.\(^{133}\) For instance, lead-white, which easily reacts to sulphur and then turns black, was used in combination with vermillion or ultramarine in countless paintings without causing any discoloration. Hence, it is remarkable that historical texts contain so many warnings about intolerant mixtures. Here, painters were also warning about mixtures of pigments that are nowadays known to be quite safe and which include *schiegel* with lead-white, indigo with carmine and red lake with vermillion.\(^{134}\) Possibly, the reason for this caution was the assumption made by the painters that the problems of mixing in an aqueous binding

\(^{128}\) Mayerne (1620-46); see Graaf (1958), p. 142-43. ‘Le vert de gris (dont on se sert seulement pour gras) est tellement ennemy des autres couleurs, qu’il les ruine toutes, presque du centre d’azur.’

\(^{129}\) Mayerne (1620-46); see Graaf (1958), p. 151, and on lamplblack: LeBrun (1635); see Merrifield (1849; 1967), vol. 2, p. 823.

\(^{130}\) Smith (1692), p. 69.

\(^{131}\) On umber: Mayerne (1620-46); see Graaf (1958), p. 151, and on lamplblack: LeBrun (1635); see Merrifield (1849; 1967), vol. 2, p. 823.

\(^{132}\) By contrast, an anonymous English text with instructions on limning (dated 1564) states that ‘all other colours’ were responsible for the discoloration of orpiment. British Library MS Sloane 3292, f. 3; see Harley (1970; 1982), p. 87.


\(^{134}\) Van Somer warned that lead-white named the colour *schiegel*, Mayerne (1620-46); see Graaf (1958), p. 150. Palomino (1715-24; 1797-97), vol. 2, p. 69, warned ‘El abilo se convenga muito al carmín y al no hay que mezclarse juntos con él, porque umbra se produce, y resulta de los dos un color infame, que no se sabe qué es?’ For the warning about vermilion and red lake see note 138. Recent publications about the qualities of yellow lakes, lead-white, red lakes, indigo and vermillion make no reference to any problem. Respectively: Stoll (1981); Gettens et al. (1993); Schwebke & Roosen-Runge (1986); Schwebke (1997); Gettens et al (1993).
medium would apply to oil painting as well. However, the difference between the 17th century and our contemporary view may also be due to the fact that we still do not completely understand the problems surrounding the use of historical pigments in mixing paint. Here, differences in mixing ratios, quality differences or the pigments' adulteration may have played a role. The problems that were encountered while mixing umber or lampblack will probably have been caused by the bleeding of these pigment's tar and other hydrocarbon compounds into the top and lower paint-layers.

Painters' warnings mostly concerned the same pigments. However, opinions differed about the degree of incompatibility. While The art of painting in oil by the life maintained that orpiment should not be mixed with any other pigment, in the Trattato dell'arte della pittura (1585), the Italian painter and art theoretician Giovanni Lomazzo listed a large number of pigments including green earth, indigo, smalt, red lake and ochre that could be safely mixed with orpiment. Wilhelm Beurs emphasised that when mixed with light ochre, orpiment turned black and that this pigment could only be combined with light and brown schietgeel. The reasons behind these different beliefs may have been quality differences, differences in mixing ratios or a discrepancy in the understanding of the materials.

