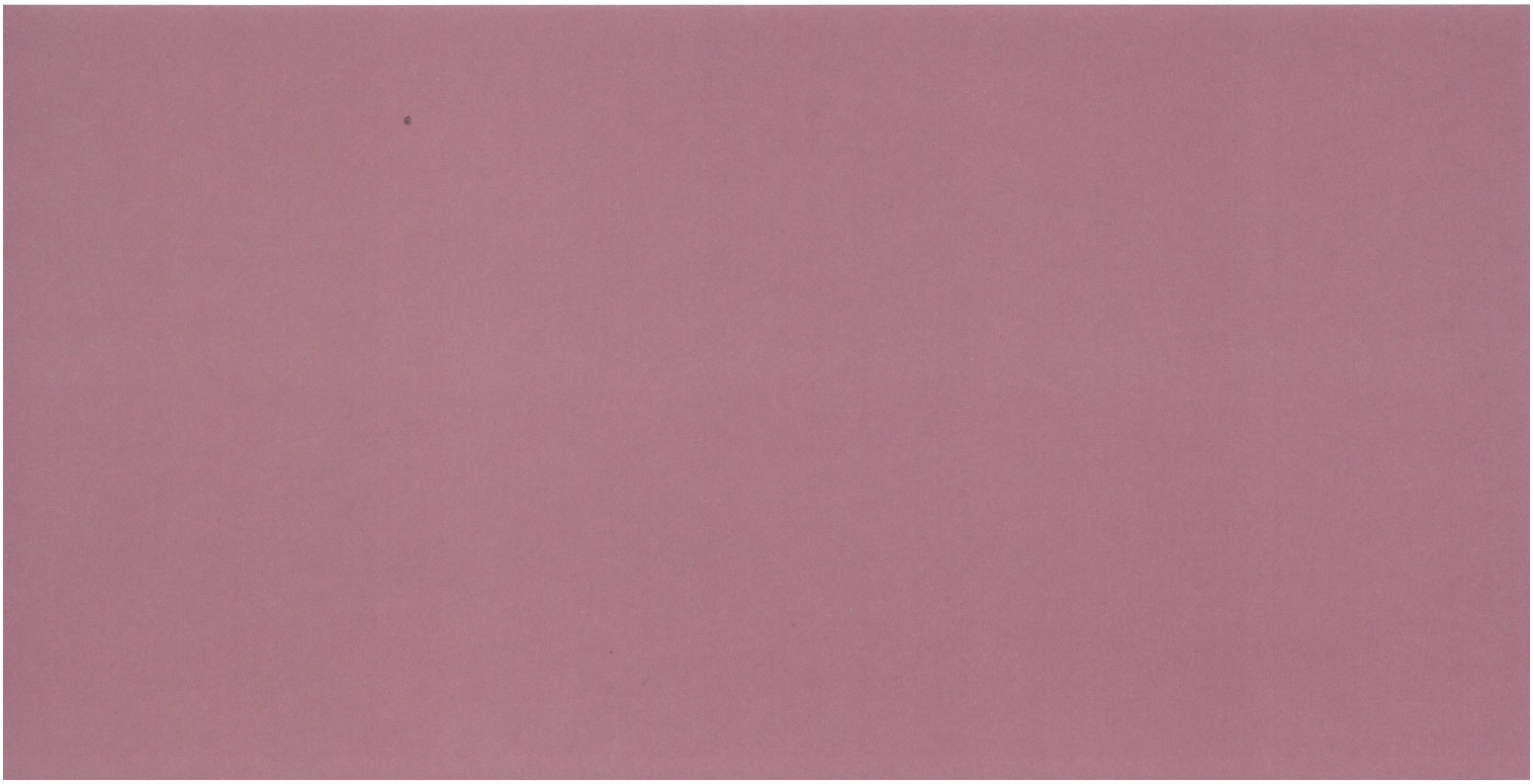
Zeitschrift: Kunstmaterial
Herausgeber: Schweizerisches Institut für Kunstwissenschaft
Band: 4 (2017)

Artikel: Tempera: on the history of a technical term
Autor: Reinkowski-Häfner, Eva
DOI: https://doi.org/10.5169/seals-882597

Tempera: on the history of a technical term

Eva Reinkowski-Häfner



INTRODUCTION

This contribution examines the historiography of the term 'tempera' – from medieval usage to the present day – in order to establish a context for the study of tempera painting in the 19th century. An earlier article by the present author on the development of how the term 'tempera', in German, came to signify 'emulsion' (Reinkowski-Häfner 1994), here is summarised and supported with references to recent research. Therein, the point of departure for the investigation was to examine why only mixtures of aqueous and oleaginous binding media were characterised as 'tempera' recipes in the sixth edition (1938) of *Malmaterial und seine Verwendung im Bilde* (*Painting Materials and their Use in Pictures*) by Max Doerner (1870–1939), even though in documentary sources before 1800, such mixtures were rarely described as 'tempera'. I concluded that the modern use of the term 'tempera' in German (its use is not consistent across the European languages), as designating an emulsion, developed in the 19th century and was firmly established in the 20th century.

The prominent German scholars of painting technique, Max Doerner, Kurt Wehlte (1897–1973) and Hermann Kühn (b. 1932), have all defined tempera as an emulsion. By 1938, both the oil-in-water and the water-in-oil (or 'inverse') emulsion systems were included in this definition. Kühn assumed that it would be possible to create oil-in-water and water-in-oil emulsions by inverting the mixing ratios and, in the case of mixtures containing egg, to employ the lecithin contained in egg yolk both as a water-soluble and a liposoluble emulsifying agent (Doerner edn 1938, pp. 173–178; Wehlte 1967, p. 601; Kühn 1981, pp. 46–47; Kühn 1984, pp. 47–48). However, egg, egg yolk, glues, casein and gums work as water-soluble emulsifiers and therefore they are only able to create oil-in-water emulsions. Water-in-oil (i.e. inverse) emulsions, by contrast, require a liposoluble emulsifier, which needs to be produced for instance by enzymatic processes or through saponification (Vilgis 2013; Dietemann *et al.* 2014, pp. 35–37, 41; Reinkowski-Häfner 2014, pp. 340–341). A high oil content in an egg yolk/oil emulsion does not result in a phase inversion – it is still possible to paint with the emulsion using water as the solvent – but in an altered consistency and different flow properties; a more or less fluid or viscous paint can be made depending on the amount of oil added. Inverse emulsions can only be thinned with oil, turpentine or varnishes, but give rise to thixotropic paints, which can be applied in heavy impasto (Dietemann *et al.* 2014, p. 31; Reinkowski-Häfner 2014, pp. 174–182).

