Verdigris Glazes in Historical Oil Paintings: Instructions and Techniques *

'Le verdégris distillé pour glacer ne meurt point.'
De Mayerne (1620-46), BL MS Sloane 2052

'Vert de gris... neure pas & elle devient noire.'
De la Hire, 1709

Interpretation of green glazes:
Green glazes were commonly used in oil paintings of the 15th to 17th centuries for the depiction of saturated green colours of drapery and foliage. These copper-based paints often reveal no crystalline pigment particles under the microscope. Today, these glazes are often covered with a brown layer and sometimes the whole glaze has become brown. In research into this discoloration attention has focused on how the glaze was made. Various opinions have been voiced on the matter. The paints were often and indeed still are regularly identified as copper resinate. This is a transparent, amorphous green of copper salts of resin acids formed when verdigris - basic or neutral copper acetate - reacts with a varnish. It was Laurie who first claimed that this green had been used by painters in The pigments and media of the old masters (1914). He maintained that it was used for the layers of transparent copper-green paint without pigment particles that he had encountered in miniatures in 8th- to 15th-century manuscripts. According to Laurie, miniaturists had made the paint by dissolving verdigris in hot varnish. He based this conclusion on two recipes for 'vernis verd comme esmeraude' and 'vert transparent' in the well-known De Mayerne manuscript (1620-46) that describe the heating of verdigris in varnish. In research into the painting techniques of the Flemish primitives, begun in 1950 at the Brussels' Institut Royal du Patrimoine Artistique, it was assumed that copper resinate had also been used in oil paintings. Since then green glazes have frequently been identified as such. Because it was assumed that artists had often used copper resinate, authors such as Woudhuysen-Keller and Brinkman focused extensively on examining how it was made, studying the sources and experimenting with reconstructions. It was thought that the heated solution was applied directly onto the painting as a glaze. Artists were also assumed to have allowed the green to cool and to have mixed the resultant glass-like substance with oil to form paint.

Yet some researchers cast doubt on the assumption that the green glazes used in 15th-, 16th- and 17th-century paintings were usually copper resinate. They felt that the identification of this material on the basis

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1. X-ray diffraction powder analysis does not yield a pattern, which confirms the absence of crystalline particles: (Kühn) 1993.
3. Mayerne (1620-46); see Graaf (1958), p. 164. In one recipe verdigris is added to a mixture of Venetian turpentine and oil of turpentine, and the mixture is heated gently until the required colour has been achieved. In the other recipe verdigris is ground with linseed oil and then common varnish is added. The mixture is stirred well and applied warm. Instructions for adding verdigris to a warm medium are further described in the following texts: a 15th-century manuscript in Rome, Biblioteca Casanatense, MS 2265, f. 99r (Transcription in: Birkmaier et al. (1995), p. 126); Birelli (1601), pp. 370-71 (Quoted in: Kühn (1993)1, p. 149 and Woudhuysen-Keller (1998), p. 141); Peacham (1606), p. 67; Luk, Veren en Verf-kunst (1767), p. 92; Birelli (1601), p. 369, also mentions a recipe in which verdigris is added to hot linseed oil in which alum has been dissolved.
4. Coremans et al. (1952-54); Coremans (1952-54); Coremans et al. (1959); Coremans et al. (1961).
of microscopic research and the positive identification of copper offered insufficient certainty. They could not exclude the possibility that in many cases the verdigris had been mixed with a medium and applied cold since, as Kühn has warned, ‘the outlines of crystals of verdigris are often very difficult to recognise under the microscope and... verdigris reacts in the course of time with protein, oil and resin media to form transparent copper salts of fatty acids, resins or proteins.’ When this happens, the verdigris particles dissolve in the medium and become invisible. So the widely identified amorphous glazes are therefore not necessarily copper resonate: it is possible that a gradual development of copper oleate or copper proteinate has taken place. According to Kühn, positive identification of copper resonate is only possible if the binding medium contains a high percentage of resin and if copper salts of resin acids are in fact found. With the increasing analysis of the binding medium of copper-green glazes in recent years, the paint appears in most cases to contain only an oil-based medium. Where paints contain resin, this appears to be only a small additional amount. This demonstrates that these paints were not made by dissolving verdigris in heated varnish. Yet how the glaze was made nevertheless remained unclear. The changes that the paints have undergone in the intervening years have meant that the precise nature of the original materials and the methods employed by the artists can now no longer be traced. Nevertheless it is essential to find out more about these aspects, if the reasons why some glazes have become excessively brown while others have retained their colour are to be understood.

**Painting instructions for green glazes**

Historical instructions recorded by artists on the use of verdigris in oil painting provide a wealth of information about the raw materials and the methods employed by painters. Remarkably, little attention has been paid to these formulas in the discussion surrounding the making of copper-green glazes. Indeed, research into the sources has focused almost entirely on a handful of recipes in which verdigris was added to heated varnish. Yet these explicitly state that this method was for paint suitable for use on glass, metal foil or for lacquering furniture. The numerous instructions for glazing with verdigris in easel-painting, recorded from the 14th until well into the 19th centuries, never recommend that the mixture be heated. These formulas always advise cold oil or cold varnish as a binding medium for verdigris. The notion that painters allowed copper resonate to cool off and form a hard, glassy mass before grinding it into a powder and mixing it into paint, is not supported in any of the sources.

Instructions for glazes with verdigris used in easel-paintings are the subject of this chapter. A large number of formulas from various periods and regions are compared in order to provide a coherent image of the historical application of the green glaze paint. This survey provides an insight into gradual developments and local variations in ways of working. The theme of the first section is the different methods for the production of verdigris. Section two focuses on the historical assessment of the colour-fastness of the copper-green glaze. The third section surveys instructions regarding the preparation of the glazes. Instructions covering the grinding the pigment, the correct media, mixtures with other pigments, ways of glazing and the build up of the paint layers are discussed. Finally, the fourth section deals with why verdigris was used less often in oil paintings of the 17th century than on those of previous centuries.

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8. Berg et al. (2000); Billing et al. (1997), pp. 39, 53-54; Pike & White (1995), p. 82. Instrumental analysis of paint samples rarely identified a high amount of resin in the binding medium and only sporadically copper resonate were identified.

9. For example, De Mayerne’s recipes were attended for ‘Les peintures à eau qui peignent ou paixent de meubles & de tissus’ and ‘Pour faire le ver transparent que s’applique sur un fond d’or ou d’argent’. The other recipes, referred to in note 3, for using a warm medium refer to similar applications, or the recipes are part of texts that deal with painting on glass or other decorative painting techniques.

10. This notion is expressed by o.a. Woodhusyen-Keller (1995) and (1998). Reconstructions by the author show that the paint obtained by this method has no advantages over ground verdigris directly applied with cold oil or cold varnish. In all copper-green glazes examined in the National Gallery, London, only once transparent green particles were found resembling ‘ground up’ copper resonate: Pike & White (1995), pp. 77-78, 82. Personal communication: Jo Kirby, Scientific Department, National Gallery, London.
I. Composition of historical verdigris

Producing Verdigris

Historical recipes for the preparation of verdigris, known variously as 'vert de gris,' 'grieks groen,' 'spanigroen' and 'verde,' advise hanging copper plates in a pot over strong vinegar. Having sealed the pot, this is then left for a number of days or weeks. The resultant layer of mainly basic copper acetate that forms on the plates can then be scraped off. Among modern writers, the term verdigris refers exclusively to these copper salts of acetic acid. As late as the 18th century, however, verdigris encompassed various other green and blue-green corrosive products from copper. Some recipes recommend smearing the copper plates with honey or eggwhite and a sprinkling of salt. This produces copper chloride and copper oxide as well as copper acetate. Besides common salt, sal volatile (i.e. ammonium chloride) was recommended, which could also produce copper chlorides. 18th-century texts also mention adding saltpetre (potassium nitrate), alum (potassium aluminium sulphate) and vitriol (sulphate of e.g., copper, zinc, potassium or iron). The use of these salts might result in the formation, for example, of copper sulphate and copper nitrate. A few recipes advise exposing copper plates or filings to urine fumes. This could result in the formation of both basic copper acetate and copper carbonate. Occasionally, recipes advise combining several of these additions. For example, in some 17th- and 18th-century recipes copper plates are heated with a mixture of salt, powdered sulphur and cream of tartar (potassium hydrogen tartrate). Since the 12th-century verdigris had been produced on a wide scale in the French wine-growing region around Montpellier as a by-product of the wine-making. Copper plates were exposed to the fumes of the fermenting dregs, the remains of the pressed grapes, grape skins and husks. The carbon dioxide released in the fermentation process led to the formation of basic and neutral copper acetate, as well as copper carbonate and basic copper carbonate. The earliest description of the preparation of verdigris in Montpellier can be found in one of the manuscripts by the Swiss physician De Mayerne (Fig. 1).


12. Rahn-Koltermann et al. (1993), and Köhn (1993), p. 131. An example of this procedure is described by Alessi (1558; 1977), ff. 29v-30r. Other recipes show that the copper could be exposed to the vinegar in a great variety of ways. Sometimes the copper slides were immersed in the vinegar: Buche of aceti (1506), ff. B3v-B4. Alternatively, the copper could be sprinkled with vinegar and then exposed to the open air: Pictorius (1713; 1747), pp. 105-06. Other recipes advise laying copper filings in vinegar, which was later poured off and reduced by evaporation: Pictorius (1713; 1747), p. N.3.

13. Various recipes for the manufacture of verdigris have been transmitted since antiquity. Reconstructions have been made at the Döme institute in Munich, and more recently by Rahn-Koltermann on the basis of these recipes, and the salts obtained have been analysed. Kühn (1993), p. 131, Rahn-Koltermann et al. (1993), Schweitzer & Mühlethaler (1968). A review of the use of copper chlorides and related salts as painting pigments was published by Scott (2000).

14. When a little salt was used, only copper acetates were formed. When more salt was added a mixture of basic copper chlorides, copper oxides and copper acetates was formed: Rahn-Koltermann et al. (1993), p. 223. Some recipes advise treating the copper filings with soap before exposing them to acetic acid. This results in a small amount of copper salts of fatty acid being formed as well as copper acetates: Kühn (1993), p. 131.

15. An example of the use of saltnic salt for producing verdigris can be found in Traktiefer (16th C.), see Vandamme (1974), p. 116. Other salts are, for example, recommended in the Witer Farbenbuch (1794), p. 117.


17. Sprong (1738), p. 60.


20. Mayerne (1623-44), f. 51r. (Transcription in Ekema Hommes (2001). For other 17th and 18th-century descriptions of the production process: Ray
The 15th- and 16th-century recipe collections consulted, describe various methods of preparing verdigris without indicating which were used often and which were not. According to 17th-century sources, painters mainly used the verdigris from Montpellier. Pomet claimed in his *Histoire générale des drogues traitant des plantes, des animaux et des minéraux* (1694), that most of the verdigris used in France and even abroad, is made in and around Montpellier.\(^{21}\) According to Pomet, the recipes that required vinegar and methods involving the heating of copper plates with salt, sulphur and tartar were of negligible importance to painters. Verdigris was already being exported from Montpellier to other parts of Europe in the 16th century. In his *Descrizione di tutti Paesi Bassi* (1567), Ludovico Guicciardini included *very good verdigris from Montpellier* among the products imported from Antwerp from France.\(^{22}\) Other centres of production existed besides Montpellier. In *Der wohl anführende Mahler* (1719) the German painter Cröker mentioned the regions of Hungary and India as major production areas and a late 18th-century German text notes that verdigris was produced in Sweden with vinegar made from wood.\(^{23}\)

Analysis of copper-green paints on 15th- to 17th-century Netherlandish, German and Italian paintings often reveals these to be of heterogeneous composition. Apart from copper acetates, copper chloride pigments such as atacamite, paratacamite and calumetite as well as copper sulphate pigments such as posnjakite, brochantite and antierite are regularly identified.\(^{24}\) Thus, paratacamite was found in the green glaze of a cloak in *The Last Judgement* by a Westphalian Master (Fig. 2) and atacamite in the green curtain in Pordenone’s *Judith with the head of Holofernes*, both in the Rijksmuseum, Amsterdam (Fig 3a-c).\(^{25}\) Sometimes small portions of these copper salts are found in compounds that consist mainly of copper acetate. Sometimes the copper chlorides and copper sulphates form a larger proportion of the copper pigment. Because the term verdigris was used to cover a range of corrosion products of copper, the painting methods for verdigris recommended in the sources would also have applied to these copper salts. Analysis of paintings has shown that the way artists used copper chloride and copper sulphate pigments in the 15th and 16th centuries was no different to the way copper acetate was used. The green copper pigments were consistently mixed with the same pigments (lead-white, lead-tin-yellow and yellow ochre), the same binding media were used and the paint-layers were also built up in a similar way. In the curtain painted with atacamite, for example, Pordenone employed methods characteristic for the use of verdigris. In the underpainting, the rendering of the folds of the fabric was made with atacamite mixed with lead-white and lead-tin-yellow. He then applied a glaze made with atacamite.