Instructions for using incompatible pigments

Painters had a number of ways of avoiding problems that they believed to be caused by incompatible pigments. First, they suggested that separate brushes and palettes should be used for those pigments. The care that was taken to avoid unintentional mixtures was not just limited to the intolerant pigments; rather it generally included all pigments. In addition to the chemical incompatibility of some pigments, a role was also played by the mixing of certain colours, which simply resulted in an ugly grey. There is frequent advice that grinding stones, palettes and brushes needed to be cleaned thoroughly. Some painters such as the Amsterdam painter Latombe regarded dirty brushes as being one of the main causes of the discoloration of paint. Latombe recommended that all brushes should be cleaned each time. In some cases, such as for the painting of a portrait, new brushes should be used. Another way of preventing problems from occurring, consisted of replacing incompatible pigments with compatible ones. The following is recommended in the studio book of La petit peintre de Mr. de St. Jehan Aragon is a red earth such as bole or red ochre, it never dies and is better for the painting of skin colour than vermilion that with the passing of time contaminates the lake. It was also possible to apply the incompatible paints separately by working them into a numbers of layers. As mentioned in chapter 1, this was regularly recommended for orpiment. Anthony van Dyck warned that orpiment when mixed with other pigments it kills them, and therefore was to be used exclusively for the final highlights, only to be applied after all the other paint had dried completely. Half a century later, Marshall Smith also considered this painting technique to be essential: 'Orpiment should be us'd only in touches by itself in drapery, gold, etc. for if it be compounded it grows foul.' Study of Netherlandish still-life paintings revealed that during the second half of the 17th


136. See note 128.

137. Mayenne (1620-46); see Berger (1901, 1973), p. 120: 'N.B. La plus parti des couleurs ne meurent[...]. que faute d'œil. bien meistre les peintours[...]. Veillez pour que le peintre qui rend faire quelque ouvrage d'importance, principalement[...]. ne porte au naturel, doute moyfais[...]. arbre des peintours neuf.'

138. Mayenne (1620-46); see Graaf (1958), p. 162: 'Aragon est une terre moyse comme du bole ou de l'ocre rouge, laquelle ne meurt jamais, & pour faire les charnoures est meilleure que le vermillon, lequel avec le temps tue la lacque.'

139. Mayenne (1620-46); see Graaf (1958), p. 175: 'L'ouvrage de jaune. Il ce sort de l'orpiment qui est le plus beau jaune que l'on saurait avoir... & meust avec toutes autres couleurs s'il les tou.... Et pour s'en servir il faut appliquer seul ayant fait la drapère [pour laquelle seule il est trés bon] avec autres couleurs jaune, & sur toute bien mélée d'eau, rechercher de la peur avec l'orpiment. Ainsi votre labeur sera beau par excellence.'

140. Smith (1692), p. 69.
century, orpiment was regularly used for depicting lemons, oranges, gold and bright yellow flowers.\textsuperscript{141} In using the yellow pigment, most painters may have been well aware of the procedures described above. Orpiment is almost always used only as a highlight on dry underlying layers of paint (Plate 1). Palomino considered indigo and carmine lake as mortal enemies and therefore recommended applying these two pigments in separate layers: To make a purple cloth, you may work first with indigo and white, when it is dry, it is all glazed with good carmine.\textsuperscript{142} The optical mixture of transparent dark red over blue resulted in a purple colour without any physical mixture of the two pigments. Sources recommend a similar principle for glaze paint made of verdigris. Depending on the type of green colour desired, the glaze could be applied over yellow, blue, green, grey or reddish undercolours.\textsuperscript{143}

Also in the composition of the ground, some painters took into account the intolerance of certain pigments. The painters' manual Brief traité, part of the De Mayerne manuscript, maintained:

 Yet, one should note and be informed that the before mentioned red lead, verdigris, smoke or lampblack are like poisons, which cause the discoloration of the colours that one applies on top and for this reason one should avoid them, when priming.\textsuperscript{144}

This early 17th-century advice cautions against some types of ground that were common at the time.\textsuperscript{145} Already in the 16th century, red lead and verdigris were added to grounds to accelerate drying. Painters also worked on a grey ground consisting of lead-white and black pigments (including lampblack).

For making the ground or the underpainting, various 17th-century authors recommend using the sediment from the kladpot or pinceliere, namely the container with oil in which brushes were kept to prevent them from drying out.\textsuperscript{146} The sediment consisted of a mixture of all of the pigments that had been used (chiefly the much employed lead-white) and it dried rapidly because the oil in the pinceliere had long been exposed to the air. Investigation of paintings has confirmed that some painters made good use of the mostly grey or brown, rapidly drying pinceliere paint for their grounds or underpaintings.\textsuperscript{147} However, given the warnings in the sources to avoid 'hostilities' between pigments even in the ground, far from all painters will have used this sediment without reservations.