Although inverse and water-miscible emulsions needed different solvents, they were classified as tempera systems by the above-mentioned scholars because they contained both aqueous and oleaginous binding media. Until now, this rigid application of the definition has been the primary meaning of 'tempera' in use in German-speaking countries. Well into the second half of the 20th century, following the definition in the art-technical sources from the Middle Ages until 1800, in other European languages the term 'tempera' was employed to designate all types of water-based binding media. For instance, in the 1950 edition of the *Encyclopedia Britannica*, tempera is described as 'albuminous, gelatinous or colloidal material other than oil' (*Encyclopedia Britannica* 1950; Reinkowski-Häfner 2012, pp. 32–34). In more recent English technical literature, however, the meaning of tempera may also be extended to encompass water-based emulsions (Mayer 1991, pp. 266–267; *New Encyclopaedia Britannica* 2007).

In view of this historical development, the definition of tempera as any emulsion that is currently prevalent in the German language requires reassessment on the basis of historical sources and painterly practice. A recent re-evaluation of the definition of tempera from a chemical point of view, undertaken by the Doerner Institut in Munich, has revealed that tempera media should not be described as emulsions, but rather as colloidal systems (Dietemann *et al.* 2014).

THE TERM 'TEMPERA' AS USED IN TEXTUAL SOURCES BEFORE 1800

My earlier article of 1994 included a list that compiled examples of the usage of the term 'tempera' in textual

sources on painting technique dating before 1800 (Reinkowski-Häfner 1994, pp. 298–299). It also took into account the variations *temperatio, temperare, distemperare* (Latin), *Temperaturwasser* (German), distemper (English) and *détrempe* (French), and named the substances and mixtures they signified. The list reveals that until well into the 16th century, 'tempera' was used as a general term for 'binding medium', i.e. it was also used for oil paints or other non-aqueous systems (Biondo 1549, p. 20). Cennino Cennini's *Trattato della pittura*, a text that meticulously describes Italian tempera painting technique as practised in the 14th century, mentions egg yolk as a binding medium suitable for painting on panels, walls and iron objects, as well as a component in a medium for mural painting comprised of both egg yolk and egg white mixed with fig sap. Fig sap has often been called fig 'milk' due to its resemblance to the same when fresh; it is technically a latex, which becomes thick and rubbery as it dries on contact with air. In the introduction to his book, *Le vite de' più eccellenti pittori scultori e architettori*, the painter and writer Giorgio Vasari (1511–1574) made a distinction between '*dipingere a uovo*' (to paint with 'egg colour' or 'egg paint') and '*a tempera*', the latter being a mixture of the entire egg and fig latex (Cennini c. 1390/edn 2011, pp. 120–122; Vasari 1550, 1568/edn 1966–1987, vol. 1 [1966], pp. 130–132; Burns 2011). In many 16th-century texts, painting with egg-based binders was already described as the painting technique of the 'Old Masters'; in other words, as a form of historical painting that was common before the advent of oil painting. As of the 17th century, the terms *tempera* and *détrempe* not only denoted binding media based on egg but primarily those based on glues and gums; in other words, water-soluble substances that were discussed mainly within the context of decorative painting and wall painting in the painters' handbooks of the following century. In these 18th-century sources, egg-based media (especially those containing egg white) were associated only with the painting techniques of the 'primitive' painters, that is, according to Vasari, those working in the period before Jan van Eyck (1390–1441) who allegedly revolutionised European painting with the introduction of the oil-based media he had invented (Reinkowski-Häfner 1994, pp. 298–299).

In his important publication of 1847, originally titled *Materials for a History of Oil Painting*, the English painter (later keeper of the National Gallery, London), Charles Lock Eastlake (1793–1865), summarised the historical development of the term 'tempera': in its most general sense, 'tempera' could simply mean 'binding medium' or it could be used in a more limited manner to encompass aqueous binding media; in its most restrictive form, it may have designated binding media made specifically of egg yolk or whole egg mixed with fresh fig sap (Eastlake 1847, pp. 100–101).

References to emulsions, i.e. mixtures of aqueous and oleaginous binding media, can be found predominantly in source texts within the context of specific recipes (not often those for paints per se), such as gilders' mordants, glazes to be applied over metal leaf and coatings (Berger 1897, pp. 14–15, 243). Mixtures of aqueous and non-aqueous binding media were recommended for the execution of the actual painting (for paint) only in exceptional cases. In the Le Bègue Manuscript can be found reference to *yaue conosite*, a wax soap mixed with glue, while Vasari (1568) provided an account of a mixture of egg and *vernice liquida* (liquid varnish), which the painter Alesso Baldovinetti supposedly used for secco retouchings on wall paintings (Vasari 1550, 1568/edn 1966–1987, vol. 3 [1971], p. 314; Merrifield 1849/edn 1967, pp. 306–309; Reinkowski-Häfner 2014, pp. 345–352). Recent research into historical painting techniques has shown that admixtures of oils to aqueous binding media for paint may be identified by analysis as early as the 12th century (Lanterna *et al.* 2002, p. 162; Thieme 2007, pp. 112, 118; Reinkowski-Häfner 2014, pp. 20–21).

THE INVESTIGATION OF TEMPERA PAINTING BY ART HISTORIANS, RESTORERS, SCIENTISTS AND PAINTERS

As mentioned at the outset, the understanding of tempera as an emulsion developed in the 19th century within the context of historicism and the interest in painting of the antique and medieval periods. Initially, antique

tempera technology was discussed primarily in relation to mural techniques (*Le pitture antiche* 1757–1779, vol. 1 [1757], pp. 273–277), while in contrast, as early as the end of the 18th century, the growing interest in medieval painting focused on the visual appearance of historical tempera in the context of easel painting (Schlesinger 1828; Fastert 2000, pp. 231–322). In newly formed collections such as those of the Boisserée brothers in Heidelberg and that established for the Royal Museum in Berlin beginning in 1822 (which opened to the public in 1830), medieval paintings provided a basis for scientific and scholarly research (Vogtherr 1997, pp. 178–213; Heckmann 2003, pp. 78–99; Reinkowski-Häfner 1994, p. 301; Reinkowski-Häfner 2014, pp. 24–26).

