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Theories about the Eyckian painting medium from the late-eighteenth to the mid-twentieth centuries

Elise Effmann

Abstract

Theories about the components of the painting medium employed by Jan van Eyck are a recurrent concern in literature that addresses the early history of oil painting. The deep colors, fine detail and excellent state of preservation found in his works have invariably led artists, historians, conservators and scientists to investigate how they were made. Before components could be defined by modern instrumental analysis in the second half of the twentieth century, research into the structure and materials of paintings relied primarily on visual examination, early scientific experimentation, information provided by late-medieval technical treatises and attempts to replicate the appearance of paintings in copies. An historical review of the most dominant theories pertaining to Eyckian works illuminates both the concerns that motivated, and the biases that influenced these investigations.

Introduction

To prove beyond a peradventure of a doubt which is the one and only Van Eyck technique will probably never be possible...Each person simply writes from his own point of view, and it is always open to question how well such a person understands the craftsmanship involved.

Max Doerner, 1921 [1, pp. 334–335]

In 1953, in reference to the recent study and treatment of the Ghent altarpiece by Jan van Eyck, Paul Coremans, the director of the Central Laboratory of the Belgian Museums, announced that ‘...the analyses carried out allow us to assert that the Eyckian medium has a base of drying oil’ [2, p. 9]. With this simple declaration, one of the most debated questions in the history of art had a substantive answer based on scientific analysis. Since then, analyses have been performed on many works by Van Eyck and the physical aspects of his medium are now well understood. However, for nearly two centuries prior to this landmark technical study, numerous efforts were made by artists, historians and scientists to understand the precise components of his medium. Both out of curiosity fuelled by the extraordinary quality of his oeuvre and out of respect for his seminal position in the early history of oil painting, practically all writers who addressed the historical development of painting voiced their opinions on the subject. Although previous publications have considered this topic, both in summary [3–5] and comprehensive terms [6–7], a review of the most widely-circulated writings that address the details of the suggested recipes does not exist in English. Pim Brinkman’s Het geheim van Van Eyck shares much with this paper in its historiographic analysis and his study of the early literature is thorough and useful [6]. However, recent discoveries about the aging process of lead-containing paints have called into question his conclusion that Van Eyck used an oil emulsion.

The ‘invention’ of oil painting

Praise of Van Eyck’s mastery of painting appeared in print soon after his death in 1441. The following decade, the humanist Bartolomeo Fazio noted that Van Eyck was ‘the leading painter of our time’ and hinted that the artist possessed a knowledge of materials beyond that of his contemporaries through the painter’s reading of Pliny and other ancient writers [8, p. 102]. In his Trattato d’architettura written between 1461 and 1464, Antonio Averlino, known as Filarete, mentioned that both Van Eyck and Rogier van der Weyden were known to be skilled in painting with oil and that ‘in Germany they work well with this technique’ [9, p. 311]. Intriguingly from the standpoint of this paper Filarete went on to briefly state that he did not know much about this medium other than that it was linseed oil, which could be lightened and clarified over time in an amoretto.

However, it was Giorgio Vasari who most dramatically influenced later historical notions of the artist’s technique in Le Vite de’ più eccellenti pittori, scultori e architettori, first published in 1550 and enlarged in 1568 [10–12]. Presumably based on earlier stories about the artist, but also embellished to amplify his own narrative of the development of painting, Vasari declared that Van Eyck was the inventor of oil painting and went on to describe the artist’s attempts to find this new medium in the ‘Life of Antonello da Messina’. Vasari’s account went virtually uncontested in references to Van Eyck for the following two hundred years and notably Karel van Mander paraphrased the tale in his early-seventeenth century Schilder-Boeck, thus transmitting the invention story to a Northern audience [13, p. 58].

Vasari noted the ‘great mastery’, ‘delight in alchemy’ and ‘inventive brain’ of Van Eyck in the beginning of his tale and went on to explain that it was the search to find a varnish that would dry without sunlight that led the artist to his discovery of the oil medium [11, p. 425]. After ‘many experiments with substances both pure and mixed together’, Van Eyck found that linseed and nut oils dried well and ‘These, then, boiled together with other mixtures
of his gave him the varnish that he...had long desired' [11, p. 425]. Vasari then stated that 'mixing colours with those oils' gave the artist a durable, brilliant and easily blended paint [11, p. 425]. The vagueness in detail combined with the notion of the secret nature of Van Eyck's discovery made the text a compelling source for later investigations into his technique.

The refutation of the legend of the origin of oil painting

The question of whether oil was used as a medium before Van Eyck was broached by Carlo Malvasia in the mid-seventeenth century when he claimed that the Bolognese artist Lippo di Dalmasio used oil before 1400 [14]. However, it was not until the last half of the eighteenth century that a more systematic exploration of the origins of Western-European painting practices was undertaken. The English writer and connoisseur Horace Walpole was the first to question critically Vasari's legend in his Anecdotes of Painting in England published in 1762 [15]. The listing of oil in a thirteenth-century payment document for paintings at Westminster, as well as a later inscription found on the Wilton Diptych that stated that it was painted before the invention of oil in 1410, seemed to him 'to leave a doubt whether John ab Eyck was really the first person who mixed his colours with oil' [15, p. 25]. Walpole's book, which was immensely popular and republished well into the nineteenth century, posed this question for the first time to a broad intellectual community.