Artists had hardly any means of distinguishing between the various corrosive products of copper.\(^{26}\)

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21 Pomet (1694), p. 31: ‘c'est ce qui fait que la plus grande partie des verd-origs qui se consomme en France, & même dans les pays étrangers, se fait italienne & auteur de Montpellier.’


24. As described e.g. by Berg et al. (2000); Kuhn (1993)1, p. 131 and references therein; Bilinge et al. (1997), p. 61; Mario & Evento (1992); Hul-Ehrenreich & Hallebeck, (1979). Within the MoLART project, copper green glazes in about 20 paintings (Netherlandish, German, Italian, c. 1450-1590) were investigated. Many glazes were found to be ‘emulases’ in microscopic examination due to the presence of opaque pigments, mostly lead-white and/or lead-tin-yellow. Light microscopy and scanning electron microscopy, combined with energy dispersive X-ray microanalysis (SEM-EDX) were used to study the green paints in cross section. Polarisied microscopy (PLM), (trans) methylation gas chromatography-mass spectrometry (Py-MAH-GCMS), and X-ray diffraction (XRD) were used on scrapings of the glazes. Light microscopy and PLM were carried out by Dr Anne Wallen (Rijksmuseum Amsterdam), Karen Green and Muned Geldof (ICN). SEM-EDX analysis was carried out by Klaus Munch (SHELL). Py-MAH-GCMS was performed by Dr Klaas Jan van den Berg (ICN) and Jerré van der Vorst (AMOLF). XRD analysis was performed by Peter Hallebeck (ICN).


26. Reconstructions in which two parts of copper acetate are mixed with one part copper chloride and one part copper sulphate show that the
They bought their verdigris from apothecaries and in the course of the 17th century from shops specialising in artists' materials. John Smith could do no more in The art of painting (1676), than recommend that decorators buy verdigris from Montpellier; he did not explain how to distinguish this from other sorts. Yet, while Pomet identified more characteristics that good verdigris should have, he was far from specific: 'We obtain two types of verdigris from Montpellier; that is powder and bread, which, if it is of good quality, must be dry and of a fine dark green colour with as few white spots as possible.' According to Pomet, greedy verdigris makers often mixed the product with substances that kept the copper salt damp so that it would weigh more when they sold it. The white spots may have been chalk, since 19th-century sources note that verdigris was frequently adulterated with that substance. These texts note that verdigris was also diluted with cheaper copper sulphate. The difficulty in distinguishing between different types of verdigris must have been a problem for artists. Indeed, they considered it to be essential to obtain a good quality product since it was felt that only this would guarantee a lasting green. Pomet claimed that paint made with poor quality verdigris eventually turned black. John Smith stated that only verdigris from Montpellier kept its colour and that 'the verdigris made at any other place will fade.' It is possible that the various copper salts, whether containing impurities or not, may have resulted in paints with varying degrees of colour-fastness.

**Distilled verdigris**

Apart from unrefined verdigris, painters also used distilled verdigris, also referred to as crystallised or purified verdigris. Broadly, two methods of distillation were used. The first involved mixing unrefined verdigris with vinegar - often distilled- and then evaporating it. The basic copper acetate dissolves in the vinegar and forms crystals of neutral copper acetate. Other basic copper salts (basic copper chlorides etc.) would also be partially turned into neutral copper acetate, thereby obtaining a purer product. Many painters' manuals recommend this method of distilling, indicating that this was used by painters in their own studios. According to De Mayerne artists would first grind the unrefined pigment into a powder before mixing it with vinegar. The fluid would be brought to the boil au bain marie. It would then be poured into a wide earthenware dish and evaporated to form the green crystals that were subsequently mixed with an oil medium. The Spanish painter Pacheco noted in his Arte de la pintura (written before 1638; published in 1662) that 'Nous ferons de Montpellier de deux mines de verdure: scumiren poudre & en pain, lequel pour être de la bonne qualité il faut qu'il soit sec, d'un beau verd-fonce, & le moines rempli de taches blanches qu'il sera possible.' 19th-century painters also chose their verdigris purely on the basis of its colour; see, for example, Hopman (1856), p. 30.

29. Pomet (1694), p. 31: 'Nous tirons de Montpellier de deux sortes de verdres, sasser en poudre & en pain, lequel pour être de la bonne qualité il faut qu'il soit sec, d'un beau verd-fonce, & le moines rempli de taches blanches qu'il sera possible.' 19th-century painters also chose their verdigris purely on the basis of its colour; see, for example, Hopman (1856), p. 30.
32. Pomet (1694), p. 31; Smith (1676), p. 98.
34. Verbal communication Dr K. J. van den Berg (ICN).
35. Mayerne (1623-44), f. 43v: 'To prepare verdigris. Take of verdigrisace 2 or 3 ooz. and grind it fine upon a painters stone, and put it in a glaize with it a narrow mouth, having covered it three fingers deep with distilled white vinegar, and having stept the mouth with a bladder mixed with 3 pinoleas. put it in a skillet with fair water and must be ground but by standing upon the coals, and when you find it daily hepted, take it up, and let it stand then put it in an esother pan well placed, and put it in cold water, which must be heated till by supping of it away, it begins to have a crust, then take it up, and set it in a cooler all night, and in ...' (7) morning you shall find it shot into small stones, which is the best green for this purpose.' For another recipe described by De Mayerne (1620-46); see Graaf (1958), p. 158.
1649) that it was usual to purify verdigris with water and a little vinegar. This would be filtered through a fine sieve to remove bits of copper, sand, and grit. The filtrate would be dried by evaporation and was then ready for use. Neither of these methods would have resulted in pure neutral copper acetate. Chalk, with which unrefined verdigris was often adulterated, dissolved in the vinegar and resulted in the formation of calcium acetate. This would remain in the subsequent dried product. Other potential impurities that were dissolved in the vinegar might also remain. The fact that calcium is consistently found in 15th- and 16th-century copper-green glazes may be attributed to this method of preparation (Fig 4a-c). Artists who used the method described by De Mayerné did not even remove the sand and copper grit. If the enormously diluted vinegar solution recommended by Pacheco was used, it is possible that not all the basic verdigris would turn into neutral pigment. And other copper salts might also remain in the filtrate.

In the second method, the unrefined verdigris would be dissolved in a cauldron with distilled vinegar or some other acidic solution. An oak base was placed in the cauldron with numerous protruding thin wooden sticks. Dissolved copper salts crystallised on these sticks into neutral copper acetate. Any remaining pieces of copper or sand in the unrefined verdigris is removed in this method. Chalk and traces of other possible copper salts are also removed, since these remain in solution in the vinegar. Distilled verdigris obtained in this way is therefore much purer than that obtained by the first method and consists almost exclusively of neutral copper acetate (due to re-crystallisation). Apothecaries traditionally employed this method of distillation. As Chambers’ Encyclopaedia (1738) relates, the crystals were used by physicians to cleanse old ulcers, eat off fungous flesh etc. In the second half of the 17th century, distilled verdigris was also produced by Pekstok, an Amsterdam firm with a small factory specialising in the production of pigments and other artists’ materials (Fig. 5). Pekstok did not make verdigris from copper plates. It was apparently cheaper to import the raw material from the wine-growing regions of France and then to improve it. In his encyclopaedia of 1694 Pomet noted that French unrefined verdigris was mainly exported to Holland. After Pekstok had refined it into a purer product it was re-exported to France. Thus Pomet claimed that all the distilled verdigris on sale in Paris actually came from either Holland or Lyon.

Yet, until well into the 17th century, it appears that artists seldom purchased this remarkably pure ready-to-use distilled verdigris. A price-list of pigments purchased by painters in the De Mayerné manuscript only mentions ‘ordinary’ verdigris and not the distilled pigment. Inventories of four 17th-century Dutch shops specialising in the sale of artists’ materials suggest that there can hardly have been any demand for distilled verdigris from painters. These shops had increasingly taken over the sale of pigments from the apothecaries. So the unrefined verdigris that apothecaries had formerly sold was available in large quantities. However, only one of the four shops had some distilled verdigris in stock. But it was apparently too little to

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36. Pacheco (1649); see Sánchez Cantón (1956), vol. 2, p. 82. See also Wögest (1679; 1687), p. 161-62.
37. A purer product may be obtained using a recipe mentioned by d’Emery (1676; 1684), p. 281. Here the mixture of verdigris and vinegar is put in pastry, which is subsequently baked. The bread will to some extent absorb the vinegar and the dissolved impurities.
38. For recent identifications of calcium in copper-green glazes: Bårås et al. (1997), Berg et al. (2000), and Unpublished MOLART results (see note 24). Of course, the presence of calcium may also indicate that a yellow colorant precipitated on chalk was added to the copper green paint to obtain a warmer more yellowish green; see Adding pigments to the glaze.
39. Chambers’ Encyclopaedia (1738), under “verdigrise.”
41. Pomet (1694), p. 32.
42. Mayerné (1620-46); see Graaf (1958), p. 146.
43. The majority of shops only had un-distilled verdigris in stock: Municipal Archive Rotterdam, Inv. van de overleden Willem Vanzuy en zijn weduwe Willemken Bouwens, d.d. 11 October 1602: Archief van de weeskamer, Inv. no. 371, f. 753v: “Een groot stuk Spaens groen,” f. 762v: “Een liaten met Spaens groen.” Municipal Archive Amsterdam: Inv. van Daniel Rulando, d.d. 15 April 1644: Archief van de weeskamer, Inv. no. 350, f. 164v: “Wat Spaen groen,” f. 195v: “8 brade Spaen groen.” It is only in Volmarinck’s shop in Rotterdam in the 1630s and 40s where a wide assortment of pigments were said,
even quote a price. Ancient instructions make clear that painters would have used the self-distilled, less pure pigment. It was only in the second half of the 17th century that they appeared to switch to ready-made distilled verdigris. This likely reflects a development in which painters prepared less and less of their own materials, preferring instead to buy ready-made products commercially. An inventory of a shop of artists' materials in Rotterdam drawn up in 1673 reveals that distilled green was kept in large quantities. In England, as John Smith wrote in 1676, the pigment was also available in the colour shops. According to Croker (1719), the sticks of crystals resembled candy sugar; according to the French painter Watin in his L'Art du peintre, doreur, vernisseur (1772), they looked like vine branches. Artists recognised differences in quality in this type of verdigris too. The handmaid to the arts (1758), claimed that distilled vinegar produced the finest crystals, yet ordinary vinegar was often used because it was cheaper. Watin advised painters to choose this distilled green with beautiful crystals, well dry, strong colour and with a velvet-like appearance. Croker stated that the best types came from France and India.

In 1702 the Dutch painter Simon Eikelenberg (1663-1738) noted the prices of many pigments in his (unpublished) Aantekeningen over de schilderkunst (1679-1704). Distilled verdigris was 8 stuivers an ounce (Fig. 6). This did not place it among the most expensive pigments, such as ultramarine and high quality red lake, which ran into several guilders an ounce. Distilled verdigris ranked among the mid-price pigments, which included indigo and yellow lake. Yet, distilled verdigris must have been considerably more expensive than the unrefined pigment. John Smith warned decorators that distilled verdigris was 'of good use in fine-work, but too dear in vulgar-painting,' for which he used unrefined verdigris. Because in easel-painting considerably less pigment was required than in decorating, it might be assumed that the difference in prices of copper greens would have been a negligible factor. Nevertheless, it did matter on some occasions. The Netherlandish painter Jacob Bherens mentioned around 1661 in his handbook that he used ordinary verdigris for 'ordinary works... but for costlier works one uses distilled verdigris.'

that the stock includes a little distilled verdigris in addition to the large quantities of verdigris. Municipal Archive Rotterdam, Inv. van Trijntje Pieters, d.d. 12 maart 1648. Archief van de weeskamer, Inv. no. 330, f. 188r: "Wat gedeistelt spaaens gron." f. 189r: "De dist el point spaaens gron." point tot refijn st. Adde ende rijffich punt spaaens gron. 7 point tot refijn st. Houndert dreinde seventen point spaaens gron. 7 point tot refijn st." I would like to thank Kees Henny for making her transcription of these inventories available to me.

44. Henry (1994).

45. Municipal Archive Rotterdam, Boedel inventaris van Ermptgen Pieter weduwe van Abraham Lambertsz. van Bubbeson, d.d. 24 februari 1673. Archief van de weeskamer, Inv. no. 461, f. 231r: "Een en half pond gedeistelt groen." This is still a small amount compared to the forty pounds of undistilled verdigris present in the shop, f. 230r: "Veertig ponden spoës groen gedeistelt voor 17." However, it should be taken into account that the pigments in the shop would also have been bought by decorators that generally used the 'raw' undistilled verdigris. See the advice by John Smith (1676), pp. 24-25 for the 'vulgar' painters.


47. Dossin (1758), p. 106, Watin (1772, 17976), p. 29: 'Il faut choisir un verd distillé, en beaux cristaux, bien sec, honte en couleur, ayant un soup d'œil réhaussé.' Croker (1719), see Schiell (1982), p. 118. See also the advice by Volpato (17th or 18th C), see Merrifield (1849; 1867), vol. 2, p. 745.