The investigation of tempera painting by art historians

Due to the availability of these collections, for the first time art historians began to apply a historical-critical method to the investigation of medieval painting. This involved critical examination of sources as well as stylistic evaluation and comparisons of the works of art based on connoisseurship. As part of the formal assessment of a work, the build-up of its paint layers was also studied. For this, criteria were employed that had been developed in interdisciplinary collaboration with restorers, and the results of material analyses were taken into account. The art historians Gustav F. Waagen (1794–1868) – with his book *Über Hubert und Johann van Eyck* (1822) – and Carl F. von Rumohr (1785–1843) – with *Italienische Forschungen* (1827 and 1831) – were the leading figures in the burgeoning historical-critical movement, focusing particularly on early German, Dutch and Italian art (Waagen 1822; Rumohr 1827–1831/edn 1920; Bickendorf 1995; Bickendorf 2004, pp. 29–44; Bredekamp and Labuda 2010). Although they were familiar with Cennino Cennini's treatise due to its publication in 1821 by the archaeologist and art critic Giuseppe Tambroni (1773–1824) (Cennini c. 1390/edn 1821), they did not consider it in the context of tempera painting. Instead, their understanding of tempera was based on Vasari's account of the history of oil painting technique, or rather its German translation/adaptation in 1675 authored by the painter and writer Joachim von Sandrart (1606–1688). From his reading of the original work by Vasari, Waagen concluded that in Italy, from the middle of the 13th century until the end of the 15th, the binding medium for tempera painting had been diluted egg yolk mixed with parchment size (Waagen 1822, p. 89). In contrast, Rumohr adhered to the German version of Sandrart, which indicated that early Italian painters (including those of Giotto's era) had ground their colours with the '*Milch unreifer Feigen und anderen minder öligen Leimen*' ('with the latex of unripe figs and [with] other less oleaginous glues'), thus achieving fluid paint application and bright coloration. According to Rumohr, this painterly tradition had been interrupted due to the influence of Greek painters, who preferred the use of wax-based media, resulting in a darker and more greenish coloration (Sandrart 1675, p. 66; Rumohr 1827–1831/edn 1920, pp. 196, 209–215, 247, 254, 265–266). The latter conclusion was based on the interpretation of analyses the Italian chemist Giuseppe Branchi (1766–1847) had conducted on paintings from Pisa dating between 1230 and 1360, which had 'confirmed' (Branchi believed) the use of wax. Rumohr did not recognise the green underpainting present in the works as the probable cause of the greenish coloration (Morrona 1792, pp. 158–166; Reinkowski-Häfner 1994, pp. 301–302; Reinkowski-Häfner 2014, pp. 33–37).

The appraisal of early painting in the North presented yet more difficulties. Vasari's claims regarding the tempera painting technique employed by Van Eyck and his (alleged) invention of oil painting were given credence despite the evidence provided by a series of publications which included chemical analyses of a number of medieval works that indicated a much earlier history for the use of oil paint (Vasari 1550, 1568/edn 1966–1987, vol. 3 [1971], pp. 301–303; Nadolny 2005). Because of these beliefs in the veracity of Vasari's account, many of the 19th-century scholars who researched painting technique did not recognise the early medieval use of oil paint in Northern Europe. Instead, they explained the

discrepancy between the appearance of early northern oil paintings and Vasari's version of events by interpreting their blended transitions as the result of a specific form of tempera painting which relied upon a special binding medium that allowed blending. Eastlake assumed that a diluent, such as honey, beer or wine, had been added to the aqueous medium (Eastlake 1847, pp. 109–112; Reinkowski-Häfner 2012, pp. 13–14).

The question of Van Eyck's technique also influenced the study of tempera. The truth of Vasari's story concerning the invention of oil painting by Jan van Eyck in the year 1410 was questioned in the literature for the first time in 1774. In that year, Gotthold Ephraim Lessing (1729–1781) published *Vom Alter der Ölmalerei* (*On the Age of Oil Painting*), a discussion of the early history of oil painting. To support his argument, he included a partial transcription of the *Schedula diversarum artium*,[1] a manuscript on the arts that includes a section on painting technique, compiled by 'Theophilus Presbyter', which Lessing believed to be a work of the 9th century. He called attention to its description of oil for painting, dating to a time long before the birth of Van Eyck. His publication, and slightly later the first edition of the *Schedula* in 1781, initiated a discussion of Van Eyck's binding medium and the age of oil painting (Lessing 1774/edn 1877; *Schedula* 12th C./edn 1781; Scholtka 1992). In citing the work of 'Theophilus', Lessing had made a compelling argument: it now seemed to many that some form of oil painting had to have been in use in the early Middle Ages, although not necessarily 'pure' oil painting proper (Lessing 1774/edn 1877, p. 432). Some scholars suggested that mixed systems might have been used; for instance in early painting from Cologne, it was posited that oil was employed in the uppermost paint layers (over tempera underpainting) or as part of a mixed media of oil paint with an added aqueous component (Boisserée 1862, vol. 1, pp. 101–102; Reinkowski-Häfner 1994, p. 301; Reinkowski-Häfner 2014, pp. 31–33, 37–42).[2]

The practice of adding aqueous media to oil paints, which was intended to result in better drying properties and a wider range of paint consistency, was already in use and certainly in the late 18th century. For instance, the clergyman Johann Caspar Lavater (1741–1801), whose circle experimented with various techniques, believed that by mixing watercolours with oil, or with oil paints, he might surpass the technique of the great Dutch master Rembrandt. This formulation, which corresponded to the definition of a tempera later developed by Doerner (Doerner edn 1938, pp. 173–178), was nevertheless described as oil paint (Meusel 1788). In 1832, the possibility of mixing oleaginous and aqueous media and thereby reducing the amount of oil used was also suggested by the Halberstadt apothecary Friedrich Lucanus (1793–1872), who believed that such a mixture would combine the advantages of both media (Lucanus 1832a; Timm 1984; Reinkowski-Häfner 1994, p. 301).[3]

In the early 19th century, none of these mixed media comprising both oleaginous and aqueous components were ever called temperas; rather, they were referred to as oil paints. As no emulsifiers were used in such formulations, they were indeed essentially modified oil paints and the modifications resulted in different viscosities and drying properties from those of pure oil colours. Commonly, such paints were used to imitate the technique of early Netherlandish and German masters. For example, in 1815 the painter and gallery director Johann Georg von Dillis (1759–1841) suggested that an oil paint with a glue component was the binding medium commonly used by the early Netherlandish school (Boisserée 1862, vol. 2, pp. 82–84; Reinkowski-Häfner 2014, pp. 124–125, 174–182). As will become evident, doubts concerning the introduction of oil painting by Van Eyck fundamentally influenced the historical study of tempera and ensured that the search for an explanation for the specific quality of Van Eyck's painting technique continued until well into the 20th century.