Within the next twenty years, two studies were published that instigated a new direction in the study of Eyckian technique. The first was Vom Alter der Ölmalerei published in 1774 by Gotthold Ephrains Lessing, the philosopher, dramatist and critic of the German Enlightenment [16]. This was soon followed by A Critical Essay on Oil-Painting; Proving that the Art of Painting in Oil was Known before the Pretended Discovery of John and Hubert van Eyck in 1781 by Rudolf Erich Raspe [17]. Both works refuted the invention of oil painting by the brothers, citing the rediscovered medieval treatises of Theophilus and Erasmus, which include recipes for oil [18, pp. 27-28; 19, pp. 228-233].

In the following century interest shifted from Jan van Eyck as the inventor of oil painting to the artist as an inventor of a new technique using oil. However, Vasari's text remained a touchstone for any discussion of the artist's practice due to the paucity of fifteenth-century treatises on Netherlandish technique. Although Raspe discredited Vasari's myth of the invention as unreliable, he referred to it when offering his own hypothesis at the conclusion of his book. He suggested that Van Eyck used nut or poppy seed oil with the addition of vitriol, spike oil or varnish to speed drying. He incorrectly noted that linseed oil was hardly used anymore and was unaware that poppy seed oil came into use in European painting only in the seventeenth century [17, p. 66].

Resin theories

It may be concluded that Van Eyck's vehicle was composed either of linseed or nut oil, and resinous ingredients of a durable kind.

Charles Eastlake, 1847 [20, p. 265]

After it was accepted that Jan van Eyck did not invent oil painting, interest shifted to discovering how the jewel-like colors, durable enamel-like surfaces and precision of detail were created with his paint mixture. Formed by and informing contemporary artistic practice, nineteenth-century writers primarily focused on resins and ingredients as the key to Van Eyck's medium. Interest in rediscovering the 'secrets' of the Old Masters spread in the eighteenth century and culminated in the nineteenth, prompting experiments with wax, thixotropic mediums and other materials to simulate earlier painting methods. Hard and soft natural resins were extensively used and written about in the growing field of literature on painting technique, well-summarized in a recent book by Leslie Carlyle [21]. The addition of resins to paint was widely believed to bring greater transparency, durability and better handling properties than oil alone. References to resins in early treatises and also Vasari's account of Van Eyck's experimentation with varnishes were seized upon to provide the literary evidence necessary to support the hypothesis that resins were vital components of the Eyckian medium.

Paillot de Montbert and Mérimée

The academic French painters Jacques-Nicolas Paillot de Montbert and Jean-François-Louis Mérimée separately advanced similar hypotheses about Van Eyck's painting medium in their respective studies of the history and technique of painting, which were published in 1829 and 1830 [22, 23]. In the concluding book of his nine-volume Traité Complet de la Peinture, Paillot de Montbert posited that the enamel-like surfaces and thin glazes of color could only be achieved by the addition of a hard resin, like copal or amber, to the drying-oil medium. He stated that artists during the time of Van Eyck painted with thin glazes of color over underpainting bound in egg or glue [22, p. 34].

Translated into English in 1839, Mérimée's De la Peinture à l'huile had a wider audience and arguably a longer-lasting impact on the discussion of Van Eyck's technique [23]. Mérimée wrote that he sought to research the processes of painting employed from the time of Van Eyck to the present, both through the analysis of early treatises and careful examination of paintings by the Old Masters. This interest was spurred by the recognition that many paintings from the fifteenth century were better preserved than the majority created in his own time, as well as by the subsequent desire to discover the 'secret', which could enhance the stability of modern paintings [23, p. ix-x]. He became convinced that Van Eyck, although not the first to use oil for painting, brought about innovation through the development of a fluid medium composed of oil and resin, and it was to this latter component that the preservation, transparency and brilliancy of the paint layer could be attributed [23, p. 7]. In addition to a comprehensive review of early and modern literature on the subject, Mérimée turned to the experience of restorers who found

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that paint from the fifteenth century was harder and tougher. It also possessed a greater resistance to solvents than that of more recent works and showed an enamel-like quality when rubbed with a file [23, pp. 14–15]. Although he did not state explicitly that Van Eyck used copal oil varnish, his stance is implied by the lengthy section devoted to the preparation of this medium. He quoted a passage from Theophilus, in which the twelfth-century monk describes a medium made from boiling oil with powdered resin that results in a brilliant and durable paint layer. Mérimée observed that, although Theophilus did not state which kind of resin was intended, copal alone had these properties [23, p. 74]. In addition, he believed that volatile oils could be added to increase the fluidity of the medium [23, p. 14].

Eastlake

Like Mérimée, Sir Charles Eastlake sought to discover the reasons for the superior durability of early paintings in hopes that his research published in his Materials for a History of Oil Painting would aid the present-day artist [20]. Eastlake was Keeper of the National Gallery in London from 1843 until the publication of the first volume of this book in 1847, and had the opportunity to examine at first hand the Arnolfini Double Portrait, acquired by the museum in 1842. A sizable part of the first volume of his work is devoted to Van Eyck’s innovations in technique.