48. Eikelenberg (1679-1704), p. 781. For example, the best quality yellow lake cost 12 stuivers per ounce and indigo 8 stuivers. Many other, mostly earth, pigments could be obtained for a few stuivers per pound. For prices of both verdigris and distilled verdigris in England in the 18th and 19th century: Briscoe (1996), p. 22.

49. Smith (1676), pp. 24-25.

50. Bherens (1661), pp. 239-40: 't lauwerr of glazuren. Groen glikk men en mijn groot stück de Pastic stien kan B slukkerde ik eerst met wit en schoonboecl met smaart. Dat is iek gijt el beugte day en diepest schaduw en maartet g' gewaat heel gedaan. Glijck wit binnen uitt voude direct dis maakt men en eerst draw get en met een naye stempel broedel met wit olly, of med wit sammersda renport met enige pallet tot (gebroken) werkstuk. spaaens groen enkel met strema of gebakene ub, en men streepelt dan g' Geslaagt gewaat daerena over, dag met in ret daat comfort kunnen aflagen, en offel dit stuk so moet men de onderste droppelen altijd weg wassen, etc. day dit vanndiert en soo over dalermaer tot kwaliteit werkstuk gebruyckt men gedeistelt spoes groen en dit blijft bestandig.'
II. Appreciation of verdigris

The colour-fastness of verdigris

Until the 17th century, descriptions of painters' experiences with the colour-fastness of verdigris in an oil medium are found only in Italian texts. *Il libro dell'arte* (c. 1400) by Cennino Cennini contains the earliest comments. Cennini ground verdigris in oil to form a transparent paint that he applied on tin foil, gold-leaf or glass. He also used the oil glaze on dry fresco paintings and over tempera paintings on panel.31 Because of the higher refractive index of the oil medium, artists obtained a more transparent paint with a richer colour compared to the rather opaque and matt tint of tempera. This type of oil glaze is often found in 14th- and 15th-century Italian paintings that were otherwise painted in tempera.32 Today, these oil glazes often show a brown discoloration. In Cennini's day it appears that this change had not yet become apparent. Cennini warned only about using verdigris in glue tempera: *it is beautiful to the eye, but it does not last.*33 In a Venetian manuscript, possibly containing 14th-century instructions, the durability of verdigris in oil is in fact emphasised: *indeed verdigris requires to be ground with this oil in order to preserve its colour.*34 The manuscript Secreti diversi also known as the Marciana manuscript, which describes methods most probably employed by artists active in Rome and Florence during the first quarter of the 16th century, also maintains that verdigris oil glazes on glass or other works remain fine for long periods.35 However, a few decades earlier, Leonardo da Vinci had some disappointing experiences with the colourfastness of verdigris in oil. He wrote around 1492:

Neutral verdigris is especially prone to dissolve in water, so that humidity can indeed spoil the paint.37 The comment that verdigris discolors even in oil, suggests that Leonardo had obtained worse results with other media, such as glue and egg tempera.

The later 16th-century Italian texts consulted, do not discuss the durability of verdigris. And the

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51. Cennini (c. 1400), f. 33v, 24v, 27r; see Thompson (1932), p. 60, 85, 91.
53. Cennini (c. 1400), f. 8r; see Thompson (1932), p. 32: "Questo chiodo e buono in tavola, temperato con cholla. Cilmar'ti di nonne artizianta mai con bucaso, perché in moto sono eminos morti... e bello all'occhio, ma non durà." Translation by Thompson (1933; 1960), p. 33.
54. Secreti and directions (14th C); see Eastlake (1847; 1960), vol. 1, p. 87: "Marciana di dato colori o l'acqua sacra la pittura e poi temprata come il terzo di l'oro battuto a vail como aia de sente de lino. Ver e che il colorato vole est massimain co queste aia de sente de lino a vedere che no pâi su colori."
55. Secreti diversi (c. 1503-1527); see Merrifield (1849; 1967), vol. 2, p. 617: "E' quando tu dipingi col verderame, macina del'afferano al medesimo modo con detto olio e con questo tempera el colore del verderame e una tanto fine bella verde e."
56. Libro di Pintura (c. 1550); see McMahon (1956), vol. 2, no. 214: "Del color verde fatto dalla roggia di rame. Del verde fatto dal rumo anticaeta che tal colore sia mesco al tabo e in se ne vna forma di sua bellezza e 'togl' non s'abito in verniciato et non volentamente se ne vna in forma che so 'togl' una barato a la spargula bagnata de semplice acqua commina con verde fiume e li lava a la roggia di rame che si fa verde e massimamente il tempo serà anco se questo nascce perché tal verderame è fatto per forza di vedi il quale così conficciata a riavere ne tempi pluviosi e massimamente essendo bagnato et lavato con la predetta spargula." This instruction is dated c. 1492 by Pedretti (1965), p. 186.
northern sources are equally reticent.58 This changed in the early 17th century, as writers began to discuss the characteristics of artists’ materials in increasing detail. The Haarlem painter Karel van Mander urged artists to avoid verdigris in his Den grondt der edel vry schilder-cust (1604).59 Perhaps he had noticed that the colour soon changed. This was certainly the experience of the artist whose manual entitled Le petit peintre Mr de St Jehan was incorporated in the De Mayerne manuscript. The manual describes that verdigris died and that this was already visible after a month (Fig. 7). This warning certainly applies to the unrefined pigment, as the manual also states Distilled verdigris, as it is called, never dies and is very beautiful for glazing... The glaze... will last eternally.60 Paint reconstructions by Kühn have shown that neutral verdigris remains more constant in an oil medium than basic verdigris, although the difference is not substantial.61 While the author of Le petit peintre considered ordinary (basic) verdigris unsuitable as a green paint, he considered the pigment’s suggestive effect to be useful. Small quantities had to be added to certain black paints that on their own hardly dry. Many of the 17th and 18th-century texts consulted recommend this method. Some authors also mention verdigris as a siccative for indigo and red lake paints.62

Many 17th-century painters agreed with St. Jehan’s Le petit peintre. The Hand-boek van de beer Jacob Bherens’ explains that unrefined verdigris nevertheless changes and becomes very dark. As already noted, Bherens reserved this pigment for ordinary works that he apparently did not consider to require durability. Regarding the distilled verdigris that he used for the cositter paintings, he wrote that this remains permanent (Fig. 8 a,b).63 Other texts are less explicit concerning the differences in colour-fastness. However, authors advise the artist to sieve the verdigris well, to grind it well or to prepare it.64 This clearly refers to refinement with vinegar, indicating that the author assumed that only purified pigments would be used. To preserve the colour of the distilled pigment considered it necessary to apply a varnish on the paint as soon as possible or to add a little varnish to the actual paint. These methods are discussed in detail below. In fact, there is evidence that 17th-century artists preferred distilled verdigris not just because of the greater colour-fastness. They seemed to prefer the type of colour of the distilled product to the one of the unrefined pigment. Eikelenberg noted that Verdigris is transparent but for glazes, a distilled verdigris is used which is purer than the other and finer in colour.65 The difference between these 17th-century texts between the two types of verdigris is

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58. The mere fact that the sources do not mention the discolouration of verdigris does not prove that artists were not aware of the fact. These manuscripts concentrate mainly on the preparation of materials and pay scant attention to the characteristics of these materials and methods of their use.

59. Mander (1604), f. 58r. Van Mander’s colleagues Hendrick Goetznas and Cornelis van Haarlem appear to have agreed with him. No verdigris has been found so their work. Hendriks et al. (1991–92).

60. Mayerne (1620–40); see Gisraf (1958), p. 175: ‘Les couleurs: meurent moins, vert de gris. Si on meurt dalle morte on s’en apercevra dans r’en mois.’ And p. 152: ‘Le vert de gris distillé qu’on applique, ne meurt jamais & est tresbeau pour glacer, en lapis, en habich, un autre drogeur après l’air fait de sceliger ou maunais & de cendres, enfince & relumino comme il faut, puis etant se il faut mettre la glaucere, qui dure perpefuelkment.’


63. See note 50. See also the comments by Bires (1636); see Klerk (1989), p. 56, Victorius (1713, 1747), p. 107, and the remark in the 1697 edition of Gowerche’s Verchierhe-boest, p. 25: ‘Men rand van dit spuis-een gruwer te welk geduistert is, ’t welk grecchi neger is, en word in de sy-veren, daarmede’t spuis-een om snep fijnjegeelt niet en brengt, gemoet om te lakenereen.’

64. Madorig (1636). 35, p. 8: ‘Las repas revdes se el color que mas iierda, y tendo de comunicar mi secreto, pues jamas se me han blendo negras, á qualquiera repa, à casa que queremos, que no se rebano verde, se pioda, boupoque de aibl, y blanco, los claves han claves, à la quera torma, y at hueve acate, que supo trepo, y hodo con cardenillo bien molido; y queren que este mas ondo, huese a bastar, y veras que verde.’ Translation by Véka (1986), p. 135, Baldimocc (1681)2, undere Verde Eetern und Verdor-moc (1623–44), f. 43c: ‘...then sholdan se w[i]th a penall, in such places as the workmen shall shanke best w[i]th transparent colour, as lacke, small, Indigo, Pinske, Ifaliansumber und verdigreus preparated: thes must be leyde en w[i]th sye not fatted.’

65. Eikelenberg (1679–1704), p. 409, ‘Lasveren Der is met doorslagen ende koudere uerschilderen... Spuis-een is doorslagen, met om te lakenere gebruyckemen gedistiltert. Spuis-een, het welk snipperen is allt anders en schoonder van kleure.’

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remarkable. This is never found in 15th- and 16th-century sources. Earlier artists appear not to have made a clear distinction between the two types of copper green. Basic verdigris is regularly found in green areas in paintings where it has been employed in the same way as the neutral pigment. Veronese, for example, painted the green draperies in the four paintings of his Allegory of love in the National Gallery, London with basic verdigris, while Holbein used this pigment for the green leaves in the background of A lady with a squirrel and a starting that is in the same collection. In these cases, the colour of these basic copper acetate paints has been relatively well preserved. An exceptional case is Jacob de Wit who, as late as 1718, used basic verdigris mixed with a large amount of lead-white for the blue-green drapery in his ceiling painting at the Cromhouthuizen in Amsterdam. Perhaps De Wit’s choice of pigment reflects the influence of decorators who continued to use basic verdigris in combination with lead-white to general satisfaction until well into the 19th century.

While writers continued unanimously to praise the colour-fastness of distilled verdigris glaze until the mid-17th century, by the close of the century opinions on the matter had begun to diverge. Some authors remained enthusiastic. The Spanish painter Hidalgo noted in Principios para estudiar el nobilisimo y real arte de la pintura (1693), that the draperies he had painted with the green glaze had not turned black. In his Vocabolario Toscano dell’arte del disegno (1681), Baldinucci praised the durability of glazes of properly purified verdigris applied on gold and silver foil as follows: Permanent green... a rather bright sort of green, called permanent because it never loses its vivacity, like all other greens do. Other authors began to voice criticisms. French painters in particular were dissatisfied. De la Hire maintained in Traité de la pratique de la peinture (1709), that it was hardly possible to use verdigris in oil painting: Because although it appears beautiful when glazed over a white ground, it is not durable and turns black after a short while. Perhaps the divergent opinions regarding the colour-fastness reflect differences in quality of the distilled copper acetate. The differing opinions may also reflect the length of time that painters wished to keep their colours. Hidalgo, who maintained in 1693 that his green draperies never turned black, had determined this, he explained, from his own paintings. Having trained as an artist in the 1680s, Hidalgo’s draperies could not have been older than about ten years. The observations of authors such as St. Jehan in Le petit peintre and Baldinucci may also have been based on paints that were still comparatively recent. The Spanish painter Palomino, author of El museo pictorico (1715-24), was familiar with the ability of glazes of distilled verdigris to keep their green colour for a long time but that they eventually

68. Decorators used basic verdigris to paint the outsides of houses, for which distilled verdigris, being sensitive to water, was unsuitable. John Smith (1676), p. 24, called raw verdigris, 'the best and most useful green of all others.' A series of instructions for painting signboards, Delormois (1733; 1753), bywonged, notes that 'the paint of verdigris is as good as the paint of gold and silver, and does not turn black or lose its verdigris after a long time.' However, Soria (1801), p. 54, 56-57, noted in his manual for decorators that although strong and resistant outdoors, raw verdigris was unsuitable for indoor paintwork because it became very ugly and dirty. The strong copper-green paint was preferred for outdoors, where discoloration was less of a problem, since it was only used as a protection for metal and wood. For the more delicate paintwork indoors, the discoloration formed a problem for the decorator too. See also Jombeert (1766), p. 124.
69. See note 64.
70. Baldinucci (1681)2: 'Verde sterno. Una sorte di color verde assai vivo, detto sterno, perché non pende mai la sua ricchezza, come fanno tutti gli altri colori verdi. Questo no è altro che una relazione fatta a fondo inerente e a corno in foglia, d'un verdigris ben purificato, e ridotto a questo stato superiore.' Sometimes, as in an altarpiece by Sanssoupo, the copper-green glaze on top of gold foil has discoloured severely. Wyk & Pelet (1977). However in some instances the green colour is quite well preserved: Speleers (1998), p. 40.
71. Hire (1709; 1730), p. 67: 'Mais cette couleur n'est pas fort en usage dans la peinture à l'aiguille, & encore moins dans la peinture à huile; car quoique l'on puisse d'utiliser fort belle étant placée sur des fonds blancs, elle en donne pas & elle devient moins par de temps après.' See also Perreyn (1756), p. xxiv, Jombeert (1766), p. 124; Waen (1772; 1976), p. 29.
died, turning into an infamous dark brown. It is conceivable that the French painters considered the long time that the glaze kept its colour not to be long enough. Either way, its tendency to discoulour ensured that eventually the pigment was hardly ever recommended for artists in the 18th and 19th centuries. Furthermore, in the early 18th century Naples yellow and Prussian blue had become readily available, enabling painters to mix more permanent green colours. The English painter Dossie wrote in The handmaid to the arts (1758):

"In oil they [crystals of distilled verdigris] hold their colour well enough to answer many purposes, where colours are not required to be greatly durable; but in paintings of consequence they cannot be depended upon, being apt to turn black with time."