\textsuperscript{141} See various entries in Wallert et al.(1999).


\textsuperscript{143} See chapter IV, section III, Underpainting for verdigris glaze paints.

\textsuperscript{144} Mayenne (1620-46); see Graaf (1958), p. 141: 'Il faut toujours essuyer et extraire avant que laisse moins le ver de gris, noir de jumeaux ou de lampe sont comme des poisons qui font mourir les couleurs qu'on y met dessus & pour estoil cause les fautes faut en empêmer.'

\textsuperscript{145} Koller (1984), p. 304. For example, priming layers containing verdigris are mentioned by Armenini (1587, 1971), p. 125. In priming layers of 16th-century Italian easel paintings, red lead has been regularly identified. There are also many examples of the use of black pigments: Dunkerton & Spring (1998), pp. 127-30. 18th and 19th century English documentary sources regularly advice a grey coloured ground layer, since this would preserve the colours painted on top. Carlyle (2001), p. 177.

\textsuperscript{146} For example: Binet (1621; 1632), p. 312, and LeBrun (1635); see Merrifield (1849, 1967), vol. 2, p. 771.

\textsuperscript{147} Wetering (1997), p. 24 believes that the complex paint mixtures used by Rembrandt for his monochrome dead-colours suggest that remains of the pinceliere were used in this stage of the work. Joyce Plester (1980), p. 41, has observed the same phenomenon in paintings by Tintoretto.
IV. Methods to combat discoloration caused by the increasing transparency of oil paint-layers

_Causes for the increase in transparency of oil paint-layers_

In general, the sources are rather silent about an effect that is now frequently noticed in old paintings: that particular layers of oil paint become more transparent in time. The difference between the refractive index of the binding medium and that of the pigment determines an important extent the paint's opacity or transparency: the smaller the difference, the more transparent the paint. Hence, the painter creates a transparent paint with red lake or ultramarine in oil because the refractive index of these pigments is close to that of oil. In art technological literature, it is assumed that when the layer of oil paint ages, the oil's refractive index increases so that it gets closer to the pigment's refractive index; this in turn would cause the paint to become more transparent. However, the exact mechanisms that take place inducing this increased transparency are still very insufficiently understood. There are chemical as well as physical explanations.

Especially paint-layers containing lead-white, which cover well when fresh, have often become translucent on old paintings. In this case the increased transparency seems due to a chemical change on the surface of the lead-white particles in the oil medium. This could be caused by the formation of lead soaps (fatty acid lead salts) resulting from an interaction between the oil and the lead pigment. In this case, the lead soaps would increase the refractive index of the oil medium. The paint's increased transparency means that the underlying layers are less effectively covered so that an underpainting or _pentimento_ may become visible. In addition, a coloured ground layer may influence the painting's appearance to a far greater degree than originally intended. An example is the still-life painting with asparagus (1679) by Adriaen Coorte (active 1685-1707). On the paper support, Coorte first applied two rather light coloured ground layers containing earth pigments. Then he blocked out the dark background while leaving a reserve of a rather square shape where the bunch of asparagus was to be painted. Subsequently, he painted the asparagus with delicate nuances of lead-white paint, which has become more transparent today. The dark background has become clearly visible beneath the asparagus' tips, but not within the square where the lighter ground colour was reserved (Fig. 11). As yet it is not clear in which cases, in which time span and to what extent these phenomena occur. It is assumed that the process occurs gradually, though already in the course of a few decades. However, when interpreting transparent paint-layers on old oil paintings, it is important not to exclude the possibility that some effects, such as a partially visible underdrawing or underpainting, may have been part of the painting's original appearance.

_Historical knowledge about the increasing transparency of oil paint-layers_

Texts on painting techniques show that a considerable increase in transparency had been noticed by the end of the 17th century. The Dutch painter Gerard de Lairesse explicitly mentions the effect in his _Groot..._

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148. This is based on measurements made by Laune (1926), (1937).