On the basis of the appearance of Van Eyck’s paintings, as well as an exhaustive analysis of both early texts and the inevitable account by Vasari, Eastlake concluded that the medium must be drying, nearly colorless, and have a consistency that ‘allowed the most delicate execution’ [20, I, p. 265]. He was the first writer to cite the fifteenth-century Strasbourg Manuscript in his discussion of the origins of oil painting and referred to its instruction to add drops of varnish to colors ground in oil [24, p. 55]. Referring to Timothy Sheldrake’s experiments published in 1801 in Transactions of the Society of Arts, which relate the attempts of this amateur artist to discover the medium of the sixteenth-century Venetian masters, Eastlake theorized that amber or copal was the resin used by Van Eyck [20, II, pp. 36–37, 51]. Sheldrake had found that paints composed of oil and hard-resin varnishes were more brilliant and more resistant to solvents and alkalis than pigments ground in pure oil.

However, the drawbacks of these vehicles are the tendencies to flow and to yellow. The darkening, Eastlake believed, could be mitigated by careful preparation as well as sparing or diluted use of the medium in light colors [20, I, p. 287] and the failure to retain crisp edges could be avoided by using the medium in small quantities where precision was required. To reduce the drying time, he believed that white copperas (zinc sulfate) mentioned in The Strasbourg Manuscript was used by the artist, and he cited recent experiments by scientists with several different metallic dryers [20, II, pp. 365–367]. Essential oils such as oils of spike and turpentine, as well as the volatile solvent, naphtha, were mentioned as possible diluents to increase precision in rendering [20, I, p. 313].

Much of Eastlake’s argument hinged on Van Eyck’s careful preparation of materials and the artist’s knowledge of aging and optical properties, and herein lies one of his most astute assessments of Van Eyck’s technique. Eastlake stressed the artist’s intimate understanding of his materials, stating that ‘Instead, therefore, of supposing that the first oil painters had achieved impossibilities by inventing a permanently colourless varnish, it may rather be concluded that they had the sagacity to adapt their processes to their materials’ [20, I, p. 275]. Eastlake recognized that the brilliance of the paint was produced optically by painting thinly with restricted use of opaque mixtures on a bright white ground [20, I, p. 400]. Although his hypothesis that Van Eyck would have varied his medium, depending on the pigment — using amber varnish for the dark colors but a ‘white varnish’ consisting of mastic and walnut oil for the lightest areas and blues — is not accurate in the specific materials, it is certainly insightful [20, II, pp. 38–39]. It has since been found that both walnut and linseed oils were used by some of Van Eyck’s contemporaries, and that both tempera and oil techniques were sometimes combined on the same panel [25, p. 103; 26, pp. 40–41, 53–54]. However, Van Eyck’s process appears to have been more simple and analysis has determined that he used both unmodified and heat-bodied linseed oil as well as differing amounts of pine resin, depending on the drying and optical properties of his pigments [26, p. 53].

Followers of Mérimée and Eastlake

For the remainder of the century, the resin theory dominated the discourse on early Netherlandish mediums. Mary Merrifield, in the introduction to her important translation of early technical treatises, referred to Eastlake’s research into the use of amber varnish [19, p. cxcviii]. Painting Popularly Explained, from 1859, by Thomas Gullick, noted that ‘Examination of the pictures...leave[s] no room to doubt that their durability is attributable chiefly to...an olio resinous vehicle’ [27, p. 231]. His recipe for amber mixed in oil with white copperas obviously stemmed from his reading of Eastlake, cited elsewhere in his book. Charles Blanc, in his Grammaire des arts du dessin (1867), mentioned that the good preservation of Van Eyck’s works was due, not to the linseed oil itself, but to the high quality of varnish that he mixed with his oil [28, p. 629]. Jacques Blockx, a Belgian chemist, wrote that he ‘shared the generally admitted hypothesis that resinous substances were mixed with (oils)’ [29, p. 96]. He focused on amber after numerous experiments convinced him of its durability and brilliance, and the Blockx paint company still manufactures his Amber Painting Medium. William Mackley, in his Handbook for Painters from 1880, wrote that he had arranged with the Messers. Mander brothers of Wolverhampton ‘to prepare pure Copal and Amber Varnishes for the painter’s use...They correspond as nearly as possible with those employed by van Eyck and the early Flemish painters’ [30, p. 46–47].

Modifications of the oil-resin hypothesis

The high viscosity and dark color of hard resin and oil mediums prompted some writers to emphasize the addition of volatile essential oils to the recipe, and others to propose soft resins instead of copal or amber. Charles Dalbon, in his book on the origins of oil painting from 1904, suggests that the principal improvement of Van
Eyck was the addition of an essential oil as a diluent to make the oil varnish more fluid, limpid and siccative [31, pp. 97–98]. The French painter Alphonse Étienne Dinet referred to Mérimeé's hypothesis that Van Eyck's medium was drying oil mixed with resin and an essential volatile oil in his own book on the practical problems that could befall the painter [32, p. 66]. Maurice Busset, an artist who wrote *La Technique moderne du tableau* in 1929, detailing his twenty years of study and experience, believed that Van Eyck's innovation was the dilution of oil varnish with an essential oil. His recipe consisted of half-parts copal or amber in oil and half spike oil [33, p. 60–61]. In *The Painter's Pocket Book of Methods and Materials* of 1937, the Precisionist painter Hilaire Hiler included Busset's recipe and mentioned that it was used possibly to 'finish pictures begun in emulsion or tempera' [34, p. 162].