Field claimed in his Chromatography (1835), ‘but it is not on the whole a safe or eligible pigment, either alone or compounded,’ Moreau-Vautier warned simply in La Peinture (1913): Verdigris: **TO BE AVOIDED.**

Changing colour from blue-green to green

The manual *Le petit peintre* states that ordinary verdigris could be seen to die within a month. This observation may relate to the colour shift from blue green to green, that occurs most noticeably in fresh basic verdigris paint and to a lesser extent with neutral verdigris. This remarkable change is discussed only occasionally in the sources and these comments are only found in instructions for decorators. A series of paint formulas for signboard painters (Amsterdam 1764-77) notes that *Verdigris is a paint that changes colour as soon as it dries.* And Simis wrote in his manual for house painters of 1801 that:

> It is noticeable that after being applied, the verdigris [here both basic and neutral copper acetate are meant] appears as a beautiful light blue showing a little greenness, only achieving its actual colour after several days.

Since the colour changed, Simis claimed that it was almost impossible to recreate the same colour twice. Moreover, in easel-painting, it made it all the more difficult to balance the colours. As is apparent below, it was this latter aspect specifically that kept 17th-century painters in particular from using this pigment.

**Incompatibility of verdigris**

When verdigris is mixed with other pigments in a paint medium a chemical reaction may take place that can result in discoloration. Copper based verdigris may react with the sulphur in sulphurous pigments such as...

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72. Palomino (1715-24; 1795-97), vol. 2, p. 70: ‘Otro verde de carbonilla. Pero sobre todas las verdes, a permanecer, es el carbonilla labrado con pincel claro, o con blanco, aunque no es tan bueno, y después de años, bañado con el mismo carbonilla, está permanente por mucho tiempo formándose, pero en comenzando a declinar, viene a parar en un purdo obscurvo infame: pero por si algún quisiere usar de el, puede asegurarle, barriendo luego que esté seco, con algunas de la burro y que se diría caldente.’


73. Dossie (1758), p. 106.

74. For Field (1835), p. 130, see Carlyle (2001)1, p. 496; Moreau Vautier (1913): ‘Vert- de gris: A REJETER.’

75. See note 60.

76. Kühn (1993)1, p. 135. It was probably not just the change of colour that persuaded the author of *Le petit peintre* to avoid basic verdigris. He presumably saw it as the start of a disruptive brown.

77. Delormois (1733, 1755), byveegsli; see note 68.

78. Simis (1801), p. 56: ‘T is mede aammerenlykh, dat het spawch oogen zoo, naa versterken te zyn, een oamen licht blauwen, en een wienig greenslag vertouwen, en eerst naa eenige dagen zoo weyweyikeyn kleur bekomen; ibh heb dikwijd over deze eigenship gedacht, maar kon er geen andere reden voor vinden, dan dat de buct, op het giff werkende, deze verandering veroorzaakte. Men kan er ook, om reden dat het zoo zoo verandert, moed een kleiner bymaaken; namelyke van nature groen, by dat, laatste redel eenigen tyd gesteld te groen waart. See also p. 57: ‘T is mede aammerenlykh, dat, als men Spanichs groen, ’t o gelyklikeyden of niet, met af van verpestyn werff, ibh dat het dan licht heff: maar, ’zoutra men er een wienig music; of haert-versus onder doet, dat het dan terstond op zijn loopt van groen is, zoo als het, afgedrolg zoode, hef.’
vermilion and orpiment. These problems arise especially in an aqueous medium. Laboratory tests have shown that reactions with verdigris hardly ever occur in oil media. Yet numerous warnings for mixtures with verdigris in an oil medium are found from the 15th century onwards. The caution that the sources reveal may have been prompted by the projection onto oil painting techniques of the problems painters experienced when mixing verdigris in aqueous media. Yet it is more likely that the difference between historical and contemporary opinion is the result of our lack of information regarding the problems that arise when mixing paints with historical verdigris. Modern reconstructions of paint mixtures have employed chemically pure (basic or neutral) copper acetate which, as has been seen, may differ significantly from the historical pigment.

De Mayerne warned: *Verdigris (which one only applies for glazing) is so much an enemy of the other colours, that it will kill them all, especially cendre d'azur.* As described in chapter II, in addition to the blue copper pigments azurite and blue verditer, the term *cendre* could denote lesser qualities of ultramarine. According to Leonardo da Vinci, verdigris could turn black in combination with orpiment. The unsuitability of this combination of pigments can clearly be seen in Marco Marziale's *Christ and the woman taken in adultery* (c.1505), in the Bonnefanten Museum, Maastricht. The woman's headscarf is painted with a glaze of verdigris on realgar, which like orpiment, is an arsenic sulphide. Despite being painted in separate layers, the pigments have reacted with each other to turn the glaze completely black (Fig. 9a-b). Various Italian texts warn specifically against the combination of verdigris and lead-white. The author of the manuscript *Secreti diversi* (1503-27) considered that these pigments corrupted each other in oil paints. During his visit to Italy from 1649 to 1651, the English antiquary Richard Symonds noted from the Roman painter Canini that verdigris and lead-white: *have an antipathy like the Devil.* In contrast, other texts, including Italian ones, recommend this combination of pigments. Analysis of paintings has revealed little of the supposed devilish antipathy. Verdigris was mixed with lead-white in countless paintings, including Italian ones, without the paint discolouring. The divergent opinions of Canini and the author of the *Secreti diversi* may be connected with the varying composition of historical verdigris, which caused problems in their works that were not encountered by other painters. Most warnings concern the incompatibility of verdigris with one or a few other (mostly sulphurous) pigments. Some painters, especially the French, considered that all contact with verdigris should be avoided. Le Brun warned in his *Recueil des essais des merveilles de la peinture* (1635), that verdigris *causes every colour with which it is mixed to die*, while Jombert wrote in 1766: *Verdigris spells ruin for all*

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80. It is also possible that an emulsion paint was used containing just a small amount of oil. Verbal Communication: Karin Groen (ICN).
81. Mayerne (1620-46); see Graaf (1958), pp. 142-43: "Le verd de gris (donne on se sert seulement pour glacer) est tellement ennemy des autres couleurs, qu'il les tue toutes, spécialement la cendre d'azur; monner si un travaux avec en prinouen (quoy qu'il semble net) qui est mettee dans de l'huile qui est seulement touche au verdice, et si les couleurs se mettent sur une peinture ou il y en ait en, tout meurt, de sorte que qui mettra travailler de verdic[...], il faudra qu'il soit penancon, palette et propre [pour] mettre a part." For a similar warning in *Le petit peintre*, see Mayerne (1620-46), see Berger (1901; 1973), p. 262.
82. Leonardo (1508-09), f. 96v; see Richter (1883; 1970), vol. 1, no. 626.
84. *Secreti diversi* (c. 1503-27); see Merrifield (1849; 1967), vol. 2, p. 609. Cennino Cennini warned for mixing verdigris and lead-white in a glue; see note 53.
85. Symonds (1650-52); see Beal (1964), pp. 226-27: "Verde Rame si rovvisa, si fa un pane di bianco. Si lascia asciugare. Se si mette fresca con la bianco ha una Antipathia come un Diavolo. Quando si toca la bianco a mette quel Verde Rame opaco web makes an incomparable color, ma tropo sbiadita. Tu guardell... Bianco Ombreggiato fatta in chiaro ocum prima, the then dry works on ye Vertgreen. Ancora p. fare un bel Verde si mistica Verde Rame & Giallo Lino p. chiaro p. cambio della bianco. Quando verdigre is dry the bianco non rial mixer con quell color."  
86. Lomazzo (1584), p. 194. Ponce (1694), p. 31, held that the addition of lead-white was necessary to preserve the green colour of basic verdigris.
other pigments and has the potential to spoil a whole painting if even a small amount is found in the priming of the canvas.\textsuperscript{68}

To avoid mixing with verdigris, De Mayerne noted one should have separate brushes, palettes and cleaning aids\textsuperscript{80} for this pigment. Another method involved applying the verdigris glaze only after the other paint-layers had dried. Richard Symonds noted down from Canini:

\textit{Verdigris is poisonous to other colours. Paint a piece of drapery with lead white. Let this dry... When it is dry, apply the verdigris on top of the lead white... when [the] verdigris is dry, the lead white has no inclination to react with this colour.}\textsuperscript{92}

Naturally, the underpainting also had to be properly dry to avoid drying cracks.\textsuperscript{93} It is conceivable that the discolouration in Marziale's work occurred because he applied the copper-green glaze when the realgar paint had not sufficiently dried. This is quite possible, since paint made of arsenic sulphides dries extremely slowly.\textsuperscript{94}

Caution was required even when painters employed verdigris as a siccative, the sources warn. The pigment could do little damage with black pigments, but it was best avoided in combination with other colours. As De Mayerne wrote: \textit{White couperose [zinc sulphate] should be used to speed the drying of red lake, this does not cause the colour to fade as verdigris does.}\textsuperscript{95}

\section*{III. Instructions for glazing with verdigris}

\subsection*{Grinding}

The sources recommend grinding distilled verdigris to as fine a powder as possible.\textsuperscript{96} Only thus is a smooth paint-film without ugly lumps achieved. Since pigments are difficult to grind fine in an oil medium as the oil can become viscous, painters generally began by grinding pigments in water\textsuperscript{98} Then they were allowed to dry before grinding with the oil. Water-sensitive verdigris formed an exception to this rule. Artists considered that all contact with water should be avoided. Because it was common practice to keep the palette under water to ensure that paints did not dry out, the Italian painter Giovanni Volpato warned in his \textit{Modo da tenere nel dipinere} (second half 17\textsuperscript{th} century or early 18\textsuperscript{th} century), but remember that lake, giallo santo and other verdigris are spoiled by the water, and must be taken off the palettes before they are put under water.\textsuperscript{99}

In the margin, beside
a series of painting instructions for various pigments, De Mayerne, noted the liquids in which they could be finely ground. Beside the instruction for distilled verdigris he wrote *without water.* Since pigments ground without a liquid had a tendency to cause dust, artists preferred to grind distilled verdigris in a solution. The Brief traite contenant la maniere d’aprendre a peindre & de savoir mesler les couleurs in the De Mayerne manuscript recommended that you should grind the aforementioned verdigris fine with turpentine and spike oil. Painters who used verdigris for lacquering furniture sometimes ground it in oil before mixing it with viscous lacquer varnish. The thin flowing poppy oil recommended by Da Sylva in his *Konst-boeck* (1735), would have been the most useful in this case.

### Oil media

For glazes with distilled verdigris, the sources consistently recommend the use of linseed oil. That this type of oil was generally used for green glazes has been established through analysis of paintings. As far, only in early Italian paintings by artists such as Cosimo Tura, Raphael and Cima da Conegliano verdigris with nut oil was found. The glazing properties of verdigris are greatly influenced by the preparation of the oil. Unprepared linseed oil results in a matt paint in which the brush lines remain visible. For a smooth film, free of brush marks and with a glossy effect, as a glaze should be, a special preparation of the oil is needed. The *Hand-boeck van de Heer Jacob Bberens* states that verdigris should be mixed on the palette with oil that has been boiled. The manuscript *Art of painting in oyle by the life* (1664) contained in the *Henry Gyles booke* advised *‘if you make a green garment, make it without verdigrease, and when it is dry glace it over with verdigrease and fat oyle.’* In the manuscript we find this type of oil also recommended for glazes made of other pigments. Pierre Le Brun (1635) also considered a *‘fat oyle’* appropriate for verdigris, as did John Smith who advised decorators to use a *‘fat-drying-oil.’*

The fat oil was prepared in various ways. Le Brun noted that *fat oyle is made by putting a bag of litharge into a pipkin with oil, and boiling it.* Smith described the same method and stated that the oil should be heated

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100. For example Pacheco (1649), see Sánchez Cantón (1956), vol. 2, p. 82, Volpato (17th or 18th C.), see Merrifield (1849; 1967), vol. 2, p. 739, Smith (1692), p. 72.