149. The influence of the rising of the oil's refractive index on the appearance of the paint-layer was calculated on the basis of the Kubelka and Munk equation by Rees Jones (1991).


152. Personal communication: Dr Klaas Jan van den Berg (ICN).

153. The paint-layer was sometimes applied so thinly to 16th-century paintings (such as those by Pieter Aertsen (c.1509-75) and Joachim de Beukelaer (c.1533–c.1575) that the underdrawing has probably been visible from the start. Verbal communication: Margreet Wolters, University of Groningen. Margreet Wolters is writing her Ph.D. thesis on the underdrawing in the studio of Pieter Aertsen and Joachim de Beukelaar.
schilderboeck, which was published in 1707. However, De Lairesse’s observation must have occurred at an earlier date because he went blind in 1689. Before depicting the required subject, de Lairesse advised underpainting each part of the painting’s composition on the coloured ground, with a uniformly coloured ground layer. This layer had to be approximately the same colour as the colour that the painter ultimately wanted to achieve.\(^\footnote{154}\) De Lairesse argued that the layer contributed to the colours’ preservation:

> Through its similarity to the tints and colour that one covers it with, which will preserve their perfect beauty and power, this cannot occur when the ground is of another colour and tint, like white on black, light blue on dark yellow or red, and so forth, shining more and more through due to the length of time, no matter how thickly it is applied in paint.\(^\footnote{155}\)

This remark is obviously connected with the oil paint-layers’ increasing transparency, so that an underlying layer in a different colour than the one on top would create a disturbing effect once it became visible. From the indication length of time we may deduce that this phenomenon occurred in the long term. According to De Lairesse, it made no difference whether the paint had been applied as a thick or thin layer. However, he believed that applying an extra layer of paint in approximately the same colour effectively prevented the problem.

The increased transparency of oil paint caused by ageings as mentioned by De Lairesse, is not explicitly referred to by sources before the end of the 17th century. Nonetheless, there are a number of early remarks that can be connected with the phenomenon. The early 17th-century authors that recommended using good quality pigments for underlayers may have taken into account the paints’ increasing transparency. Likewise, contemporaneous warnings for priming layers made of umber and black pigments, may indicate that painters had observed that in time dark underlayers became disturbingly visible due to the increased transparency of the paint-layers applied on top.\(^\footnote{156}\) In the beginning of the 17th century, Karel van Mander described in his *Den grondt der edel vry schilder-const* (1604) how some painters developed their composition after the dead-colouring stage. Other painters, though, drew the composition on the panel in an extremely precise manner and applied from the start the right colour for every part of the depiction: *from the very first every colour is applied to its place so as not to die.*\(^\footnote{157}\) The discoloration, to which Van Mander referred, may well have been caused by an underpainting in a deviating colour, which would have produced a disturbing effect once the paint started to become transparent. A mid-16th-century ordinance of the St. Lucas Guild can also be read as a reference to the paint’s increasing transparency. It forbids painters from completing their paintings with just a single layer of paint and they were obliged to dead-colour their work first.\(^\footnote{158}\) Miedema interpreted this ordinance by pointing out that this obligation was aimed at preventing the underdrawing from

\(^{154}\) De Lairesse (1707), vol.1, p. 331. De Lairesse stated that the painter should not apply fine and costly paints to this underlayer *maar gemene als ze scheets, hyt ek ze en niet dekkken.*

\(^{155}\) Ibid.: *door haare overeenkoms met de tinten en kobur die men daar over heen stryckt, welke kunnen volkomen schoonheid en krucht beloven, teggen niet gescheiden kan wanneer de grond vanen onder kobur en tint is, geelyt is op zwart, lichtblauwe op donkergeel of rood, en zo voort, uytvende door de lanklyeyt van tyl meer en meer door, al ware het nog ze rei en de riew aangejekt!* According to Anton Raphael Mengs, the increased transparency of paint-layers in Raphael’s *Transfiguration of Christ* was also due to ageing; see chapter IV, paragraph *Anton Meng.*

\(^{156}\) On the other hand, these recipes do not discuss the tone of the ground layers but only problematic brown and black pigments that may equally have been used in a light tinted ground layer.