Maximilian Toch, a chemist and engineer in New York, conducted a series of experiments on the yellowing of linseed oil, which he summarized in a chapter on the 'Photo-chemical deterioration of oil paintings' in his *Materials for Permanent Painting* of 1911 [35]. He noted that gum dammar, when mixed with lead white and linseed oil, was the only resin that did not darken when exposed to sunlight [35, p. 37]. After observing the yellowing of linseed oil when subjected to the same experiment, Toch concluded that Van Eyck probably used a medium composed of a small amount of linseed oil and mastic or dammar varnish [35, p. 39]. However, his grasp of the history of painting technique was not equal to his scientific training, since although mastic had been used since antiquity, dammar had been known in Europe for fewer than a hundred years. He was also unconcerned by the vulnerability of the paint to damage in restoration, something that would be considerable over time with a medium composed primarily of dammar or mastic.

In the *History and Methods of Ancient and Modern Painting* from 1913, James Ward referred to Van Eyck's technique not as oil painting but as 'varnish painting' [36, p. 222]. Ward believed that the medium was composed of mastic or dammar — which would keep the colors lighter and brighter than amber — dissolved in turpentine oil with a small amount of linseed or walnut oil. He also believed that further dilution of the vehicle with oils of turpentine or spike, naphtha, poppy oil or walnut oil would be necessary to slow the drying and prevent cracks from occurring. Charles Moreau-Vauvhear in 1912 stated that it 'seems certain that...they then painted with a substance that was loaded with resin and moistened with oil. This very thin, supple and delicate material, brilliant as precious stone...[was], no doubt, the great secret of the van Eycks' [37, p. 139]. The medium that he proposed had a base of both amber and mastic with zinc sulfate or calcined bone added as a siccative.

**Emulsions and mixed techniques**

Modern attempts to explain the Flemish method of the fifteenth century, particularly that of the Van Eyck's, have brought about a prevailing view that both oil and tempera were used then but there is a difference of opinion about how the two may have been combined.

George Stout, 1933 [38, p. 187]

The twentieth century brought with it new approaches toward the identification of Van Eyck's medium, which were as tided to their own artistic climate as the resin theories were to the nineteenth century. The tendency of oil-resin vehicles to be viscous and to darken was increasingly viewed as inconsistent with the luminosity and precision of Van Eyck's work. The unvarnished paintings of the Impressionists heralded a break from traditional technique, and interest grew in alternative media to oil, such as watercolor and tempera, which could be used to create matte surfaces and lighter tonality. These factors, combined with an increased scientific understanding of chemical and physical properties of paints, paved the way for alternative hypotheses on Van Eyck's technique, which primarily focused on the use of emulsions as mediums and a technique of layered applications. Emulsions of aqueous media and oil were particularly attractive to this new generation of investigators because they would theoretically combine the advantages of both binders — the precision and fast-drying of tempera with the blending and luminosity of oil. Although the linear development of painting technique from tempera to oil promoted by Vasari is now understood as overly simplistic, under this persevering view, a transitional phase in which both oil and aqueous binders would be combined seemed quite logical.

The theories that Van Eyck achieved his brilliant colors with oil glazes over a tempera underpainting or that the paint texture was modified with the addition of an aqueous component were broached in the nineteenth century. Paillet de Montabert wrote generally that Van Eyck painted in light glazes on top of distemper or tempera [22, p. 34]. The French painter and author Jehan Georges Vibert, suspicious of the oils used by modern-day artists, believed that Van Eyck used a large amount of resin in his medium, which he painted over an 'ébauche' done in egg [39, p. 8]. Giovanni Secco Suardo, the Italian restorer and connoisseur, and Albert Ilg, the Austrian art historian, both noted earlier nineteenth-century references to oil mediums mixed with aqueous components in their historical studies of painting techniques of 1858 and 1873 [40, pp. 70–71, 168–169; 41, p. 185]. However, it was not until the end of the century with advances in organic and physical chemistry, as well as growing experimentation in painting practice, that theories about the use of mixed or layered oil and aqueous mediums came to fruition.

**Berger**

In 1897 the German artist Ernst Berger introduced the first fully articulated emulsion hypothesis in his five-volume study of historical painting techniques [42]. After citing references to early uses of emulsions in the *Mappae Clavicae*, *the Lucae Manuscript*, Cennini, and in Vasari's 'Life of Alessio Baldovinetti', he discussed the possibilities of an 'Oeltempera' technique that he had devised through numerous painting experiments. He divided these into two groups — mixtures of gum and oil and ones of egg yolk and oil, both of which could be diluted with a large portion of water once emulsified. The significant amount of water rendered the medium less than one-quarter oil, which he viewed as an advantage for durability. Berger noted that the two emulsions behaved differently when
painted. The gum-oil emulsion had a tendency to bead up and required a surfactant like ox-gall or vinegar to allow it to be applied evenly. On the other hand, egg-oil tempera did not develop the same problems. Fine details, glaze and opaque applications and blending were also possible. By varying the components, a wide variety of effects could be achieved using the two emulsions. The greatest problem encountered by Berger with this technique was that his ‘Oeltempera’ dried matte due to the large amount of added water, and he addressed this concern with two possible systems of application. In the first, the medium was to be applied in layers on a gesso ground remaining matte until the colors were saturated by a final varnish application. The second was that each layer of ‘Oeltempera’ would be saturated by an intermediate varnish layer as the artist painted. Whichever the application, Berger believed the key to clearer, more brilliant paintings was thinner and fewer layers [42, pp. 266–270].