102. See note 50.

103. *Art of painting* (1664), p. 101


105. LeBrun (1635); see Merrifield (1849; 1676), vol. 2, p. 817: ‘Heus grauce se fait avec de la bitharge que 1’ex est dans un saclet en une claptine avec de l’huile, puis en la far broyée,’ Smith (1676), pp. 38-39. The preparation of oil thickened in sunlight and the heat of the sun is described on pp. 40-41, *Art of painting* (1664), p. 97: ‘How to fatten Oyle. Take broiled oyle & put it into a broad laden thing and in a pint of oyle put the quantity of a poundful or two of white lead, being ground in oyle, and mingle them together and then cover it close, and stir it where the sun doth shine, & if you sometimes stir it together it will fatten the sooner, after this manner you make the oyle fit either to work with all for gold ary which must be [your] thickest, but it is to be worce with all or for to glace with all it must not be build so thickes. For gold ary it is usualy a thicknes as sate or still arremp.’

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for one hour. This would result in a viscous thick drying oil. Smith made another type of fat oil by placing a glass of linseed or nut oil with a small amount of litharge in the hot sun for one month in the summer. The resulting thickened oil dried particularly well. The *Art of painting in oyle by the life* recommended the same method for making fat linseed oil but using lead-white instead of litharge. It may perhaps seem unusual that quick-drying oils were used for verdigris, which in itself has a scatitive effect on the drying process of oil. In this case, it was the gloss and the viscosity of the oil that made painters decide to use the substance. The manual *Art of painting in oyle by the life* notes that oil for glazing should be nearly half as thick as oil for gilding, which should have the consistency of stiff syrup. Paint reconstructions with these thickened oils reveal that the paint is indeed glossy and that the brushstrokes even out to form a smooth layer, as Smith noted, 'it shall also add a beauty and lustre to the colours; so that they shall dry with a glass, as if they had been varnished over'. Some paintings clearly show that this kind of paint must have been rather viscous. Because the syrupy paint was difficult to spread, it was applied in a thick layer. An example is *Saint Mauritius* by an anonymous master of the South German School (second quarter of the 16th century; Fig. 10). Oil heated to a high temperature, especially when mixed with litharge, acquires a dark colour. Smith stated that the oil's 'deep reddish-colour' considerably influenced the eventual colour of the paint; with a white pigment the paint became yellow, while blue paint acquired a greenish hue. This was of course not the intended effect when using these cool colours, but may have been just what was required for verdigris, since its sharp blue-green colour gained a warm hue in this oil. When painters used oils thickened in the light and heat of the sun, which were 'very white and clear (for the sun takes away all the colour)' according to Smith, the colour of the oil did not, of course, influence the result.

Binding medium analysis of verdigris glazes on 15th- to 17th-century paintings have frequently revealed the presence of a pre-polymerised, heat-bodied oil. This suggests the artists used the heated or 'fat' oil referred to in 17th-century recipes. Glazes in paintings by Geertgen tot St Jans (Fig. 11a-c), Cima da Conegliano and in those of an anonymous master of the anonymous master of the South Netherlands School (Fig. 4a-c) and Cornelis De Heem (Fig. 12a-b), appear to contain small quantities of lead. Since no pigments containing lead are present in the paint-layer, the lead may derive from the oil medium. We may assume, therefore, that the fat oil as described in the above recipes may have been common use. Lead has also been identified in a browned glaze in Marco Marziale's *Christ and the woman taken in adultery* (Fig. 9), although this oil had not been heated. Perhaps Marziale used oil to which lead-white had been added and which had been placed in the sun as described by Smith.

**Varnish media**

Analysis of media from oil paintings reveals with increasing clarity that artists varied the media they used depending on the pigment used and the type of paint-layer (for example, opaque or glaze). Rather than with linseed oil, blue pigments appear to have been mixed with media that did not tend to yellow as much,

107. The painting was restored and examined by Esther van Duyn, Stichting Restauratie Atelier Limburg.
such as nut oil and sometimes poppy oil. Small amounts of resin are often found in the oil media of verdigris and red lake glazes.\(^\text{113}\) This specific technique was described by Armenini in *De’veri precetti della pittura* (1587):

> And when the sketch is dry these artisans paint over lightly with verdigris mixed with common varnish [probably a pine resin/linseed oil varnish]; this varnish is usually placed in all colours which veil other colours below.\(^\text{114}\)

Adding varnish to the oil medium raises the refractive index of the medium slightly, giving a greater colour saturation and transparency. It also makes the paint more glossy and fluid. These qualities of the verdigris’ glaze were described by LeBrun: *In order to make a very beautiful glazing green, one must use verdigris with a varnish; this is very beautiful and fluid, and in this way it does not change so quickly.*\(^\text{115}\) According to LeBrun, the varnish had an additional advantage: it prevented the discoloration of the green glaze. Various other authors shared his opinion. An artist’s manual entitled *Pictoria*, part of a relatively unknown manuscript by De Mayerne, recommended: *To preserve the colour of verdigris well, a little varnish should be mixed on the palette.*\(^\text{116}\) The Spanish painter Pacheco (1649) claimed: *Verdigris... it is ground in oil, as has been said. After glazing the first time, it is customary to glaze it one or two times more, adding a little varnish to it and in this way it stays very brilliant.*\(^\text{117}\) Pacheco noted that varnish was generally only added to the top paint-layers. 17th-century authors stated that just a small amount of varnish needed to be added to the oil medium. In this they were apparently describing general practice, since analysis of binding media in works by artists such as Geertgen tot St Jans, Marco Marziale and Pieter Pietersz has shown that copper-green glazes contain only a very small amount of resin acids.\(^\text{118}\) The paint instructions for easel-paintings differ in this respect to those for decorative techniques. In the latter case, distilled verdigris was mixed with pure varnish. Authors often recommend a resin oil varnish, but others also advise a varnish made of resin in a solvent.\(^\text{119}\) In that case the paint contains no oil at all. An example of this method is found *Der wohl anführende Maler* (1719) by Croker:

> Note, however, that if you wish to glaze with this and to keep the beautiful light green colour, you should prepare it with a clear and colourless spike oil varnish, but not with a drying oil, which is rather yellow and turns the bright green paint in the course of time into dark green.\(^\text{120}\)

Watin (1772), also recommended a spirit varnish (in this case with turpentine) since this ensured that the

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113. Billinge et al. (1997), pp. 53-55, Beng et al. (2000), and unpublished MOLART results (see note 24).

114. Armenini (1587, 1791), p. 126: ‘*et quaedam ad resumum cal, tamen ut viridescere, debeo habitaque vernicem commune, quod ad melius motire in totis et coloribus quando est solutum neglecti etiam et sit in vita.*’

115. LeBrun (1635); see Merrifield (1849; 1967), vol. 2, p. 813: ‘Pour faire de tres beau verd glace, faut employer le verdige avec du vernis; cela sera fort beau et bien lustrant, et il ne mourenera pas a tout.’ For other sources that claim that a better result obtained by the addition of varnish: Bherens (1661); note 50, and Deesse (1758), pp. 105-06.

116. Mayerne (1623-44), f. 80r: ‘*Dropes vertes Divenant premiers de vertes de blanc & de noir charbon de pierre, puis glace pour la 2, jus de verdes, relatuez de mascaiz. Pour bien faire tenir la couleur au verdi faut y meler un peu de vernis, sur la palette.*’

117. Pacheco (1649); see Sánchez Cántón (1956), vol. 2, p. 82: ‘verdigrisillo... moldeado, como ce ha dicho, a olio; y siempre, después de haberla la primera vez, volvemos a escorrer y tornamos a hablar solamente un poco de barniz y quedo muy lúcido.’

118. Unpublished MOLART results (see note 24). See also Billinge et al. (1997), pp. 53-55, and Beng et al. (2000).


120. Croker (1719); see Scheull (1982), p. 108: ‘Merke aber: wenn du damit lackieren wilt, und er seine schöne tief grüne Farbe behalten soll, so musst du ihn mit einem leisten und wasser Speck-Oel-Vernis anmachen, nicht aber mit dem trocknen Oel, welches etwas gelbe ist, und musst solche tief gröne Farbe mit Zeit dunkel-grün.*
bluish water-green colour of the glaze would never turn yellow or otherwise discolour. 121 Paint reconstructions employing a varnish based on turpentine have revealed the accuracy of this observation. 122 Of course, this type of glaze remains susceptible to solvents for a long time. It is therefore a dangerous choice for easel-paintings, since any attempt to remove a discoloured top layer of varnish can easily damage the green glaze. Despite its solubility in the 18th and 19th-century artists did in fact use the pure resin glaze. Croker mentions this type of paint as being used for paintings. 123 Bouvier praised the method in his famous Manuel des jeunes artistes et amateurs en peinture as late as 1827. He advised the artist to apply a thin and even layer of distilled verdigris in a varnish made up of copaiva balsam and turpentine oil on a completely dried underpainting:

This paint does not change at all when used in this way; it is so embedded in the copaiva balsam that it hardens in the varnish that dries in an instant, ensuring that the air has no time to effect it. This beautiful green therefore remains constant. I am absolutely convinced of this because I used this method more than fifteen years ago and can vouch that it is just as brilliant as on the first day. 124

Varnishing the glaze after drying

Other ways of preventing discoloration of verdigris glazes also existed. As already mentioned in chapter II, artists usually advise applying a separate layer of varnish over this paint. The instructions suggest that in this case the glaze was made with an oil medium only, that is without an addition of varnish. Artists had already noted in the 15th century that the colour-fastness varied between varnished and unvarnished copper-green paint layers. Leonardo da Vinci warned that Green made of copper... loses its beauty like smoke if it is not quickly varnished. 125 Over a century later, De Mayenne noted in his manuscript how quickly this varnish should be applied: To prevent this colour from dying, as soon as it dries (which will be in two or three days), one must cover it with a varnish (Fig. 13). 126 After two or three days the varnish can be spread without mixing with the layer of verdigris. Here, it differs from the final varnishes recommended in the sources. These were used for two reasons: firstly to restore the intended colour saturation of paint-layers that turned dull once they had dried and, secondly, to protect the paint from external damage by, for instance, dust and humidity. In general these varnishes were not applied immediately and usually they were brushed or rubbed onto the painting's entire surface area. Therefore, it is likely that authors were recommending a local application of varnish for verdigris glazes. The great extent to which local varnish seems to have been applied over verdigris glazes in the first half of the 17th century is apparent from the fact that the method is mentioned no less than five times in the De Mayenne manuscripts alone. 127 One of these instructions, that in Le petit peintre, notes that a thin layer of

121. Watin (1772, 1776), p. 46: "Quand on veut employer le verd d'eau au vernis, il faut bruyer séparément à l'étoile de l'air et à l'essence; ou incorporer le vert-de-gris dans la quantité nécessaire de blanc de céruse pour veuler toute la peinture; et détruire le tout avec un vernis à l'essence. Ce verd d'eau ne pârit jamais. See p. 29 and p. 57 for the preparation of Vernis d'Holand, pour détruire et retarder le vert-de-gris."  
122. When verdigris is mixed with oil, within a few days after application the paint obtains a more yellow-green hue. However, when verdigris is mixed with a pure resin/spirit varnish -i.e. without any oil- the paint preserves its bluish green colour. This observation is based on paint reconstructions that are two years old (natural ageing at SRAL). See also chapter II, note 124.  
123. Croker (1719); see Schießl (1982), p. 110.

124. 1 have used the Netherlands translation: Bouvier (1827, 1831), pp. 82-83: 'Deze verf zou gewoonlijk zijnde op zichzelf is, veranderd volledig niet, als men sy op deze wijze gebruikt: smelt zij voorzorgs in de olifluid, welke geen hard wordt, en in de verfin, welke ongemakkelijk droogt, te mengen is, dat de lucht den tijd niet heeft, om haast aan te tasten; zoodat dit schilderij geen onveranderlijk wordt. Ik heb er de echtheid van, wat voor meer dan rijften jaren behalve van dit heitigegeen middel gebruik gemaakt... en ik kan verzekeren, dat zij nog zou blijven zijn als de eerste dag.'

125. See note 56.

126. Mayenne (1620-46); see Graf (1958), p. 144: 'Pour empêcher que cette couleur ne meure, avant tout qu'elle soit sèche (qui sera dans 2 ou 3 jours) y faut passer un vernis qui sera dit cy apres.'

127. Mayenne (1620-46); see Graf (1958), p. 156, 162, Mayenne (1623-44), f. 109v: 'Le vernis de Mr Buan 2 lié de l'olive d'argile, 1 lié muscée. Faut mettre dedans une bouteille, et le faire bouiller dans un pot d'eau jusqu'à ce que tout soit fondue, et alors elle est bonne. Qu'on s'en serve à vernir le vert de gris et toutes autres couleurs...
varnish ensured that the paint discoloured far less—indicating that he had experienced that even with the varnish layer, the paint still discoloured to some extent. 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.128

From the instructions collated by De Mayenne it appears that artists of the period made their local varnish using a soft type of resin and a solvent. One method involves dissolving sandarac in spike oil. An artist named Mr Bunel used mastic and spike oil which he heated au bain-marie. The painter Paulus Van Somer (c. 1576–1621) used turpentine balsam and turpentine oil.129 In the late 17th and 18th centuries, the use of local varnish remained general practice. Jacob Bogdani, who made his name at the British court with his still-lifes of flowers and birds, noted in 1691 how he glazed the foliage with distilled verdigris and oil, after which, 'As soon as dry, varnish them places over with copolla [= copal] varnish or else it will turn black.'130 Copal resin mixed with twice the amount of turpentine oil was heated in a sand pan over a charcoal fire until the copal resin dissolved. Bogdani also used this varnish for covering the entire painting. The Spanish artist Palomino, who felt that the green colour of verdigris glazes may be secured by varnishing it after it is dry, did not advise the use of a specific varnish; instead he referred to a variety of solvent- and oil-based varnishes.131

In oil paintings, brown varnish layers are sometimes found on layers of green copper-containing paint, which may have been a part of the original paint-layer.132 These may be layers of varnish that have been applied to protect the verdigris. However, it is probable that in the past most of these layers of varnish were removed when paintings were cleaned. Local varnish on verdigris is therefore an example of a method, which may have been widely employed by artists of which, today, virtually no traces may remain.