\(^{157}\) Mander (1604), f. 47r: *‘elcke cursor van eerste op hare plaats leggen om niet verteren.* According to Pauw de Veen (1996), p. 229-30, the term ‘leggen’ is often used as a synonym for aanleggen that is to lay in a paint-layer.

\(^{158}\) This concerns a 1546 hallmark of the St. Lucas Guild in Den Bosch: Miedema (1987), p. 141: *‘Iern sullen alle schilders الرحمن wieren te werkken goede vereren . . . ’elcke cursor van eerste geloovigen ende alwien op raven dekkhen grunds, wanneer dit lyt principaal oorwenen open hare lyt principaal sullen meegen ten sritte opmaken.*
eventually becoming visible because of the layers' increasing transparency. Still, it is remarkable that, although the early 17th century texts provide detailed information about other aspects of discoloration, they do not explicitly discuss the phenomena associated with the paint's increasing transparency. This may suggest that these phenomena were not yet clearly visible or that in general painters did not find them disturbing.

V. Gaining knowledge about the paint's discoloration.

Transfer of and development in knowledge

Painters must gradually have gained insight into the permanence of pigments in an oil medium and the durability of painting techniques. Knowledge that painters initially did not have about problems, grew to become widely accepted among later generations. Vasari, recorded that three panel paintings by Pietro Perugino (c.1450-1523) had deteriorated a great deal, and in the dark parts where there are shadows, they are full of cracks. According to Vasari this had occurred since Perugino had not allowed his underpaint-layers to dry enough before applying new layers: But Pietro could not know this, because in his time they were only just beginning to paint with oil. To an important extent, such knowledge will have been handed down within the studio tradition from master painter to pupil. We may, therefore, assume that in the 17th century, much about discoloration must have been generally known since oil paints had already been in use for some two hundred years. Yet painters did not have such a long background for using the full range of pigments. For instance, they had to discover for themselves what was the best and most durable method for working with small that had only entered general use around the middle of the 16th century. In addition, technical and stylistic developments had resulted in new painting techniques with a durability that was yet to stand the test of time.

Sources suggest there was a constant search for methods of improving the permanence of both their pigments and binding media. The instructions for purifying and bleaching oil media, and for decontaminating lampblack, were but a few examples of this. The texts also attest to painters seeking new painting methods that would increase durability. When a painting technique is mentioned that was considered to be durable, it is regularly described as being the secret of a particular painter or as being a new method. For instance, Malvasia claimed this when describing Guido Reni's preference for applying his paint with extra lead-white in order to overcome the paint's tendency to darken. According to Malvasia, this working method was contradictory to those of the good masters of the past because these painters warned against the excessive use of lead-white. For instance, Reni's master Lodovico Caracci (1555-1619) regularly harped on about lead-white as follows: Even a brush stroke of it, should not be applied before considering it for an entire year. Lodovico's caution was presumably caused by the fact that the excessive use of lead-white imbues the paint with an overly cool and chalk-like quality. Guido Reni's method of mixing the paint with extra lead-white was not based on ignorance but aimed at overcoming the paint's discoloration. That this way of working was indeed 'new' in the 17th century appears to be backed up by a remark by the Spanish painter Pacheco. In his advice to paint particular colours in a lighter shade (as mentioned above), he also stated that this was a new opinion.

159. Vasari (1568); see Mâlinesi (1878-85), vol. 3, p. 574: 'Questa tre tardi hanno partito assai, e sono per tutte, negli onci e dove sono l'ombre, crepate; e ciò avviene perché quando si lavora il primo colore che si pone sopra la maschera (perchè col colore tre muti di colori si danno, l'onci sopra l'altro) non è ben secco, onde poi col tempo nella quarta brama per la giovinezza loro, e vengono ad aver forza di fare qu'crepali: il che Pietro non potè notare, perché appunto ne' tempi suoi si cominciò a colorare bene a dio.' Translation by Bull (1987), vol. 2, p. 92.