The investigation of tempera painting by restorers and scientists

Restorers and scientists also tried to determine what materials were used in tempera painting. The painters and restorers Christian Koester (1784–1851) and Jakob

Schlesinger (1792–1855), both of whom worked at the Boisserée collection and at the Royal Museum in Berlin, investigated the technique of Italian tempera painting using original works as well as Cennini's treatise. In the second volume of Koester's *Ueber Restauration alter Oelgemälde* (*On the Restoration of Old Oil Paintings*) published in 1828, an article by Schlesinger 'Ueber Tempera-Bilder und deren Restauration' ('On tempera paintings and their restoration') described the build-up of the paint layers in early Italian painting as several tempera layers followed by the application of glazes. Schlesinger's essay offers a description of Italian tempera painting that remains valid until this day. Both restorers employed egg-bound paints for retouching, as they saw restoration as a reconstruction of the original painting as regards layer build-up, material and surface appearance. They indicated that their tempera binding medium was egg yolk, which had been diluted with a little vinegar. As for the whites, they believed that the Old Masters had ground them with a refined glue. Their own retouching of such works could be finished with a glaze in oil (Koester 1827–1830, vol. 1, pp. 25–27; Schlesinger 1828, pp. 35–42; Schießl 1990, pp. 107–111; Rudi 1999, pp. 126–132; Perusini 2012, pp. 165–169; Stehr 2012, pp. 103–119).

By the 19th century, organic chemistry was beginning to develop and chemists felt increasingly confident in their ability to identify organic components, an optimism which also extended to attempts to analyse historical paint media (John 1814; John 1836). This led to the increasing use of chemical acumen and materials analysis in the investigation of painting technique over the course of the 19th century. Today however, looking back on these early studies, it is clear just how technically constrained 19th-century scientists were and how clearly their results were coloured by their expectations, as analytical organic chemistry was still in its infancy and historical paint media present a particularly difficult challenge to analysts (Nadolny 2003; Bensi 2013). In addition to the chemical analysis of a tempera painting published by Branchi, the analyses by the painter and Heidelberg University drawing professor Jacob Roux (1771–1830) (who had earlier trained in the sciences) and the pharmacist and analytical chemist Philipp Lorenz Geiger (1785–1836) were of great significance at the time. These were conducted on paintings from the Perugino era and were published in the second volume of *Die Farben* (*The Colours*) in 1828. With the results of Sandrart's description together with Geiger's analysis and his own experiments, Roux was convinced that they had effectively 'proven' that in Perugino's time artists were painting in a tempera consisting of a 'resin'-based (fig sap) binding medium that had been rendered water-miscible by means of mixing with egg yolk.

From Sandrart's description of tempera, Roux concluded that the medium consisted mainly of fig sap, which was emulsified with a small amount of egg yolk, ideally in a ratio of three parts fig sap to one part egg (Roux 1828, pp. 10–11). The composition of fig sap was also an important aspect of Roux's theory: in 1827 Geiger and Reimann had published an analysis of this material (republished in Roux 1828), in which they stated that it was primarily a mixture of two resin-like substances, a wax-like portion and a caoutchouc-like one (they had also found 'gum' and 'protein' components). One of these Geiger and Reimann described as very similar to '*Cerin*' which, in the early 19th century, was the material regarded as the main constituent of wax (Geiger and Reimann 1827; Schubarth 1829, p. 625). However, due to the state of organic analysis, Geiger overlooked the importance of the enzyme ficin in fig sap, which plays a significant role in transforming egg white from its natural, highly viscous state to a smooth, fluid liquid when the two are mixed, a property that was first noted only much later by Wilhelm Ostwald in 1930 (Ostwald 1930; Reinkowski-Häfner 2010).

Roux thus forged a connection with the prevalent contemporary understanding of an emulsion as artificially fabricated 'milk' (i.e. an aqueous solution with a 'milky' appearance) such as the aqueous extract of oil seeds or other aqueous liquids containing water-insoluble resins that had been transformed into a water-miscible state through the addition of egg yolk (Zedler 1734). It is therefore purportedly the first attempt to 'scientifically

verify' a reconstruction of historical tempera as an emulsion. In 1832, Friedrich Lucanus repeated Geiger's claim of having confirmed the recipe described in Sandrart's text. He simultaneously referred to Jacques-Nicolas Paillot de Montabert (1771–1849), who in 1829 in his *Traité complet de la peinture* under *'peinture à l'oeuf'* ('egg-based painting') had also proposed the possibility of mixing egg yolk with resins or 'wax oil' (Lucanus 1832b, pp. 135–137; Paillot de Montabert 1829–1851, vol. 8, pp. 600–602 and vol. 9, pp. 449–450).[4]

Based on what they believed the findings of their research showed, Roux and Geiger developed a form of 'synthetic tempera painting' using caoutchouc and copal or mastic resins, emulsified with egg yolk, which were intended to replace fig sap. Caoutchouc was mentioned time and again in texts on 19th-century painting practice, as in Franz Xaver Fernbach's (1793–1851) treatise on encaustic painting in which caoutchouc, as an additive to the binding medium consisting of amber and wax, was meant to function as a retardant to drying (Fernbach 1845, p. 209). A few years later, in 1849, the French painter Casimir Augustin Gay (1784–1855) developed a technique for what he called *'peinture mate monumentale'* ('matt monumental painting') that utilised a binder composed of caoutchouc and olive oil, copal resin, almond oil, wax oil and benzine (Gay 1849, pp. 38–53).

In his book of 1845, *Die endlich entdeckte wahre Maler-Technik des klassischen Alterthums und des Mittelalters* (*The True Painting Technique of Classical Antiquity and the Middle Ages, Finally Discovered*), the drawing teacher Friedrich Knirim (1808–1875), likewise inspired by Geiger's analysis, identified the tempera formulation that he believed had been in use from antiquity until Van Eyck's time: a mixture of fig sap and egg yolk, 'a singular type of watercolour paint containing resin, oil and protein' (*'eine einzige Art von Harz-, Oel- und Eiweißstoff-haltigen Wasserfarben'*). Knirim claimed that it combined the advantages of Van Eyck's supposed resin-oil paints with the merits of watercolour, and could be substituted in modern painting by a mixture of copaiba resin and wax that he had proposed earlier in 1839 (Knirim 1839; Knirim 1845, pp. 73, 97; Reinkowski-Häfner 1994, pp. 302–303; Stehr 2012, pp. 166–169; Reinkowski-Häfner 2014, pp. 64–66, 72–73). Due to Knirim's influence, this medium was chosen for the execution of the wall paintings in the Munich Residenz, such as the *Odysseesäle* (*Odyssey Hall*) (1836–1865) by Johann Georg Hiltensperger (1806–1890) and the first paintings of the *Griechische Landschaften* (*Greek Landscapes*) (1838–1850) by Carl Rottmann (1797–1850) (Rott and Poggendorf 2007; Memmel 2008, pp. 78–82; Kinseher 2014, pp. 27–48).