Adding pigments to the glaze

To achieve an attractive green glaze, yellow and sometimes brown paints were added to the distilled verdigris. The methods for oil painting differ in this respect from those for paints used in illumination and tempera painting, which regularly advise that the verdigris be mixed with the juice of rue, saffron, turmeric or aloe.133 However, juice of rue was not generally recommended for oil paints.134 Leonardo used turmeric and aloe for oil painting, but warned that in this technique a combination of saffron and verdigris might look good initially, but would soon turn black.135 17th-century painters may also have found turmeric and

\( \text{varnis} \text{h} \text{es} \text{a} \text{d} \text{ig} \text{h} \text{s} \text{e} \text{c} \text{h} \text{i} \text{ll} \text{a} \text{g} \text{a} \text{s} \text{e} \)
aloe less suitable for oil painting. Their instructions for glazing mention mixtures with yellow lakes only. Thus Beurs noted distilled green, mixed with a little yellow lake. Paint reconstructions reveal that a small amount of this yellow lake is indeed enough to obtain a fine grass-green colour. That light-sensitive yellow lake could fade with time would not have mattered greatly, since the verdigris paint itself eventually acquires a warmer hue. Yellow lake’s tendency to fade or disappear was even seen as an advantage by the author of the 18th-century treatise *Lak, vernis en verf-kunst* (1767) as he thought it would temper the tendency of distilled verdigris to turn black.

For beautiful verdigris, prepare a bluish ground. When dry, take verdigris and yellow lake, since although yellow lake tends to disappear it tempers the verdigris which otherwise turns black, whether used in paint or glaze.\(^{137}\)

In old paintings a yellow lake is often no longer visible in paint cross-sections. But analysis can reveal the presence of aluminum or calcium, which may indicate the presence of a substrate on which the yellow dye was precipitated. Of course, the presence of calcium may also be due to impurities in the (distilled) verdigris. Occasionally, brown layers that contain no copper have been identified on top of verdigris glazes. Often this is assumed to be the original discoloured glaze of yellow lake applied over the verdigris to give it a warmer green hue.\(^{139}\) The following instruction by Leonardo may refer to this practice (Fig. 14):

If you have finished a work with this simple green, and you glaze it thinly with aloe dissolved in water, then the work has a very beautiful colour. This aloe can be crushed in oil, and also together with copper green, and with any other colour that you wish.\(^{140}\)

Since the gum resin aloe dissolves in water, Leonardo was probably referring to a jelly-like paint, which might well have bonded with the green oil glaze.\(^{141}\) However, Leonardo’s recipe is the only text on oil painting to suggest applying a yellow glaze *over* a green. It is indeed unclear whether the method was ever in general use. To date, traces of yellow lakes have only sporadically been identified in the brown layers. The latter may in fact often be the remains of a locally applied varnish.

Some pigment combinations described in the sources have not as yet been encountered in actual paintings. For example, 15th- to 18th-century sources from various countries recommend that verdigris be

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\(^{136}\) Beurs (1692), p. 100. See for example Smith (1676), pp. 24-25, and *Of limning in oil colours* (c. 1650); see Hardie (1919), p. 98.

\(^{137}\) Lak, vernis en verf-kunst (1767), p. 93: ‘Een schommel waam groen. Leg een blauwsigig grond, daarin een roze waam groen en het 'wetgevel' onder een, want het groen ’t verfgevel weefrekken oit, dat het niet waam groen tegen, anders wert het ouwt daer mende gepelotert of gepelotert.’ Distilled verdigris is presumably intended in this instruction since all the preceding instructions refer to this pigment.

\(^{138}\) See section 1. Paint reconstructions indicated that a small addition of chalk preserved the glazing properties of the verdigris paint. Adding more chalk makes the paint less translucent. In this case the chalk can be used for the rendering of the modelling.


\(^{140}\) See note 135.

\(^{141}\) Aloe is a medicinal gum resin that dissolves completely in water and acetic acid: Berg et al. (1963), p. 199. Leonardo claimed that aloe also dissolved in alcohol and oil. According to Mills & White (1987, 1994), pp. 148-49: ‘The material known as aloe may sometimes have been used in painting or the decorative arts as a yellow or yellow-brown glaze.’
mixed with indigo.142 This paint was intended for shaded areas of drapery and foliage painted with verdigris. Various 16th-century Italian texts advise a combination of verdigris with asphalt, mummy and other bituminous paints. Verdigris would have served as a siccative in this brown-black paint that dried with difficulty of its own accord. Canini informed Richard Symonds that a considerable amount of verdigris was required: Asphalt is human flesh. This is your deepest black and the hardest to dry. To make it dry well, you should mix it with a lot of verdigris and boiled oil, as verdigris makes every paint immediately dry.143 Painters also used that pigment combination for the particular colour effect, being especially suitable for the dark shading in green areas. Leonardo noted that, To make beautiful green, take the green and mix it with mummy and you will make the darkest shadows.144 Armenini wrote in 1587 about a mixture with a greasy lampblack he had made from the soot of Greek pitch (i.e. colophony):

smoke of Greek pitch, because it does not have body, is incorporated most beautifully with verdigris, well ground with oil. One-third part of verdigris is used to two-third of soot, and they are mixed together on the stone with some oil and a little common varnish.145

Since a large amount of verdigris was added to the soot paint, it would seem that the copper pigment was not exclusively intended as a siccative. Armenini probably also recommended this combination of pigments for its fine colour. To date, no instances of the combination have been identified in paintings of the time of Leonardo and Armenini. However, regular layers of a brown cuprous matrix containing grains of verdigris have been found in shadow areas of green drapery.146 These are generally identified as a browned copper-green glaze. However, where the verdigris has actually been combined with a bituminous paint (in which the verdigris is partly dissolved), the brown colour may to an extent have been intended by the artist.

Ways in which to apply glazes evenly

Study of paintings has indicated that 15th- and early 16th-century painters generally mixed verdigris with lead-white or lead-tin-yellow, often with both pigments and in various proportions depending on the depth of shadow. Yellow ochre was also regularly added.147 The verdigris glaze that was applied over the underpainting also served to enhance the modelling. It was applied more thickly in the shadow areas, while a little lead-white and lead-tin-yellow could be added for the lighter sections (Fig. 15).148 In 16th- and 17th-century paintings green glazes are less often used for the rendering of the modelling of the drapery. In paintings of this period we see the glazes usually applied as a uniform layer over the light, medium and dark tones of the underpainting without differentiating the thickness or colour. In the Portrait of a nobleman in armour (School

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143. Symonds (1650-52); see Beal (1964), p. 227: 'Spalnu si carne humana, to ye deepest black, hardest to dry. Per farlo occorrere bene si miscia lattiona di verde rame & olio ad uso p. che verde rame fa secare subito ogni color.'

144. Leonardo (1483-1518), f. 262v; see Richer (1960), vol. 1, no. 618: 'Per fare verde bello, inghi il verde e mescola colla morma e farai l'obra più scura, poi per la più chiara, verde e supera, e per più chiara verde e giaudo e pe' luma vollo colotato...'

145. Armenini (1587, 1731), p. 124: 'il fumo di pece preno il quale perche egli non ha corpo, s'incorpora benissimo col rendersi bene mascinato con olio premo, del quale vi si ne mette un terzo & foro di fumo che così s'accomprano in la pittura a giugnere del olio, & un poco di vernice dentro comune.'


of Brescia, first half of the 16th century) in the Rijksmuseum, Amsterdam, the glaze is only slightly thicker over the shadow areas (Fig. 16a−c). An example of a completely even glaze is the curtain in the still-life with game known as A dog and a cat near a partially disemboweled deer (1656) by Jan Baptis t Weenix also in the Rijksmuseum (Fig. 17a−c). A number of 16th- and 17th-century texts show how artists prepared this glaze to ensure, as Armenini noted in 1587, that the given colour is uniform and no brush strokes can be detected. Armenini continued: With a coarse brush of miniver, one veils the sketch uniformly; next one pats it either with the palm of the hand or with a little wad of cotton wool covered with linen. It has been assumed that this method was specifically used for copper resinate since this viscous paint would have been hard to apply with the brush in a thin even layer. As has been shown, however, considerably thickened ‘fat’ oil was often used for glazing, both for verdigris and other pigments. Patting with a cloth or the palm of the hand is therefore the ideal way to disperse this type of viscous, jelly-like paint. In his Arte poética, e da pittura e symmetria com principio da perspectiva (1615), the Spanish artist and writer Felipe Nunes advised using a piece of linen filled with a wat of cotton for verdigris and red lake:

Wrap a bit of cotton with a very soft linen cloth, making a kind of brush with it. The cotton must remain inside the cloth so its fibres do not make a mark or adhere to the painting. As you spread the verdigris you will see the lights appear as light green and the darks as dark greens. In addition to verdigris, the studio manual Brief traite in the De Mayerne manuscript also recommended a cloth filled with cotton for white, vermillion, lake and schetzgroen. Copper-green and red lake glazes regularly reveal the pattern of the weave, as in the green drapery in the Marziali painting (Fig. 9a, c). Naturally, the glaze could also be applied simply with a brush. According to Nunes, the artist should begin by applying a thin layer with an ordinary brush and then dispersing it with a fuller, more resilient brush. According to the Art of painting in oyle by the life, red lake could be applied with a cloth, while an old worn-down brush was more appropriate for a copper-green glaze. Indeed, a highly inventive way of applying this thick green paint was also suggested:

while you are a glairing let one hold a chafindish with coles on the backside of the cloth against that place you are a glairing and it will spread the better, & dry the sooner, if you glaze on a board you must wash the place & let it dry before you glaze thereon, or else warme the board before you begin to glaze. The warmed support would make the viscous paint more liquid and easier to spread out in a thin layer. Jacob Bhenens described another way to make applying verdigris glaze easier. This involved rubbing a well-

149. Verbal communication from Dr A. Waller, Rijksmuseum, Amsterdam. See also Waller & Oosterhout (1999), pp. 44-46.
150. Laie et al. (1999).
151. Armenini (1587, 171), p. 125: ‘Si giunge poi con verdigris un poco di vernice comune, & di quella canta, e con accompagnato a ven venutato tutto egualmente con un pennello grosso da raso, & composto di lato, e con la pianta della mano, e con un pianimazzolo di bumbase coperto di tela linea, fin che il color dato a veglia esser per tutto eguale, senza che vi apparisse egual almeno di pennellate.’
152. Nunes (1615), see the translation by Veliz (1986), p. 5.
155. Art of painting (1664), pp. 103. The instruction for red lake is given on p. 102: ‘when it is dry glaze it over with faire lak, that is strike it thine allaver & then rub it all over w[i]th a little lawd stufft w[i]th cotton, this is to make florat, lake he even.’
dried underpainting with an extremely thin layer of varnish or oil: 'When the underpainting is dry, it is first rubbed in with a white oil [a pale oil, poppy or sun-bleached oil] using a pure, blunted brush or also with varnish.'

According to Bherens, the glaze should be spread over the entire drapery in one go in the wet varnish, although not so thick that it might start to run, and if it does then the lowest drips should always be removed. The risk of sagging paint could be avoided by applying successive thin glazes. Moreover, this was more likely to provide a smooth result than a single paint-layer. In the instruction quoted above, Pacheco advised two or three layers. The *Art of painting in oil by the life* also recommended multiple layers:

> For green use as little verdigrease as you can, but this (as some painters say) if you make a green garment make it without verdigrease, and when it is dry glaze it over with verdigrease and fatt oyle, as soon as that is dry glaze it over with fatt oyle again, or else the verdigrease will spoyle all... for you must glaize over anything where in you use verdigrease or indicio or else they will spoil all.

According to this instruction, one layer, or better still, several layers, is required to prevent verdigris paint from discolouring. Pacheco stated that green remained extremely radiant with multiple glazes and Hidalgo noted that this contributed to the preservation of the colour:

> For any drapery that you want to prevent turning black and losing its form work the underpainting with indigo and white, making the lights very light if you want them to be beautiful, and [use] a good drier to dry them quickly, and glaze with well-ground [neutral] verdigris. If you wish it to be even finer, glaze it once again, and what a green you will see.