Eibner
In 1906, the German scientist Alexander Eibner wrote an article refuting Berger’s hypothesis and, among other points, he noted that the matte-drying emulsion contradicted Vasari’s explicit statement that Van Eyck’s paintings dried with a gloss without varnish [43]. Eibner concluded his paper by stating that many questions could be answered with chemical and microscopic investigation and specifically noted that the absence of nitrogen in a sample would indicate the absence of egg in a medium. In his early publications, Eibner agreed with exponents of the oil-resin theory and allowed for the possibility that some type of diluent like turpentine was used to improve handling [44, p. 423]. By the late 1920s, his life-long research into the chemical and physical properties of oils and other paint materials had led him to posit that stand oil, which he found was less affected by water and yellowed less than raw oil or oil varnishes, was the medium of Van Eyck [45, pp. 151–152].

Laurie
The British chemist Arthur P. Laurie wrote several important works during the first half of the twentieth century, describing his scientific investigations of historical painting techniques and the physical and optical properties of paints [46–48]. Laurie was one of the first to incorporate systematic scientific testing of materials into his assessment of Eyckian technique. In his first book on painting materials, The Materials of the Painter’s Craft of 1910, he noted that Eastlake’s work on the historical development of painting technique was out-of-print and out-of-date and that ‘there is no book in the English language which covers all the ground and brings together the latest results of inquiry and research’ [46, p. ix]. He conducted various experiments, such as exposing pigments dispersed in different vehicles to moisture and sunlight, in an attempt to understand the preservation of Van Eyck’s colors [46, pp. 304–306]. He concluded in this book that the artist could not have painted in pure or boiled oil, amber-oil varnish or copal-oil varnish because he believed these mediums were permeable to moisture [46, p. 306]. Laurie, in fact, mentioned how Eastlake’s notion of varnish as the key to Van Eyck’s medium had influenced the views of others. Contradicting the historical information put forth in Eastlake’s book, Laurie stated that there was very little evidence that varnish was commonly used in the fifteenth- or sixteenth-centuries as a painting medium [46, pp. 345–346]. He proposed the structure of the painting as a tempera underpaint followed by an emulsion of balsam and egg white, which would allow touches of impasto as well as speed the drying, and then finished with a final resinous varnish. He believed that this system would ensure the physical compatibility of each successive layer [46, pp. 375–376].

Sixteen years later in The Painter’s Methods and Materials [47], Laurie retracted his claims that pine balsams and highly resinous mediums were necessary to protect the pigments used by Van Eyck. The good preservation of color in many tempera paintings indicated to him that artists of the time had pigments of great permanency. He wrote instead that the good condition of Van Eyck’s works could be attributed to ‘very careful and methodical painting on a sound wood panel’ as well as ‘the thorough understanding and successful use of the combined tempera oil technique’ [47, p. 48]. He came to the conclusion, on the basis of experiments to imitate brushwork, that it is ‘highly probable’ that early fifteenth-century painters used stand oil or varnish mixed with a little egg yolk, which resulted in a medium that ‘will paint out nicely, leaving firm, crisp strokes which do not flow’, unlike varnish alone [47, p. 189]. He also felt that the brilliance of color could be attributed to the execution of paintings in thin layers, which, although they may yellow and become more transparent over time, would still retain their color due to the brilliant white ground [47, pp. 146–147].

In an article from 1934 published in the early conservation journal, Technical Studies in the Field of the Fine Arts, Laurie again changed his position on the medium used by Van Eyck due to his research into the properties and use of stand oil proposed by Eibner several years earlier [45, 48]. He noted that stand oil, partially polymerized in the absence of oxygen, flows less than many other oils and that it has a greater degree of resistance to yellowing and cracking, and forms a smooth glossy surface upon drying. Laurie became convinced that it, alone, was the probable medium. Vasari’s statement that the work required no varnish was also cited by Laurie in support of the use of stand oil in these early years of Netherlandish painting. Laurie also believed that as a taste for freer brushwork developed in the sixteenth century, stand oil was replaced by raw oil, which allowed a more fluid application of paint.