To summarise, a discussion regarding the composition of historical tempera paints was under way by the beginning of the 19th century. Schlesinger and Waagen had established a specific material definition of the term 'tempera' and had also, based on the texts of Cennini and Vasari, provided a description of how it was used. Equally, new tempera painting methods were introduced through the reinterpretation of historical textual sources.

Interpretation of tempera painting by painters

Painters played a substantial role in the investigation of tempera. Scores of publications on the techniques of the Old Masters and how to make use of them to improve one's own painting bear witness not only to the loss of workshop traditions but also to a new self-image of painters who saw themselves as scholars and who wanted to attain new means of expression in painting (Pietsch 2011; Pietsch 2014). Numerous inventions such as Montabert's and Fernbach's wax painting techniques, as well as stereochromy[5] and casein painting, influenced the practice of wall painting in the 19th century and served to replace fresco techniques. In the context of easel painting, artists were looking for alternatives to oil paints, which they found in formulations based on wax, resin or tempera. Failure to abide by the technical rules of painting and the material composition of oil paint had been identified as the causes of darkening, fading and cracking of modern oil paintings. Equally, the dark tone of works in oil dating from the 17th and 18th centuries no longer accorded with contemporary taste. Painted on

dark grounds, with paints that were far too rich in oil content and composed without regard for painterly rules and proper drying between stages of work, the surfaces of such paintings wrinkled and cracked. Such unwanted alterations stood in stark contrast to the luminous colouring and good condition of the Pompeian wall paintings or the appearance of a freshly cleaned work by Van Eyck (Kinseher 2014, pp. 26–76).

Painters who chose to work in tempera sought a historical and durable binding medium while at the same time seeking to wed the positive characteristics of oil paints (long malleability and depth of colour) to those of watercolours (favourable drying properties and durability).[6] The recipes used often originated from the traditional craft of decorative painting. Artists attempted to define a tempera technique for easel painting while distancing themselves from the less prestigious associations with craftsmanship through the reconstruction and reinterpretation of historical painting techniques (Reinkowski-Häfner 2014, pp. 70–71, 91–96; see also the second article by the author, in this volume).

For instance, the reception of medieval wall painting and its technique manifested itself in the almost slavish orientation of the Nazarenes towards early German, Netherlandish and Italian art, which they sought to imitate, among other things, in fresco. However, by the addition of protein binding media to their fresco colours and by the application of numerous thin, transparent layers both *a fresco* and *a secco*, they attained a high degree of elaboration as well as an approximation of oil painting for their mural works (Reinkowski-Häfner 2014, pp. 80–127). On canvas supports, tempera was used for large wall paintings and in the transposition of the aesthetic of fresco painting into easel painting (Droste 1980, pp. 54, 83–95; see also the contributions by Perusini and Perusini, as well as the second contribution by the author, in this volume).

As of c. 1840, tempera was also used for the underpainting stages in easel paintings, with the intention of replicating the technique of the Venetian Old Masters (Reinkowski-Häfner 2014, pp. 155–157). Arnold Böcklin (1827–1902), the most important proponent of tempera painting in the 19th century, tried to attain the coloration and transparency of early Netherlandish paintings and the appearance of Italian Renaissance works by means of modifying the tempera formulations described by Cennini and in 'Theophilus' (the *Schedula*); he was also inspired by the appearance of antique wall paintings. His binding medium, composed of frankincense and sandarac resin ground into water (Schick 1901, pp. 76–77), may also have been influenced by the writings of Roux (see above). Hans von Marées (1837–1887) and Franz von Lenbach (1836–1904) also believed their method of alternating between layers of tempera and layers of oil to be an adaptation of an antique painting technique or that of Titian.

Mixtures of aqueous and non-aqueous binding media provided painters with a large spectrum of possible paint consistencies with which they could attain varied surface effects. Such tempera formulations were also adopted by later Modernist painters and those belonging to the Neue Sachlichkeit (New Objectivity) movement. They were chosen not only for a durable result or as a quotation of the painting technique of the Old Masters, but also because they facilitated a rapid style of painting with a low degree of elaboration, a bright, matt appearance and a lively surface texture (Lutz 2014; Reinkowski-Häfner 2014, pp. 146–148, 157–173, 202–209; Winkelmeyer 2014; Neugebauer 2016, pp. 423–426; see also the contributions by Beltinger, Neugebauer, as well as the second contribution by the author, in this volume). The appearance of tempera painting and the variation that occurs depends on the material used (for discussion of the same, see the contribution by Neugebauer, in this volume).

THE CONTRIBUTION OF PAINT MANUFACTURERS, THE GERMAN SOCIETY FOR PRPM AND RESEARCHERS AROUND 1900

The paint industry played an important role establishing the definition of tempera as an emulsion. Products were regularly reviewed in the periodical *Technische Mitteilungen für Malerei* (*Technical Communications on*

Painting, abbreviated herein as *TMM*), first published in 1884, which became the mouthpiece of the Munich-based Deutsche Gesellschaft zur Beförderung rationeller Malverfahren (German Society for the Promotion of Rational Painting Methods, abbreviated herein as the German Society for PRPM) in 1886. The principal task this institution had set for itself was to provide quality assurance of painting materials and to analyse the numerous new inventions in the field of pigments and painting. In 1893 the society organised a convention and an exhibition on painting technique in the Munich Glaspalast where many of the commercially available tempera paints were introduced and discussed (Munich 1893; Kongress 1893; Reinkowski-Häfner 1994, p. 304; Kinseher 2014, pp. 18–25, 76–149). Paint manufacturers reinforced the already well-known concept of tempera as an emulsion through their offerings of oleaginous-aqueous tempera mixtures which they produced as thick pastes packaged in tubes. The Berlin decorative painter and paint manufacturer August Wilhelm König criticised this procedure, noting that in the case of casein paints such 'buttery' emulsions could only be obtained by adding ingredients that were detrimental to the beauty and long-term stability of the paints. His own products, therefore, were not sold as ready-to-use paints in tubes but as freshly prepared casein or tempera media with the pigment component packaged separately (König 1897, pp. 11–12, 22).