Since the browning of verdigris takes place on the paint surface, a thick layer of multiple glazes will certainly enhance the durability of the colour, since the paint underneath, which is not discoloured, affects the eventual colour optically. Areas in paintings that consist of several (glazing) paint-layers of verdigris have therefore retained their original colour more or less intact. In contrast, paint applied in a single thin layer, like the outermost leaves on trees that overlap with the sky or the ground, are often subject to browning.

It was imperative, when applying these uniform glazes without differentiation, that the shape of the folds be evident in the underpainting. A sharp contrast between light and dark would have been needed to ensure that the suggestion of folds remains convincing through the glaze. The Spanish artist Nunes warned, and see that you make the highlights quite light and the darks quite dark. Hidalgo noted in the recipe cited above that the light parts of the underpainting should be extremely light. The large brown drapery in Frans Hals' *The banquet of the officers of the St George civic guard* (1616), in the Frans Halsmuseum in Haarlem, illustrates what this kind of contrasting underpainting would have looked like (Fig. 18a, b). The verdigris glaze that once covered this drapery has disappeared almost entirely probably as a result of the harsh cleaning methods in the past. The fresh grass-green has only been preserved underneath the frame. In the now exposed underpainting, Frans Hals rendered the folds of the fabric in detail with strong lights and deep shadows. Naturally, artists could also add light and dark accents over the glaze as is demonstrated in the *Portrait of a nobleman in armour* from the School of Brescia (Fig. 16). Yet, 17th-century painters appear rarely to have applied these accents over verdigris glazes. This is remarkable, since this method was often employed on layers of red lake and ultramarine glaze.

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156. See note 50.


158. See note 64.

159. This phenomenon was described by Billing e et al. (1997), p. 80.

160. See for Nunes note 152 and for Hidalgo note 64.
Underpainting for verdigris glaze paints

As has been noted in the previous section, verdigris glazes were applied in 15th- and 16th-century paintings over an underpainting of verdigris with lead-white and/or lead-tin-yellow (Fig 2, Figs 11, 15, 16). This pigment combination was recommended in contemporary instructions.162 17th-century authors also regularly mentioned methods of a similar nature. In the 1630's, Pacheco advised that *other times green is worked with verdigris and white and glazed with the same verdigris.*163 Analysis of paintings has shown, however, that this was not general practice in the Spain of Pacheco's day.164 In fact, Pacheco was not attempting to provide an accurate report of the methods in use among his contemporaries in Spain. It was often the description of the unusual, in the sense of rarely employed, techniques that particularly interested him. Around the mid-17th century this method was, however, used by the Dutch painter Weenix for the deep green velvet drapery in his still-life with game (Fig. 17). With various layers of verdigris and lead-white he rendered the modelling of the fabric, over which he applied an even glaze. Because he was working on a dark coloured ground, Weenix had relatively little difficulty in creating the shadow areas with the transparent verdigris paint. Painters working on a light ground had to paint a dark underpainting to achieve the same effect. As De MAYERNE noted: *'Where the darker shall lie in the workes it will not be amisse to lay a thin grounded of bone black ground w[i]th ynised eyle and shadowed very thinne.'*165 Pieter Pietersz painted the background in his Portrait of a woman (1597) in the Mauritshuis, The Hague, with a thinly applied, almost black paint over which he added a verdigris glaze, which has now disappeared almost entirely as a result of cleaning.166 Originally, he would have seen a deep dark green, against which the woman in her white cap would have stood out in clear contrast (Fig. 19). A black supportive tone is also found in the verdigris coloured dark green trees in Van Eyck's *The mystic lamb.*167

From the second half of the 16th century, painters generally used other pigments in underpainting for drapery finished with verdigris glaze. For example, in 1577, an unknown master of the Southern Netherlandish School employed lead-tin-yellow and azurite for St Barbara's gown in *Scenes from the life of John the Baptist* in the Rijksmuseum, Amsterdam (Fig. 4b).168 Two Armenini instructions of 1587 reflect the changing practice. Besides the traditional formula for an underpainting using green, lead-white and black pigment, Armenini included the new method:

*Some craftsmen follow a new way for making green drapery. A little coarse smalt and giallo santo [a lead yellow] are mixed together on the stone, producing a very good green for sketching drapery. And when the sketch is dry these artisans paint...*

161. Sozzani (1998). 17th-century artists' instructions often describe how the modelling can be reworked over a red lake or ultramarine glaze while this is recommended only once with respect to a verdigris glaze.

162. Anonymous MS (c. 1496-98), f. 143r: "Wibh ACKEN grie on spangrun... Wibh Acken mucen saym spangrun..." Strasburg MS (15th C.), see Borradaile (1967), pp. 84-56, Lomazzo (1584), p. 194.

163. Pacheco (1649); see Sánchez Canton (1956), vol. 2, p. 82: 'Otras veces se labra con el carbonilla y blanco y se mete otra con el mismo carbonilla; y otros sobre el blanco un poquito de giallo sin que no esté muy amarillo, y labran con esto y el carbonilla; después, la hacen.' Translation by Velázquez (1986), p. 72. Pacheco's *Arte de la pintura was completed in 1638 but only published in 1649. For other instructions Realet (17th C.); see Merrifield (1849, 1967), vol. 2, p. 653, O'Leary *in Oyle Colours* (c. 1650); see Harde (1915), p. 99, Fontaine (1679), vol. 2, p. 10, Nunez (1615); see translation by Velázquez (1986), p. 4.


165. Mayerne (1623-44), f. 43v.

166. The painting was restored by Carol Poth and examined by Petria Noble, Conservation studio, Mauritshuis.


over lightly with verdigris.\textsuperscript{169}

A green underpainting made from yellow and blue pigments was regularly recommended by northern authors of the first half of the 17\textsuperscript{th} century. The manual \textit{Le petit peindre} describes a method for green drapery, which is almost identical to that used by the masters of the Southern Netherlandish School:

\textit{Distilled verdigris, as it is called, never dies and is very beautiful for glazing of, for instance, a stone, a costume or a drapery after these have been painted with schijtgeel, or massicot or cendrée, shadowed and heightened as they supposed to be. Once it is dry the glaze is applied that will last eternally.}\textsuperscript{170}

Another manual collected by De Mayerne, advises the same pigments for a bluish green, with a little lead-white for the lightest areas and some charcoal black for the darker shades.\textsuperscript{171} Later 17\textsuperscript{th}-century instructions for drapery no longer describe these underpaintings as mixed with yellow and blue.

Rubens underpainted a green drapery in his \textit{Elevation of the cross} at the Cathedral of our Lady in Antwerp in an almost monochrome paint which he made from lead-white and charcoal black and just a little red earth and azurite.\textsuperscript{172} His method went back to a long tradition. A grissaille painting under a verdigris glaze is also found in Jan Gossaert's \textit{Adoration of the kings} at the National Gallery, London.\textsuperscript{173} Monochrome underpaintings are mentioned frequently in sources from the late 16\textsuperscript{th} century to the early 18\textsuperscript{th}. De Mayerne, for example, noted: \textit{Green draperies. First they have to be dead coloured with white and carbon black, then they have to be glazed for two times with verdigris.}\textsuperscript{174} In 1661 Jacob Bhereens noted his method for Green, such as can be seen in my large piece [enitled] The poetry.\textsuperscript{175} He also used white and black paint to provide an underpainting with great contrast between the light and shadow areas: \textit{That is, I made the highest light and the deepest shadow and made the whole fabric like white linen. What made this method efficient was the separation of the rendering of the form of the drapery from the rendering of the eventual colour. Painters would model the folds of the cloth with cheap and easy to use grey paint made of lead-white and black pigment. Once everything had been depicted, a uniform green glaze was sufficient to provide a convincing suggestion of green fabric.}

Alternative pigments which were easy to use and not too expensive, such as ochre, umber and other earth pigments, could also be used for the rendering of the modelling. By varying the colour of the underpainting, artists were therefore able to achieve a range of green tints with the same green glaze. As De Mayerne noted, \textit{Distilled verdigris is only for glazing over white and black, or over massicot or all other colours}.\textsuperscript{176}

\begin{itemize}
\item \textsuperscript{169} Armenin (1587; 1971), p. 125: 'Si il suonno si ha da far verd, il modo predestin sarà, che dopo che è verde, negro, e bianco à cara buggiar,' p. 126: 'Ma nelle bugge de i pani che sono da far il rossone andar più erba siala de gli altri, i quali à bene fari di qua colori medicare manco fari, e come albero che nel fare i suonno verde tengono non sauto, pigliano del smalto verde con quella urte, e questi medicari insieme à la pittura se fanno esser un verde bonissimo per la ubbiaggio quelli, i quali accennò il relato e renderà vero.'
\item \textsuperscript{170} Mayerne (1620-46); see Gras (1956), p. 152: 'Le vert de gris distillé qu'on applique, ne membuat jamais être fresche pour glacer, en lapis, en habiti, on autre drapé avec l'aurer doit de schijtgeel ou massicot & de condre, saflon & relaim comme à faire, puis c'est en il faut mettre le glaceur, qui dure perpetuellement.'
\item \textsuperscript{171} Mayerne (1623-44), f. 109r: 'Du beau bergblau mechi de jauné hâlgielg avec quelqu peu de blanc pour rendre plus clair. Les teintes les faut accomoder avec schijtgeel et non bolchiell, le tenant clair & brun avec tijiel. Cela gelosser avec du gelosceller sangue donne un beau vert. La couverre a eit pointe d'un vert tirant sur le bleu avusoir auis & hâlgelg. Les teintes invariable avec schijtgeel, le tenant aces brun, l'achs bolchiell lavier avec sangue.' Art of Painting (1664), p. 103: 'Pour un green takes resive, & pale mastic for yellow dyspot pinke, verditer, & verdigrus for yellow shadows, being dry glazy is withis fait style & verdigrus.' Biens (1636) advised a mixture of green ash, pale mastic and schijtgeel; see Klerk (1989), p. 56.
\item \textsuperscript{172} Kockaert (1992).
\item \textsuperscript{173} Billinge et al. (1997), pp. 93-94.
\item \textsuperscript{174} Mayerne (1623-44), f. 8Wr, see note 114.
\item \textsuperscript{175} See note 50. For other instructions for a monochrome underpainting for verdigris glazes \textit{Of Limning in Oyle Colours} (c. 1650); see Hardic (1919), p. 98, Symonds (1650-52); see Beal (1984), p. 227, Cröker (1719); see Schéll (1982), p. 110, Tientjude (c. 1650); see Sanz (1987), p. 262.
\end{itemize}
century Venetian artists such as Veronese and Titian used reddish underpainting.\textsuperscript{177} Because the build-up of dark red under the transparent green absorbs almost all the light, these painters were able to achieve deep and intensely coloured shadows. According to Beurs (1692), a brilliant green was achieved when one paints it first with a pure, strong yellow and then glazes it with distilled verdigris.\textsuperscript{178} A method for grass-green drapery noted by Marshall Smith, is based on a brownish-yellow underpainting mixed with yellow ochre, umber and bone black with a lead-tin-yellow for the highlights.\textsuperscript{179} Late 17th-century texts mention indigo and lead-white underpaintings for 'sea green' drapery.\textsuperscript{180} Hidalgo claimed that with this underpainting, green drapery would never lose its form or colour. A cool underpainting could indeed contribute to the optical preservation of the area. When, with the passing of time, the verdigris started to acquire a brownish tinge and became less transparent, the blue underpainting still maintained its effect through the upper paint-layer. The discoloration was therefore effectively 'neutralised,' ensuring, as Hidalgo claimed, that the green lasted longer and the suggested folds remained visible.\textsuperscript{181}

IV. Diminishing use of verdigris in the 17th century

Compared to the 15th and 16th centuries, verdigris - both in opaque and transparent paint-layers - was used less frequently in the 17th century. Analysis of paintings has shown that artists of this period occasionally used green earth or green verditer, but that they generally made green colours by mixing yellow, brown, blue and black pigments.\textsuperscript{182} In a characteristic remark, Beurs noted (1692), that We shall ignore the green since it can be made by tempering yellow and blue.\textsuperscript{183} In the northern Netherlands, this changing preference is especially noticeable in landscape painting. The verdigris that 15th- and 16th-century artists often employed for foliage and grass was now hardly ever used.\textsuperscript{184} Early 17th-century texts reflect this change in preference. Biens (1636), advised the use of a glaze of verdigris for painting drapery, but he noted that the pigment did not serve for landscapes.\textsuperscript{185} Various handbooks in the De Mayerne manuscripts are also typical. These often recommend verdigris glazes for drapery, but never once mention the pigment in the detailed instructions for painting landscapes.\textsuperscript{186} De Mayerne also noted that only some painters glaze their beautiful trees with verdigris, implying that this method was no longer current in his day.\textsuperscript{187} De Laisses noted in his chapter on landscapes in the Groot

\textsuperscript{176} Mayerne (1620-46), see Graaf (1958), p. 144: 'Vond de grijs distrille te zot que pour qnirr te brun en bleu ne, noe mantuit, ne toutes les autres couleurs.'


\textsuperscript{178} Beurs (1692), p. 108: 'Wat de Spaanse vliegen, gerne tornen, en goudvliegen belang, merkt kortlijck aan, dat menz eerst schildert schonen en werck, en daarna met gedisillieert gyns laassert.'