Doerner
Max Doerner, a professor at the Academy of Fine Arts in Munich, published Malmaterial und seine Verwendung im Bilde in 1921, based on his researches into painting technique and supplemented by his practical experience as an artist [1]. Like many other writers on the subject, Doerner was concerned that a basic understanding of the history and properties of materials had been lost to the detriment of contemporary painting technique. In his discussion of the techniques of the Old Masters, he used the example of Van Eyck to explain what he called the
‘mixed technique’, a layering of tempera and oil, which was clearly influenced by his reading of Ernst Berger’s research. He argued that Van Eyck, through a rational approach toward his materials, would have exploited the precision and fast drying of tempera and the ability to glaze and blend with oil [1, pp. 333–334]. For the tempera vehicle he posited that Van Eyck used an emulsion of egg with an oil varnish, which could be thinned with water when combined. He believed that the oil medium was sun-thickened with the addition of either a soft resin like mastic or a balsam like Venice turpentine [1, pp. 331–332]. Modeling derived from white tempera painted into a colored oil imprimatura while still wet and color was to be added with resins oil glazes. This process of layering was to be repeated until the desired effect was achieved.

To address the continued popularity of Doerner’s book, in 1968 Helmut Ruhemann, Consultant Restorer for the National Gallery in London, commented on Doerner’s method, stating that the earlier writer ‘...based his suppositions regarding the techniques of the masters chiefly on the methods he himself and his pupils used in their copies; when they obtained effects which they found similar to the originals, they concluded that they had hit on the actual material and process used by the master’ [49, p. 357]. Ruhemann observed that the copy test is not a reliable way to understand technique, particularly because one is forced to simulate the properties of paint that it acquires through its age, as did Doerner by the admixture of resin to the medium. He noted that much of the work of Doerner’s students was in poor condition after only forty years.

The Artist’s Handbook of Materials and Techniques by Ralph Mayer, perhaps the best-known and still most often consulted books on art technique in America, supported Doerner’s hypothesis when it was first published in 1940 [50]. Mayer referred to the differences in opinion between Laurie, Doerner and Eibner, but noted that ‘they are based on more solid factual foundations than were possible a generation ago’ [50, p. 23]. Although numerous revisions have been made to the text, the most recent edition (1991) still propagates the mixed technique by stating that early Netherlandish paintings ‘were produced by employing alternating coats of tempera and oily or resins mediums’ [50, p. 16].

Maroger

Like Doerner, Jacques Maroger, a painter and conservator at the Louvre and later professor at the Arts Students League and the Maryland Institute of Art, had an enormous impact on contemporary artistic practice, counting Reginald Marsh, Raoul Dufy and Roger Fry among his champions. His Eyckian medium, which he described in 1932 in Musement [51], consisted of linseed oil heated with calcined bone, litharge, other driers and resin, and this resinous oil was then mixed with gum arabic or hide glue to form an emulsion, to which drops of water could be added to modify the consistency. This complicated recipe reputedly increased the brilliance and drying speed of oil paint.

A decade later Maroger wrote an article in a popular arts magazine entitled, ‘The secret of Van Eyck regained’, in which he stated that ‘decidedly the material discovered by Van Eyck for oil painting is an emulsion of water with gum arabic and of resins oil’ [52, p. 222]. After receiving inquiries for the details of the recipe, the magazine printed ‘How to make the Maroger medium’ several months later [53]. By this time he had modified his earlier medium and instructed that dammar and linseed oil were to be melted together over heat and whipped with gum arabic after cooling to create an emulsion. Dry pigments were to be ground separately with ‘black oil’ consisting of white lead mixed with linseed oil. Thus prepared, the paints were to be diluted with either more black oil or the emulsion, depending on the desired effect. As he explained: ‘The emulsion gives transparency to the color; the black oil is the dryer and gives precision’ [53, p. 40].

Frederic Taubes, an American artist who wrote numerous handbooks on painting techniques himself, responded negatively to Maroger’s article and mentioned a demonstration of the medium by Maroger that he had witnessed [54]. In addition to questioning the historical accuracy of Maroger’s conclusions, he cast doubt on the long-term stability of the method due to the high proportion of lead drier contained in the mixture, which is liable to weaken the film. He also believed that the high proportion of dammar and gum arabic was unsound and that ‘Mr. Maroger’s formula, no matter how well it handles, will not insure permanence in a painting’ [54, p. 298].

In his 1948 book The Secret Methods and Materials of the Old Masters, Maroger’s recipe for the emulsion changed to one part egg yolk, one part boiled oil and turpentine, and two parts water [55]. He called the boiled oil the ‘basis of [Van Eyck’s] discovery [and] was essentially the same as our stand oil today’ [55, p. 149]. The emulsion was to be painted in a tempera technique of small hatching strokes into a ‘couch’ of boiled oil and turpentine, which would be applied only to the areas to be worked on that day, much like a giornata in fresco. The painted areas were then blended with a dry brush ‘fusing them with the oily varnish’ [55, p. 152]. The finished picture would be given a coat of the boiled oil and turpentine varnish to even out the gloss. Maroger did not give a reason for his change of mind, but perhaps it was prompted by Taubes’ criticism, since the lead drier, gum arabic and dammar were all excluded from the recipe. It is interesting to note that some of Maroger’s mediums, including his Black Oil are still commercially available.