Presumably inspired by the Austrian art historian Albert Ilg's (1847–1896) translations of Cennini and the *Schedula*, which came out in 1871 and 1874 respectively (Cennini c. 1390/edn 1871; *Schedula* 12th C./edn 1874; Dobslaw 2009, pp. 76–80), from 1875 the Dresden paint manufacturer Hermann Neisch sold an egg-oil tempera paint packaged in tubes (Neisch 1939), and from 1877 the manufacturer Richard Wurm offered an emulsion product as a system with two components, so-called tempera paints in tubes and an attendant vehicle packaged separately, to be mixed with the 'paint' at the time of use (Wurm c. 1900, pp. 8–9).[7] These, presumably the earliest commercially produced tempera products, were joined in 1892 by *Lompeck'sche ächt italienische Temperafarbe* (Lompeck's true Italian tempera paint) from Herz & Co., a company probably owned by August Wilhelm König (Munich 1893, p. 38; König 1893, p. 284; König 1897, p. 16), and in 1893 by Wilhelm Beckmann's *Syntonosfarben* (Syntonos paints) (Kongress 1893, pp. 508–510; *TMM* 1895; Keim 1903, pp. 322–323), which also contained an emulsion as a binding medium.[8] In 1889, Neisch described the tempera of Cimabue's era as a mixture of aqueous substances and vegetable oils that dried to a water-resistant finish that could then be varnished (Neisch 1889; *TMM* 1899). In 1893, the apothecary Ernst Friedlein (1841–1919), who sold a tempera paint with a binding medium consisting of casein and oil (Eibner 1909, p. 271), defined the tempera of the Old Masters as a 'drying emulsion' ('*trocknende Emulsion*') and 'oil milk' in a communication in *TMM* (Friedlein 1893a). Friedlein was invited to lecture on the 'inner essence of the tempera technique' at the *Kongress für Maltechnik* (*Congress on Painting Technology*), organised by the German Society for PRPM, where he stressed once again that for all 'tempera technicians [...] the basis [...] was always an emulsion, i.e. an intimate bonding of a drying oil or wax with a viscous emulsifying substance' (Kongress 1893, pp. 467–468). He distinguished the tempera of the Old Masters from other new tempera products that were 'in fact a form of gouache painting on canvas, impregnated with a resin solution'. He was obviously referring specifically to the Pereira tempera of Baron Alfons von Pereira-Arnstein (1845–1931), which had been patented in 1889 and 1891 (Friedlein 1893a; see also the contribution by Beltinger, in this volume).

Unlike the large majority of paint manufacturers, Baron von Pereira-Arnstein sold a 'tempera' system with multiple components consisting of pigment ground with a 'base' binder and several painting media containing vehicles that could be mixed with the pigment mixtures, all strictly avoiding the use of oil. The resulting paints, which were only weakly bound with a small amount of size, were meant to be painted out in layers, fixed through frequent applications of intermediate varnish and thereby transformed into a form of resin painting (Pereira 1891b, pp. 13–44, 50–51; Pereira 1909, pp. 23–92; see also the contribution by Beltinger, in this volume). In response to

complaints that his system was too complicated (König 1893, pp. 285–288) and that the colour would darken during varnishing (Munich 1893, p. 78), by 1897 at the latest, Pereira had extended his range to include an oil-gum-emulsion, the 'Pereira-Medium-Tempera', which was deplored by his critics as a sign of inconsistency (Linke 1906; Pereira 1909, pp. 73–75, 93–95, 118–119; Linke 1910; Reinkowski-Häfner 1994, pp. 304; Reinkowski-Häfner 2014, pp. 366–370; Kinseher 2014, pp. 65–69; Beltinger *et al.* 2015, pp. 56–58). In 1909, the chemist Alexander Eibner (1862–1935) remarked that Pereira tempera was not a tempera 'in the proper sense of the word', because the binding medium did not contain any oil – only sturgeon glue. Only the 'Pereira-Medium-Tempera', could indeed be classified as such in Eibner's view, since it contained both an aqueous component (gum) and oil (Eibner 1909, p. 266).

Although a wide range of ready-made tempera paints was available, many artists, for example Julius Exter (1863–1939) and the group around Wassily Kandinsky (1866–1944), still experimented with recipes for grinding 'home-made' tempera formulations (Wackernagel 1997; Schwabe 2013a; Schwabe 2013b; see also the contributions by Kinseher and by Neugebauer, in this volume). Many recipes for 'home-made' tempera were discussed in *TMM*; in addition to aqueous and oleaginous components these featured various substances such as honey, sugar, vinegar, sal ammoniac, soap and glycerol. Meanwhile further discussions of the composition of tempera paints sought to resolve the issue of how to guarantee the highest effectiveness in a long-lasting paint layer (Berger 1897, pp. 258–260; Wirth 1900; Trillich 1926; Ostwald 1904, pp. 141–146; Pohlmann 2010a, pp. 92–97).

At the turn of the 19th century, three researchers were of special importance for their roles in promoting the definition of tempera as an emulsion: the painter Ernst Berger who derived his definition of tempera from documentary sources, the painter Max Doerner who arrived at his definition through his painterly experience and by copying Old Masters, and the chemist Alexander Eibner who attempted to bring clarity to the tempera discussion by defining tempera through investigations in the fields of material and natural sciences.

Ernst Berger's views on the 'discovery' of Van Eyck

In his book *Quellen und Technik der Fresko-, Oel- und Temperamalerei des Mittelalters* (*Sources and Technique of Fresco, Oil and Tempera Painting of the Middle Ages*), Ernst Berger made a distinction between tempera 'in the old sense', such as the gum tempera described in the *Schedula* (or also as found in the Pereira temperas), and tempera 'in the new sense', which he defined as an emulsion (Berger 1897, pp. 257–260; Kinseher 2014, pp. 174–230; see also the contribution by Kinseher, in this volume). Berger had interpreted chapter 26 in the *Schedula* as describing the threefold application of a paint bound with gum and the final application of a varnish, as a threefold application of gum-based paint and oil varnish, which is somewhat reminiscent of Pereira's technique (Berger 1897, pp. 52–53; Scholtka 1992, p. 16). According to Berger however, Van Eyck had recognised that, rather than applying separate layers as described in the *Schedula*, the aqueous paint could be mixed with the varnish to create an emulsion in order to achieve good handling properties, a paint that dried more rapidly and with a higher gloss. As Berger interpreted Vasari's description, Van Eyck's invention was not, therefore, oil paint but a conversion of oil into a water-miscible state, i.e. a 'synthetic' emulsion. This emulsion – 'oil tempera' – was better suited for the repeated alternation between (aqueous) paint layers and oil or oil varnish glazes which, according to Berger, had been characteristic of the Eyckian technique. The painting process could then be finished with oil or varnish paints (Berger 1895b, pp. 208–211; Berger 1897, pp. 252–253).