\textsuperscript{179} Smith (1692), p. 84.

\textsuperscript{180} Smith, (1692), p. 84, Palomino (1715-24; 1795-97), vol. 2, p. 70.

\textsuperscript{181} The cool underpainting of browned copper green glaze of St John's green cloak in Maarten van Heemskerk's The Virgin and St John the Evangelist, National Gallery, London, appears to have contributed to the preservation of the green colour: Dunkerton et al. (1988), p. 28.


\textsuperscript{183} Beurs (1692), pp. 4-5: 'T groen daeneen daar om oer om dat men' nit greel en blaanu temperen hun.'


\textsuperscript{185} Biens (1636); see Klerk (1982), p. 56: 'Tut groen neemt groen as clus met schip-gel of bloek mustwist glettemert, stem men gerschede schier terre verd, dat silouh is, maer quan; groen homt groen roote color ten war gedisillieert om ichteren meede te glicteren, maer is tut landschappen onwindelich.'

\textsuperscript{186} Mayerne (1620-46), see Graaf (1958), pp. 154, 156, 161-63; Mayerne (1623-44), ff. 88v-82v.

\textsuperscript{187} Mayerne (1620-46); see Graaf (1958), p. 156: 'Quelques des glaucere leurs buis; arbres, avec le verd de gris, mais ne subdit pas d'y mettre leernes.'
This disapproval is hardly surprising, given the caution with which 17th-century artists treated verdigris. They thought that the green colour could only be retained if the pigment was applied uncontaminated by any other paints. For example, as a glaze, protected as soon as possible by a layer of varnish. As already seen, green drapery was regularly painted in this manner in the 17th century. Artists in the 15th and 16th centuries would have applied the green copper pigment in landscapes along similar lines. They mixed verdigris with just a few pigments and carefully built up the green of trees and grass layer by layer, based on a planned composition. The trees on Van Eyck’s *The mystic Lamb* are an example of this technique. A similarly cautious methodical approach is often found in incarnates, drapery and brightly coloured objects in 17th-century paintings. In landscapes of this period, however, a less constrained manner of working can be discerned (Fig. 20). Painters such as Jan van Goyen and Salomon and Jacob van Ruysdael used a rudimentary underpainting, establishing only the basic shapes of the composition. Small forms were determined in the main paint-layers. Artists preferred ochres and other earth pigments that were easy to use and, moreover, cheap. They often mixed these and other pigments, such as lead-white, smalt, azurite, lead-tin-yellow and yellow lake into a myriad of green, blue and brown hues. The various tints were often painted into and over each other wet in wet. Indeed, changes were frequently made during the painting process. The instability of verdigris colour would have prevented artists from using this pigment under these conditions.

The diminishing popularity of verdigris glazes was not due only to difficulties involved in using the pigment. When the glaze is applied in the manner advised in the sources, the result is a painting with a defined shiny, bright green area. A complete glaze undermines the unity of the painting; the area stands out as a more saturated, darker passage which optically comes sharply to the fore. This is an effect that would be difficult for a final varnish to even out. This would not have been a problem for 15th- and 16th-century artists. Their paintings consist of a combination of clearly defined often brightly painted sections. In the course of the 17th century, artists began to see the colour effect resulting from the use of verdigris as problematic. Remarks by two of the leading 17th-century Dutch art-theorists are characteristic of this changing preference. Hoogstraten noted in his *Inleyding tot de booge schoole der schilderkonst* (1678), that the colour of verdigris was too cruel, and De La Laurens commented on verdigris that although it is the most beautiful, it is neither the most pleasant nor the most lovely to the eye. Similar opinions are also found among artists abroad. According to Richard Symonds the Italian painter Canini considered that ‘*Verde Rame which makes an incomparable color, ma troppo sfacciata. Too garish.*’ It is the harshness, the garishness of the green colour that artists found increasingly unsuitable. Mixtures of the yellow and blue pigments available in the 17th century, such as combinations of azurite or smalt with lead-tin-yellow, or ultramarine or indigo with yellow lake,

188. Lauresse (1707), vol. 1, pp. 359. ‘*Dongen en gebreken van het spauwgroen… Niet dat men ook, om een schoon groen te hebben, het spauwgroen moet gebruiken: want toewel het schuimite g’s, is het malien het aangenaamste en lieflijkste in ‘t oog niet, te meer droomen het oog geweld verterreft en van koude veranderen.*’

189. See note 167.


192. Only a few texts advise using verdigris in landscapes. For example Cröker (1719); see Schiefl (1982), p. 108, advised mixing the verdigris with lead-white, lead-tin-yellow and yellow lake to make a green paint for highlights on foliage.


194. Hoogstraten (1678), p. 22: ‘*neuer de menschen wel, dat enye zoo wel het groen, als het rood of geel, niet onzer wil lachen. Terra rvol is te zwart, spuice groen te smal, en dus niet onbetuigd.*’ See for La Laurens note 188.

195. See for the remark by Canini note 85. Pacheco also preferred a subdued green mixed with black and yellow; see Pacheco (1649); see Sánchez Cantón (1956), vol. 2, p. 82.
produced the more subdued green tints that painters preferred.  

In the northern Netherlands, this changing preference may have been related to changing ideas about the pictorial function of colour in a painting. Paul Taylor has shown that the concept of *houding* played a central part in this debate in art theory in the Northern Netherlands of the 17th century. *Houding* related to both the harmony of colour and the illusion of space (with both relief and aerial perspective) in a painting. It was about the subtle balance of strong and weak nuances of colour as well as light and dark tints that brought the form forward or allowed it to recede into the background. It enabled the spatial relationships between objects in a painting to be clearly defined, allowing a logical suggestion of three-dimensionality to emerge without sharp divisions. It is clear that when these painters considered the nuances of colour, the colour shift of verdigris to a warmer green would have been a disadvantage. Moreover, it was considered inappropriate to contrast colours too harshly in paintings. Lairesse noted, 'avoiding this [background colour] which makes them [the colours] too constrained, too cruel and hard; and preferring those that make them seem more lovely.' Von Sandrart, who discussed the Dutch artistic concept of *houding* in detail in his *Teutsche Academie der edlen Bau*, Bild- und Malerey Künste (1675-80), explicitly stated:

> It is, incidentally, my firm opinion... that all hard, light, strong and high colours should be entirely avoided and utterly rejected, as the embodiment of all discord in a painting, whenever their hard, gaudy nature is not broken, and muted, or intelligently tempered with other concordant and harmonious colours. These fresh and unbroken colours then, as they are used by card-painters and dyers, as well indeed as by others who wish to understand something of our art, are not more tolerable in an intelligently made painting than it is healthy and pleasant to eat raw red meat straight from the butcher's.

Not only is it difficult to balance strong colour areas with other hues, they also tend to disrupt the three-dimensional illusion of the painting because they are so optically prominent. According to Sandrart it was the art of mixing, breaking and reducing colours from their crudezza that made a painting conform to nature. An isolated green area would therefore rarely have been appropriate. It is only in a few specific cases that the garish colour effect came into its own. In the *Still-life* by Abraham Mignon, the green tablecloth forms a powerful counterbalance to the profusion of objects on the table. The hard, protruding green also enhances the sense of depth in the work (Fig. 21). In most paintings the bright verdigris green was restricted to an occasional accent. For example, Cornelis de Heem restricted the use of verdigris glaze to the bagpipe in his *Still-life* in the Rijksmuseum in Amsterdam. Today this glaze has a more subdued dark green colour (Fig. 12). The sources reflect the common method. Beurs recommended a verdigris glaze only for the shiny bright green beetles depicted in still-life's. Bogdani noted that he painted leaves in his flower pieces with ultramarine and yellow lake using a glaze of verdigris and yellow lake only *In some clear places that the light shone*

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196. Where verdigris was used, as in the still lifes by Pieter de Ring and Abraham Mignon, it was usually employed as an opaque paint mixed with lead white and plenty of yellow ochre to form a subdued green rather than as a glaze; see Hermens et al. (1999); Bijl & Waller (1999).


198. Lairesse (1707), vol. 1, p. 209. 'vermeelden die wolke ten is onvemelende, te weerd en hard doen zijn; en verhazande gülde die den leeftyk doen wierken.'

199. Sandrart (1675-80), vol. 1, p. 85: 'Deze of gryze grünhe, die, also Ende de zachte, were die gryze Drukkken, eene Gemälde bestelten, wann nicht dier harten, enhet Art gebrochen, und gelümmelt, oder mit Versaunte diser ander unvemeliche und vertrugliche tempera wurz. Dann die frische gryze Farben, te von Kartensaulen und Farbure, auch wol von ander, die in unserer Kunst etwas verstellen wollen, gebraucht werden, sind so wesen in einem vernuuffigen Gemälde zu dulzen, als wesen grün und angemeltn, das rohe Fleisch aus der Mütze ungeknackt zu essen.' Translation by Taylor (1992), p. 226.


201. Sandrart maintained that Rembrandt in particular had performed miracles with *houding*. Hoogstraten (1678), p. 306 also claimed that when grouping tone and colour Rembrandt *blijf dergelyk lang in het groent, en wo zal volk in 't art hystrogen van houding vermelten.' It is hardly coincidental that Rembrandt in particular never used verdigris and always preferred a more subdued green mixed with yellow and blue. In Rembrandt's use of pigment: Bumford et al. (1988), pp. 21-26 and verbal communication: Karin Groen (ICN) and Rembrandt Research Project (RRP).
thro' the leaves & very rich parts.  

Joris Dik has pointed out that early 18th-century painters such as Van Huysum increasingly abandoned the idea of *houding*. Like 17th-century masters, Van Huysum placed his bouquets against a dark background in his early paintings. The spatial relationship between the flowers and fruit are clearly defined by the bright and muted colours and the subtle and deep shading. In his later work, like the *Vase with flowers* (1722) at the J. Paul Getty Museum (Fig. 22), Van Huysum preferred light backgrounds that project forward optically. Bright and light colours and the absence of dark shadows make it impossible to establish spatial relationships in the bouquet. Instead of using subdued tints, Van Huysum painted with a bright green. For that he no longer needed to use the awkward and unstable verdigris. In the early 18th century, the newly available Naples yellow and Prussian blue enabled Van Huysum to mix a bright green paint that was very easy to use and maintained its colour.

**Conclusion and Summary**

The study of a large group of historical recipes and application instructions has established a clear picture of the way verdigris glazes were used in oil paintings. This knowledge assists in the interpretation of data obtained from scientific research into transparent copper-green paints in Renaissance and Baroque paintings and contributes to a greater insight into the changes to which these paints have been subject in the course of the centuries.

First and foremost, there turns out to be little basis for the assumption that copper-green glazes consist of a *copper resinat* made by artists by dissolving verdigris in heated varnish. In fact, the instructions show that the glaze was made with finely ground verdigris mixed in a cold oil or varnish medium. The historical term verdigris related to a range of green and blue-green corrosion products of copper, which painters rarely differentiated. In addition, the various methods for distilling unrefined verdigris resulted in products of varying degrees of purity. These processing methods explain the frequent presence of copper chlorides and copper sulphate pigments in the glaze. To date, analyses of binding media of glazes have generally revealed linseed oil to be the main component. The oil often appears to have been heated to a high temperature. A small amount of resin is also regularly identified. The old texts discuss the preparation and function of these media. Artists boiled the oil to obtain a thicker and more fluid medium that provided a more uniform and glossy glaze. To accelerate the thickening of the oil, a little lead-white or lead-oxide was often added. This may explain why in copper-green glazes with no lead pigments nevertheless sometimes a small amount of lead is identified. The addition of varnish was intended to improve the glazing properties of the paint. The ancient instructions show that verdigris could be mixed with a variety of pigments, while the composition of the underpainting could also vary. Analyses of copper-green glazes often indicate the presence of chalk. The historical texts show that this may be due to various reasons. Painters may have added a yellow lake with a substrate of chalk to the verdigris. The verdigris may also have been adulterated with chalk. The purification methods employed by artists appear not to have removed the substance. Italian instructions reveal that it was not unusual to mix verdigris with bituminous paints. Indeed, caution should be exercised in identifying brown cuprous matrices in paintings as a *browned* copper-green in every case.

From the early 16th-century painters referred to the lack of colour-fastness in verdigris glazes. On the other hand, they praised the durability of the paint. The sources show that the colour-fastness depended on the purity of the pigment and the skill with which the specific painting technique for this particular pigment was employed. To prevent discoloration in the pigment, some varnish was regularly added to the oil.

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medium, sometimes verdigris was mixed in pure varnish, although it was more usual to apply a layer of varnish over the glaze as soon as it had dried. At present, brown layers that contain no copper, which seem to be a part of the original paint layer, are regularly found on copper-green glazes. Modern researchers have assumed that these layers are the remnants of a yellow lake that was applied over the verdigris to create a warmer green. However, the historical texts reveal that these layers are just as likely to be the remains of the local varnish. Finally, the historical texts offer an insight into why verdigris was used less frequently by artists from the early 17th century, even though no alternative bright green pigment existed. This reflected changing views regarding the pictorial function of colour in paintings, in which an isolated area of harsh green was rarely required.