Ruhemann

Throughout the 1930s, there was an ongoing debate about Van Eyck’s painting technique in the art magazine Technische Mitteilungen für Malerei published in Munich by the German Society for the Promotion of Rational Painting Techniques. Maroger’s hypothesis received much attention, as did the writings of the German scientist Walther Ruhemann [56]. His experiments with emulsions led him to see flaws in Berger’s hypothesis, observing that paints made with a high proportion of an aqueous component were less durable than those with a larger percentage of oil. He also differed from Maroger in believing that the emulsified medium was the primary binder, rather than an additive to pigments ground in oil. Ruhemann described the properties of numerous aqueous
materials emulsified with oil and noted that the gum water in oil emulsion produced a paint of superior consistency. Ruhrmann’s recipe was composed of one part gum arabic in three parts water, added to four to six parts oil and then heated in a water bath to produce a finely divided emulsion.

**Other hypotheses**

In 1909, Sir C.J. Holmes, artist and director of the National Portrait Gallery, wrote that the key to Van Eyck’s process was the lightening of the oil medium by exposure of the painting to the sun ‘not so much to dry the pigment, as to extract the excess of oil, which otherwise would have accumulated near the surface...and would have given the work a yellowish tone’ [57, p. 195]. He noted that this process created a beautiful enamel-like quality and ‘one is tempted to wonder whether the medium of the Van Eyck’s contained any varnish at all, and whether their results were not produced simply with linseed oil and sunshine’ [57, p. 196]. Although his book was entitled *Notes on the Science of Picture Making*, Holmes’s knowledge of the ‘drying’ of oil was lacking, as he was unaware that the solidification of paint is a result of polymerization rather than evaporation.

Another curious view was put forth by Joseph van der Veken, a painter, forger and restorer who believed that Van Eyck did not use oil at all and that the precision of his work could only be achieved by using an egg white medium blended with a badger hair brush [58]. He arrived at these conclusions both through his restoration of several of Van Eyck’s paintings, including the *The Madonna of Canon van der Paele* (Bruges) as well as by his painting of the copy of *The Just Judges* to replace the stolen panel of the Ghent altarpiece. This view was maintained by Leo Puyvelde, the Director of the Royal Museums in Brussels, in his 1956 monograph on the brothers Van Eyck, despite the fact that medium analysis of samples from the Ghent altarpiece at the beginning of the decade had finally established that oil was the primary component of the medium [59, p. 7].

**The modern era of conservation science**

One could object, in fact, that all the theoretical deductions or the most evidential historical considerations are only small things compared to a direct examination of the material constitution of the paintings of Jean van Eyck by micro-chemical analysis, which alone could answer the question in a definitive manner and without doubt.4

Alexander Zilory, 1947 [7, p. 171]

**The Ghent altarpiece**

In 1950–51, the Central Laboratory of the Belgian Museums under the direction of Paul Coremans undertook the conservation of the Ghent altarpiece. The resulting study, which was the first in-depth technical analysis of a large painted work done in conjunction with a full-scale restoration, produced both a book devoted to the scientific analysis of a single art object as well as an article in the newly established journal, *Studies in Conservation* [2, 60]. The importance of this research is reflected by J.R.J. van Asperen de Boer’s later characterization of this project as ‘a milestone in the history of the examination of works of art. It still stands as the model of a conscientious scientific restoration coupled with a penetrating, careful and intelligent examination’ [61, p. 143].

Scientific analysis of the paint structure through cross-sections, microchemical tests, X-radiographs and ultraviolet light was viewed by the laboratory both as an essential tool to yield information for the treatment of the panels, as well as a method to gain valuable information on how the paintings were made. Of course, the chance to characterize the medium was of intense interest. Solubility tests and staining for proteins allowed the general categorization of the media but not of lesser components [2, p. 20]. It was found through microchemical analysis that Van Eyck’s medium was primarily drying oil with the addition of variable quantities of ‘x’, which was possibly a natural resin but could not be identified by the tools available at the time [2, pp. 70–71, 99; 60, p. 150]. It was discovered that the final ultramarine layers were executed in an aqueous medium rather than oil, and was suggested that this choice was made by the artist in order to retain the bright and pure color of the ultramarine, as well as to allow the pigment to be used more economically than if ground in oil. The brilliant greens were achieved with a glaze of ‘copper resinate’ (now more accurately referred to

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4 On pourrait objecter, en effet, que toutes les déductions théoriques ou les considérations historiques les plus probantes ne sont que peu de chose auprès d’un examen direct de la constitution du véhicule des tableaux de Jean Van Eyck au moyen d’une analyse microchimique, qui seule pourrait trancher la question d’une façon définitive de sans appel.

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as a copper green glaze) applied over lower layers of malachite and yellow lake, although the presence of malachite has since been disproved by later studies [62, p. 33]. Cross-sections showed a complex layering system calculated to achieve specific effects.

Perhaps the first popular publication to include the new findings on Van Eyck's technique was Frederic Taubes' *Mastery of Oil Painting* from 1953 [63]. Although Coremans had only speculated that 'x' was a natural resin, Taubes used the study to bolster his own view: 'Backed by results of an unsailable scientific examination, we are thus obliged to accept oil and a hard resin as the only medium employed by van Eyck' [63, pp. 22, 27]. Since 1946, Taubes had marketed his 'Taubes Copal Painting Medium' manufactured by Permanent Pigments, which he said 'produces an oil color comparable to that seen on early Flemish paintings' [63, p. 157].