The mixed technique according to Max Doerner

As mentioned earlier, Max Doerner also defined tempera as an emulsion and agreed with Berger's interpretation of Van Eyck's invention. In his book *Malmaterial*

und seine Verwendung im Bilde, a summary of his lectures on painting technique at the Munich Art Academy published in 1921 (Doerner 1921), he introduced the term '*Mischtechnik*' ('mixed technique') for the succession of layered applications of paint and glazes in alternating media. According to Doerner, in the build-up of layers of tempera emulsion and oil or oil varnish glazes, Van Eyck had managed to maximise the advantages of each of the respective binding media. Like Berger he was of the opinion that Van Eyck had improved upon the older manner of tempera painting by inventing an emulsion that allowed for the application of impastoed white tempera highlights in the underpainting stage. Equally, he posited, when the Venetians began to paint on canvas supports, they required a binding medium that had an even smoother, more spreadable consistency and had met this need by mixing tempera paint and oil paint (Doerner edn 1928, pp. 337–338, 350).

While Doerner was interested in reconstructing the techniques of the Old Masters, for him, the authenticity of historical recipes was not of prime importance as long as he was able to find a binding medium that allowed him to attain similar effects to those he was seeking to emulate. He believed that an emulsion was the binding medium best suited for achieving such effects and he 'held the view, that an emulsion is the essential element in tempera' (Doerner 1926, p. 148).

The scientific definition of Alexander Eibner

In his publications of 1906 and 1926, Alexander Eibner, director of the Versuchsanstalt und Auskunftsstelle für Maltechnik (Research Institute and Information Centre for Painting Technology)[9] in Munich, tried to replace the confusing 'art-historical concept' of tempera painting with one that was based upon 'material science, [and] natural science'. His definition of a tempera took egg yolk as its starting point, as it is the earliest known emulsifier to be used for painting (as described by Pliny). According to Eibner, egg yolk is the most stable natural emulsion and is miscible with water, but not water-soluble when dry like glue- and gum-based paints; the latter, he suggested, should be distinguished from tempera paint as watercolour and gouache, respectively. In his PhD dissertation, *Zur Kenntnis der Temperabindemittel* (*Understanding Tempera Binding Media*), which was supervised by Eibner, Heinrich Tittel (1897–1941?) investigated the components of egg yolk, which indicated the role played by lecithin as an emulsifier. Until then it had been suspected that the emulsifier component was vitellin (a phosphoprotein, the major protein in egg yolk). Based on this and his own study of natural egg emulsions and wax emulsions, Eibner suggested that every emulsion used in painting (including synthetic emulsions made from gum and oil) should only consist of three components: the aqueous and oleaginous phases and the emulsifier (Eibner 1906; Eibner 1909, pp. 270–271; Tittel 1925; Eibner 1926).[10]

Water-in-oil emulsions

Despite all the efforts to define the term 'tempera' in a definitive manner made by these various scholars, no consensus was found; the discussion around the subject continued to evolve and the water-in-oil emulsion aspect now became a focal point. In 1910, the chemist Walter Ostwald (1886–1958), son of Wilhelm Ostwald (1853–1932), made the distinction between oil-in-water and water-in-oil emulsions (Ostwald 1910a; Ostwald 1910b). This was subsequently described by William Clayton and Otto Lange as a dated 'phase-volume-theory' and replaced by more modern models, which explained that different types of emulsions were based on different types of emulsifiers (Clayton 1924, pp. 2–4, 63–76, 128; Lange 1929, pp. 15–20, 28–63, 283–285). Equally, the painters Richard Lindmar (1867–1956) and Walther Ruhrmann (1897–1968) introduced the distinction between two different forms of emulsions in painting – in 1926 they developed a binding medium which they classified as a water-in-oil emulsion that they then in their turn presented as the 'real' medium of Van Eyck. However, descriptions of its manufacture and composition reveal that the paints did not contain an oil-soluble

emulsifier and could therefore not have been bound in an inverse emulsion: they must have been oil paints that were modified with aqueous media (Lindmar 1935; Ruhrmann 1934a; Ruhrmann 1934b; Ruhrmann 1937).[11] The *Oeltemperafarbe* (oil tempera paint) developed by the Munich artist Karl Lupus (1870–?) and patented in 1906 was not a proper water-in-oil emulsion either – it was produced by grinding a mixture of egg yolk and poppy seed oil on a muller while at the same time extracting water from the resultant mass by continuously heating it until a buttery consistency was attained. Paints bound in this medium were only miscible with a mixture of the medium itself and with mastic varnish dissolved in turpentine (*TMM* 1911; Dietemann *et al.* 2014, p. 37).

The first real water-in-oil emulsion or rather a saponified oil colour must have been the so-called Wurm tempera, an artists' paint in tubes which was already being sold in 1877 by its manufacturer, Richard Wurm of Munich. The exact composition of Wurm tempera is unknown, but the product in the tubes could be blended with oil, turpentine or a separate vehicle (Wurm sold his vehicle under the designation '*Malmittel*', which is simply 'vehicle' in German) that had been developed specifically to be employed in conjunction with Wurm tempera and which was sold along with it, packaged in its own bottle.

Although the manufacturer did not actually designate it as such, given what we know of its composition, it would seem that Wurm tempera must have been ground as an 'inverse emulsion', stabilised by a liposoluble emulsifier derived from tallow and alkalis. It mixed readily with oil, but the *Malmittel* probably contained soap, enabling a rich variety of technical applications that could be adapted to accomplish what was essentially oil painting as well as to thin watercolour painting when mixed with *Malmittel* (Wurm 1900, pp. 8–9; Berberich 2012, pp. 21–53; Neugebauer 2016, pp. 157–160). In 1906, *Weimar-Farbe* (Weimar paint) was introduced by the laboratory of the Saxon-Grand Ducal Art School in Weimar; it was an oil-resin-based paint that could be converted into an emulsion that could then be manipulated both with oil and water depending on the amount of wax soap it contained (*TMM* 1908; Reinkowski-Häfner 2014, pp. 375–376). In the 1938 edition of Doerner's book *Malmaterial und seine Verwendung im Bilde*, the last to be published during his lifetime, these oil-miscible mixtures were designated as water-in-oil emulsions and categorised under tempera. Thus, in Doerner's last work, the concept of the range of materials designated by the term 'tempera' had been extended to include a mainly oleaginous binding medium (Doerner edn 1938, p. 176).