160. See note 50.
Ways of gaining knowledge

Painters naturally studied old paintings so as to gain new information about the varying degrees of durability of painting techniques. This allowed them to observe the effects of ageing in a particular material or painting technique. The sources regularly refer to old paintings in order to demonstrate a material or technique’s good (or limited) durability. Richard Symonds noted down that the painter Francis Barlow (1626-1702), famous for his pictures of horses, dogs and birds, had told him once that: ‘the green head of a mallard’ [= wild duck] he used verditer but it began to grow discolored as he ther observed.161 In his instruction blue drapery made with Santo Domingo blue, Pacheco referred to the discoloured paintings of other painters and to his own well-preserved works. Hidalgo did the same when publicizing his secret for a durable green: ‘The colour of green robes is the one most often lost, and since these have never turned black for me, I must communicate my secret.’162 Vasari reported, how an altarpiece by Titian (c.1477/80-1576) had deteriorated very quickly so that the painter had to make it again.163 He also described how a small panel of the Madonna and child by Leonardo da Vinci (1452-1519) had already been ruined in Vasari’s days: either because of the mistakes made by whoever primed the panel with gesso, or because of his [Leonardo’s] own capricious way of mixing any number of grounds and colours.164 At other times, Vasari did have clear ideas about the underlying causes of an extremely rapid ageing of paintings. He noticed the excessive darkening of shadow areas in some painting made by Fra Bartolomeo, Raphael and Giulio Romano in the early decades of the 16th century.165 As will be dealt with extensively in the third chapter of this dissertation, Vasari attributed this darkening to these painters’ use of black pigments and especially lampblack and ivory black.

Painters sometimes tested the materials’ durability before actually applying them to their paintings. De Mayerne and the Dutch painter Eikelenberg reported a number of experiments to test the permanence of unusual materials or those processed in a special way.166 According to De Mayerne the painter Daniel Mytens (c.1590-1646) had tested the pigment tin white in oil paint. Mytens concluded that tin white could not be used in this technique because it turned black in the sun and when mixed with lead-white ruined this pigment.167 Eikelenberg’s writings include an extensive report of an experiment that aimed at determining the permanence of an indigo that had been purified in a special way (Fig. 12). He mixed his indigo with various quantities of lead-white and then used it to paint pieces of prepared paper, a number of which were kept in his studio while the others were placed in the open air. He compared the results four months later.168 With these kinds of experiments, painters were testing their paint by trying to accelerate the ageing process by exposing the paint to extreme conditions such as bright sunlight, rain and wind. Their experiments were apparently constantly testing the durability of one

161. Symonds (1650-52); see Beal (1984), p. 304.
163. Vasari (1568); see Milanesi (1878-85), vol. 7, p. 444.
164. Vasari (1568); see Milanesi (1878-85), vol. 4, p. 47: ‘Mas, o sia per opus di che la sengozio, o per per quelle sue tinte e capricciosa misture delle mistiche e de lebber, e oggi molti giusti.’ Translation: Bull (1987), vol. 1, p. 269.
165. Respectively: Vasari (1568); see Milanesi (1878-85), vol. 4, pp. 185, 378, vol. 5, p. 533.
166. The fact that De Mayerne mentioned several painters’ experiments shows that this was common amongst painters at that time. De Mayerne, being a physician, also tested materials for his own interest. Eikelenberg was a painter with a scientific background. His extensive way of testing materials would not have been representative of painters’ general working methods.
167. Mayerne (1620-46); see Graaf (1958), p. 165. Anthony Van Dyck also tried to use tin white in oil painting. He concluded that, when used in oil, this pigment has not enough body so that it was only suitable for the art of illumination. Mayerne (1620-46), see Graaf (1958), p. 165.
168. Eikelenberg (1670-1704), pp. 786-87. These tests will be considered in greater detail in chapter V.
material, sometimes when mixed with one other pigment. The sources provide nothing to suggest that painters also researched the durability of a technique such as the particular construction of a paint-layer. Presumably they based their knowledge of this subject exclusively on the evidence of old paintings.