**Emulsions revisited**

Although Coremans did not find any evidence of an emulsion in the samples taken from the Ghent altarpiece [2, p. 76] two decades later the emulsion theory would gain force once again. In 1973 Leopold Kockaert, a scientist at the Royal Institute for Cultural Heritage (formerly the Central Laboratory), reported that bubbles of unpigmented translucent material were visible in a cross-section taken from the light yellow of a garment in the central panel of the Ghent altarpiece [64]. Microchemical and staining tests seemed to indicate the presence of a proteinaceous material in the oil. Kockaert noted that this would give the paint a mayonnaise-like consistency and allow fine detail and good handling properties. In the results of staining tests taken from three paintings by Van Eyck published several years later, he stated that Van Eyck seemed to paint with three different types of mediums, depending on the purpose: in egg for the pure blues, in an emulsion of drying oil and protein (egg in some areas and gelatin in the yellow highlights) and in oil with resin in the glazes [65, p. 124].

Kockaert's work was widely accepted and Brinkman's book, in fact, discusses at length the use of an oil emulsion by Van Eyck [6, pp. 177–186]. However, analysis done in the following decades by other institutions has failed to find evidence of a proteinaceous component in areas other than ultramarine blue [25, 66]. A 1993 paper by E. Melanie Gifford et al. focuses on the medium analysis of pre-Eyckian works and underscores the potential for false-positive results in biological staining techniques – such as through interactions between acidic stain formulations and lumps of carbonate pigments [67]. It also highlights the necessity for cautious interpretation of results that have been obtained by different but complementary methods. Moreover, the recent work by Jaap Boon and his colleagues at MOLART (the Dutch project on Molecular Aspects of Ageing in Painted Works of Art) as well as the Scientific Department at the National Gallery in London has upset Kockaert's supposition by demonstrating that these 'bubbles' are not evidence of emulsions at all but are aggregates of lead soaps that form as paint ages under certain conditions [68, 69].

**Conclusion**

With complementary instrumental techniques, like Fourier transform infrared (FTIR) microscopy and gas chromatography/mass spectrometry (GC/MS), analysis has become far more sensitive and able to characterize individual constituents of the binding media. For instance, in the mid 1990s researchers in the National Gallery of Art in Washington, D.C. identified linseed oil with a possible addition of a diterpenoid resin using GC/MS on a sample taken from the architecture in the *Annunciation* [66] and although the medium in two other samples was too degraded for the fatty-acid ratios to be identified, a diterpenoid resin was also found in the green glaze from Gabriel's cloak. The possibility of an aqueous glaze on the Virgin's blue mantle was also investigated. Due to the poor preservation of the final layer, no protein was detected in any blue sample using high performance liquid chromatography (HPLC). However, the close correspondence to the layering system found by Coremans et al. in the Ghent altarpiece as well as a positive biological stain for protein (Ponceau S) have led Gifford et al. to conclude that the final layer of blue glaze was bound in a water-based proteinaceous medium [66]. More recently for the 1998 symposium at the National Gallery in London that explored the current state of technical and historical scholarship on Van Eyck, Raymond White summarized the findings from the *Arnolfini Double Portrait* and the *Portrait of a Man* [25, 70]. He found that although some of Van Eyck's contemporaries employed egg tempera layers under oil ones, the use of aqueous binders or emulsions could not be detected in the Van Eyck portraits in their collection. Instead, the simplicity of Van Eyck's technique is borne out by the finding that the medium in these paintings is linseed oil alone, either raw or heat pre-polymerized, sometimes with the addition of a little pine resin [25, p. 104; 26, p. 53].

Since the late-eighteenth century, investigations into Jan van Eyck's technique have been a means to define and comprehend his artistic mastery. The desire to find a more durable medium for modern-day use, a curiosity about the early history of oil painting, an interest in applying scientific experimentation and reasoning to the question and, finally, the desire for a 'secret' medium to enable the imitation of the colors and brushwork have each motivated enquiries and hypotheses about the constituents involved. Each investigation has been grounded in its moment in time, both in its response to earlier and contemporary theories, as well as to the artistic climate. The resinous oil theories of Mérimeé and Eastlake grew out of, and then fed, the artistic popularity of resins in the nineteenth century. Similarly, the emulsions of Berger and Laurie and the complex layering systems of Doerner and Maroger were deeply connected to the growing scientific understanding of materials and to the advent of modern painting. Conservation science, beginning with the analysis of the Ghent altarpiece in the early 1950s, has allowed for the confirmation in substantive terms of what some early authors had already recognized through their own analyses of treatises and close examination of paintings – namely, that Van Eyck used materials that were widely available and achieved his effects through a thorough understanding of materials and their optical properties, as well as a deliberate, yet
simple, system of application. In 2000 White attributed Van Eyck’s genius to his ‘acute power of observation of the subtle nuances and interplay of light, shade and tone, coupled with a gift for recreating them...’ [25, p. 104]. A century and a half earlier, Eastlake stated that Van Eyck ‘was endowed with an extraordinary capacity for seeing nature...The same mind that was capable of receiving such impressions was also likely to devise suitable means to embody them’ [20, I, p. 267]. This conclusion is strikingly similar to that of Raymond White and serves as a reminder of the way that earlier research can still resonate today.

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