Tempera emulsions at the turn of the century

As we have seen, in the early 20th-century literature on research into painting techniques, tempera was defined as a type of emulsion, building upon the German reinterpretation of the term that had begun in the first half of the 19th century. Since the methods of working and visual preferences of artists of the period were generally formed by their experiences with oil painting, they tended to look for a binding medium that could be manipulated in a similar manner to oil paint but which would be miscible with water and dry more quickly. Somehow, the property of being miscible with water had become associated with the idea of a media system that offered better long-term stability. However, painters and paint manufacturers did not always produce real emulsions; instead their efforts often resulted in simple mixtures of oil and aqueous binding media, which were sometimes unstable. Nevertheless, in most cases, due to their thixotropic properties, these mixtures could be manipulated to suit a more varied range of applications than those achieved with oil paints. A secondary effect of the industrial production of emulsions was that it proved beneficial to the development of the soap and stearin industry, since soaps were often used as emulsifiers. The wider understanding of the properties of emulsion systems was also enhanced by the emerging field of colloid chemistry from 1861 as well as later industrial research into the technical aspects of emulsions starting in the 1920s (which were of particular

importance in the context of house paints) (Ostwald 1910c; Lange 1929, pp. 15–20, 28–63; Obst 1931).

CONCLUSION: THOUGHTS ON A NEW DEFINITION OF THE TERM 'TEMPERA'

At the close of the 19th and the beginning of the 20th century, particularly in German-speaking countries, the spectrum of the materials encompassed by the term 'tempera' broadened to include not only aqueous binding media, but also oil paint systems that were modified with aqueous components as well as inverse emulsions that could be manipulated by the addition of oils. This more inclusive definition of 'tempera' has once again drawn the term closer to its etymological origins; that is, tempera as signifying the vehicle, the binding medium. Due to the formulaic use of 'tempera = emulsion' and its opposing concept 'emulsion = tempera', oil-based systems were also classified as temperas as soon as scientific analysis of binding media established the presence of minor additions of aqueous media or of saponified components of oils, resins and waxes in the oil matrix.[12] The presence of such materials often gave the dried paint layers a matt appearance. As mentioned above, they were added to the paint to give it more body and to change its drying properties, not to purposefully create a form of tempera painting (Reinkowski-Häfner 1994, p. 307; Carlyle 2001, pp. 109–110). The intended meaning of terms such as 'oil tempera' and 'fatty tempera' – which, depending on the author employing the terminology and date of the text in question, may signify either an oil-in-water emulsion or an inverse emulsion – remains unclear in many texts. Translation of the term 'tempera' in source texts of earlier centuries must be undertaken with great care and take into consideration the context of use and intended meaning; for example, '*tempera d'oglio*', a term used by Biondo in 1549, is oil paint (Reinkowski-Häfner 2014, pp. 14–15, 18–19).

This article has introduced a range of 'temperas': first, those in the art-technology source literature dating before 1800, which Eastlake had summed up as water-miscible media; second, the definition that developed in Germany in the 19th and 20th centuries, which include water- and oil-miscible emulsions; third, the definitions employed in other European languages, which emphasise the water-miscibility of 'tempera' binding media; and finally, the definition derived from the fact that we know from scientific analyses of historical paintings that since the 12th century, binders based on egg with the addition of oils or resins have been employed. The 1994 publication by the present author suggested acknowledgement of such inconsistencies in the meaning of the historical term 'tempera' by citing which binding medium was intended in each case. In my opinion, it would be preferable from now on to classify only water-miscible systems as temperas, both emulsions or otherwise, not least because the paint industry does not currently offer any oil-miscible tempera products. While oil-miscible paints were still classified as tempera and understood as such around 1900, today such materials should be classified as modified oil paints or as inverse emulsions, but not as 'tempera'.

The most recent approach to the problem is that of Wibke Neugebauer. She respects the historical development of the term 'tempera' by providing a specific definition of tempera for the period under examination by recognising its changing character (Neugebauer 2016, p. 35). She finds the definition of 'tempera' in each case by a combined examination of the art-technological sources, examination of surface phenomena of paint layers and analyses of paint materials (Neugebauer 2016, pp. 35–61, 397–405). This approach provides a way forward in recognising the hugely varied historical meanings of this term.

1 The manuscript of the *Schedula* used by Lessing and the section on painting technique it contains are now generally agreed to date to the 12th century. Recently the source of much study, the *Schedula* has been shown to be a compilation, not an original work by a single author (Clarke and Stijnman 2012).

2 Regarding the discussion on the invention of a new painting method by Van Eyck see Schölzel 2005 and Effmann 2006. On the current state of research on Cologne painting see Baum and Walcher 2013.

3 Lucanus was an enthusiastic amateur of art who hoped to improve the practice of both painting and painting restoration by devoting his chemical knowledge to the subject. He is the author of one of the earliest tracts devoted to the restoration of paintings.

4 'Wax oil' (*huile volatile de cire*) was the term used for a wax distillate, an important ingredient in Paillot de Montabert's wax painting.

5 Stereochromy is a painting technique in which pigments are bound in 'water glass' (i.e. water-soluble silicate compounds), or affixed with an applied coating of it.

6 Tempera was sometimes referred to as a '*Mittelding*' (literally, as a 'middle thing' – a mixture between oil paints and watercolours) (Meusel 1788; Field 1836, p. 192).

7 See also the collection of artists' letters in the estate of the Munich-based company Richard Wurm, Bayerische Staatsbibliothek Munich (Wurm ANA 416).

8 On the composition of the binding media of Lompeck's true Italian tempera paint and of Syntonos paint, see the contributions by Pohlmann *et al.* and Dietemann *et al.*, in this volume.

9 The Versuchsanstalt für Maltechnik (Research Institute for Painting Technology), founded in 1884 (see also the contribution by Kinseher, in this volume) added 'und Informationsstelle' (and Information Centre) to its name in 1903.

10 On the emulsifying properties of egg yolk compare Phenix 1997 and Dietemann *et al.* 2014, p. 37.

11 Philipp 1938–1939, vol. 2, p. 438: Patent claim Lindmar no. 1485–482 137. Kl. 22, registered 1926, issued on 22.8.1929.

12 Regarding the current state of chemical analysis of temperas, see the contributions by Dietemann *et al.* and Ferreira *et al.*, in this volume.