The guarantee period for colour-fastness
Sources rarely reveal the length of time that had to elapse before painters could judge whether a particular pigment or painting technique was durable. Generally the only indication of time was that a particular colour disappeared quickly or was preserved for an extremely long time. More concrete evidence is sometimes found in reports of experiments to determine the materials’ durability such as Eikelenberg’s experiment with indigo that was mentioned above. When compared with the paint on the papers that had been kept indoors, the paint on the papers that had stood outside for four months had hardly discoloured. Therefore, Eikelenberg regarded this pigment as being especially durable. Another example is an experiment performed by Paulus van Somer that was recorded by De Mayerne. In order to discover which pigments would discoulour, Van Somer suggested exposing a painting to the evil vapours of the shut-shed. After two or three days, all the pigments had discoloured that would ever discoulour with the passing of time - at least, that’s what Van Somer wants us to believe! These kinds of remarks suggest that if pigments did not discoulour after spending a few days, weeks or months in extreme conditions, painters would assume that the pigments’ colour-fastness had been guaranteed which was reason enough to use them in their paintings.

Some remarks by painters about the durability of old paintings reveal the length of time that had to elapse before, when exposed to normal conditions, a particular painting material or technique could be judged to be durable. Pacheco recorded the following about the composition of a priming that was made of a type of clay, which according to him was frequently used in Seville and which he strongly recommended:

This is the best priming, and the one I would always use without further modifications, because I see my six canvases in the cloister of the Mercedarians preserved without having cracked nor shown any sign of flaking since the year 1600 when they were begun, which is enough for me to approve the soundness of this clay preparation.

The fact that Pacheco’s Arte de la pintura was completed in 1638 shows that for him a period of less than forty years was enough to judge whether or not a particular material or its application was durable. In his previously mentioned advice to use a lighter shade of the colour blue, Pacheco stated that this method guaranteed an extremely durable result because the blues that the painter Mohedano had painted in this way had remained blue. But if the blue is painted light, it stays blue always, and its highlights and shadows can be seen.

... I have observed this in the painting of Mohedano, who followed this method.

The Spanish painter Antonio Mohedano lived between 1561 and 1625. If we assume that Mohedano would have been no younger than twenty when he first set up as an independent painter, the paintings that Pacheco had in mind would have been fifty or sixty years old at the most.

In the 17th century, paintings that had not (markedly) discoloured within a few decades were apparently considered to be especially durable. So when authors state that a particular colour would last an extremely long time, or eternally or forever, they in fact refer just to a period of several decades. It is

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160. Mayerne (1620-46); see Greaf (1958), p. 150.

169. Pacheco (1649); see Sánchez Cantón (1956), vol. 2, p. 76: ‘Esta es la mejor emprezousión y lo que yo soyo siempre, sin más invaciones, porque veo conversadouso més seis lunzas del claustro de la Merced, en haber hecho quatro en estado de color desde el año de 1600 que se comenzaron, que me bastó para aprobar la seguridad de este aparato de bano.’ Translation: Velázquez (1986), pp. 68-69.

170. Pacheco (1649); see Sánchez Cantón (1956), vol. 2, p. 85: ‘y desde claro, siempre es azagá y se ven sus claros y oscuros, así lo he observado con atención en las pinturas de Mohedano, que aquí esta opinión.’
important to bear this in mind when interpreting the methods described in the sources for preventing the paint's discoloration. These reveal that painters believed that, despite all the problems, if one had enough knowledge and skill, it was possible to make extremely durable paintings. It is easy to understand their optimism considering the length of time that was actually implied. Painters were dealing with an ageing process than occurred within half a century, a space of time in which they themselves would be able to observe how paintings changed. By preventing discoloration for that length of time, they also amply covered the period in which a purchaser or patron would be able to notice how the painting had aged. However, striving for roughly fifty years of colour-fastness will also have guaranteed the colour's preservation over a longer period of time. Today there is evidence that during this period a certain stability occurs within the drying and aging processes in the layer of oil paint.\textsuperscript{172}

Of course, the question now is whether the colour's 'guaranteed' preservation meant that painters expected that their paintings would more or less maintain their original colours for many centuries - in fact right up to the present day. One of the few remarks where a painter referred to this length of time is found in the correspondence between Albrecht Dürer (1471-1528) and Jacob Heller. Heller, a rich textiles merchant, had asked Dürer to make an expensive altarpiece depicting the Ascension and coronation of the blessed Virgin Mary. While he was working on the altarpiece (1507-09), Dürer kept Heller informed of his progress. He informed Heller that he was only using the best pigments for the altarpiece and was taking the greatest possible care with the painting. Dürer guaranteed that these measures would ensure that the altarpiece's middle panel would still be pure and fresh of colour in five hundred years time.\textsuperscript{173}

By using a special varnish that Dürer promised to apply after several years, the work would maintain its beauty for yet another hundred years. The period for which Dürer guaranteed the colour-fastness of his altarpiece cannot have been based on practical experience. Indeed, in his day, five hundred year-old oil paints simply did not exist for him to refer to. However, the period of time that he mentioned demonstrates that, at least in Dürer's day, the life expectancy of paintings was sometimes anticipated to be very long indeed. As in the case of Dürer's altarpiece, these would have been extremely expensive paintings that had been worked on for a very long time and involved the honour of both the painter and the patron.

There is little evidence that painters attempted to preserve the colours of less prestigious works for a similar period of time. Certainly there was not much concern about the durability of the colours on paintings that were cheaply churned out on a mass scale.\textsuperscript{174} Reflecting the current mood of transience, some painters regarded their paintings' ultimate deterioration as inevitable and even necessary. This is expressed in the Dutch painter and poet Philips Angel's 1642 eulogy to painting:

\begin{quote}
There are no things beneath the sun's rays that are certain to last forever; they are all subjected to change, nothing maintains a motionless self-preserving state other than the unchanging constant god; in the same way paintings can last a few hundred years, which is enough.\textsuperscript{175}
\end{quote}

\begin{footnotes}
174. For instance, no effort appears to have been made to achieve durability in canvas paintings made with watercolours that were cheaply mass-produced in Mechelen from the second half of the 16th century: Tamié (in preparation). See also chapter III, note 20.
175. Angel (1642), p. 25: 'daar en zijn geen dingen hier bovenste welke van de zon bewallen worden, die verachtan zijn van alijt te dagen; of sy zijn de verander ricly onderworpen, nacx en beloont een onvergetelliche self-styrende stent, dan allenlck een onveranderliche een-styrende godt; noch so komen schildererye enige heenderde jaren dagen, het welcke gheenouli is.'
\end{footnotes}
Conclusion and summary

In this chapter the references to discoloration in historical texts were brought together in order to give a coherent survey of the traditional knowledge on the ageing of oil paint and the painters' attitude toward this phenomenon. The sources reveal that 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. A survey was given of the numerous instructions concerned with preventing discoloration caused by the yellowing and darkening of the oil binding medium, the discoloration of pigments, the incompatibility of pigments and the increased transparency of oil paint-layers. Sources also provide evidence of painters' constant search for new methods of improving the colour-fastness of their paints. Time and the cost of materials played an important role in the production of paintings. In many cases, the making of durable paints was a time-consuming process. The use of expensive and colourfast pigments could raise the price of a painting above the acceptable. The sources indicate that in the choice of materials and technique, the priorities will have differed per painter (and painting). These choices prove to be partly responsible for the paintings' current good or poor condition.