Resumo

A escolha do ligante para as tintas da iluminura foi um dos aspectos técnicos mais importantes a ter em conta no passado, uma vez que este pode interagir de forma diferente com os pigmentos e contribuir de forma decisiva para o efeito visual. O temperar dos pigmentos para a iluminura ocupa uma parte significativa da maioria dos tratados medievais sobre técnicas artísticas, sendo descrito com detalhe tanto a sua preparação como as misturas e aplicações. Este artigo estuda e organiza a informação relativa aos ligantes referidos em importantes fontes históricas e textuais, com o objectivo de esclarecer se a escolha de um certo ligante estava associada ao tipo de pigmento ou ao efeito visual final; e também, de fornecer um instrumento útil de apoio à documentação necessária às análises em laboratório e à própria interpretação dos dados analíticos. ●

palavras-chave

LIGANTE
ILUMINURA
TRATADOS MEDIEVAIS
INVESTIGAÇÃO DAS FONTES

Abstract

The choice of the binding media in manuscript illumination was one of the most important technical aspects as each medium interacts differently with pigments and optical results can be quite different. Most medieval treatises on art technology dedicate extensive parts on tempering pigments for illumination, explaining with details their preparation, mixtures and use. The paper will study and organize the information regarding binding media quoted in these important historic textual sources, with the aim to clarify several technical issues concerning the choice of a binder in relation to the pigment to be used or the wanted final appearance of colours; and second, to provide a useful tool for the documentary support of laboratory analysis and for the correct interpretation of analytical results. ●

key-words

BINDING MEDIA
MANUSCRIPT ILLUMINATION
MEDIEVAL TREATISES
SOURCE RESEARCH

BINDING MEDIA IN MEDIEVAL MANUSCRIPT ILLUMINATION: A SOURCE RESEARCH

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Introduction

Manuscript illumination is an aqueous painting technique and therefore needs a binder to keep the pigment particles together, facilitate its application with a reed, quill or brush, and also improve its adherence to the surface of parchment, the writing material *par excellence* in European Middle Ages.

The choice of the binding medium was very important because each medium interacts differently with pigments and can change its optical properties. Thus, medium preparation and mixture with pigment was one of the essential parts of the whole process of manuscript illumination. A good example is the scheme of painting materials and techniques in medieval treatises on art technology, where tempering is as important as pigment identification, preparation and mixtures. What is more, the anonymous author of the late eleventh century treatise *De clarea* warns that to make something beautiful it is necessary to prepare materials properly, in his case the different ways to prepare glair (Thompson 1932: 15).

Medieval treatises on art technology are one of the most important sources for the study of binding media in manuscript illumination (Clarke 2001). Illumination was a major sumptuary art, as illuminated manuscripts were gifts of high esteem due to the wealth of materials and the symbolic value of images. For this reason, it is not surprising that illumination is one of the techniques that constantly appear in these treatises, either as specific technical process or as part of pictorial arts. The study and organization of this information can, first, clarify several technical issues concerning the choice of a binder in relation to the pigment to be used or the wanted final appearance of colours; and second, can provide a useful tool for the documentary support of laboratory analysis.

Binding media

The principal binding media used in manuscript illumination were clarified egg white or glair (*clare, albumen, glarea, albugine ovi*); gums, such as gum arabic (*gumma*): and glues, such as fish glue (*ichtyocollon*), casein glue (*glutine casei*) or parchment size (*cola pergamena*). In most cases binders were applied alone, but depending on the technique or pigment, mixtures were also prepared in different proportions.

Glair

Glair (from the late Latin *clarea*, from Latin *clarus*, clear) is the settled liquid of the egg white froth. There are three ways to prepare glair that, ultimately, are the three ways to make the egg white in to foam. First, by whipping egg whites (*verberata, fracta, percutita*) with a wooden whisk [1] or spoon; second, by pressing and squeezing them with a sponge (*cassata, spongiata*); and, third, by passing them through a wool or linen cloth. A survey of medieval treatises points out that until the twelfth century whipping was the only method used. The reason is given by the anonymous author of *De clarea* treatise who states that the use of a sponge or a filter could contaminate glair either with grease and dirt of hands or with impurities of the sponge or cloth and the result would be a weak and brittle binding media (Thompson 1956: 15). When Theophilus in his *Schedula diversum artium* [2] refers to glair it is always the one prepared by whipping (Hawthorne and Smith, 1979: 31-38). However, it seems that since the thirteenth century the sponge method gained currency and the references to *clara ovi spongiata* become more common [3]. In very few cases it is recommended the use of a funnel-shaped wet linen filter to prepare glair (*Heraclius treatise*, Merrifield, 1967: 233).

Glair beating was a laborious and complicated process, mostly because any failure would mean the loss of its adhesive power. *De clarea* text is quite explicit: containers should be very clean without grease and brass vessels shouldn´t be used, as glair can turn greenish (Thompson 1932: 17). The last comment is interesting because it shows also how everyday experience interferes with artistic praxis: copper containers stabilize egg white foam and does not settle, something desired for culinary purposes but not for artistic ones (McGee 2004: 102-103; Perego 2005: 511). Moreover, if egg white is not well beaten pigments could not be tempered easily, states again our anonymous author (Thompson 1932: 19). Glair consists mainly of water (circa 88%; Colombini and Modugno 2009: 167) and proteins (with hydrophilic and hydrophobic amino acids) and a strong beating that creates foam means that proteins become completely denaturized and, once settled, glair can be mixed with water and become a binding medium for manuscript illumination. Again the author of the *De clarea* treatise draw special attention to the fact that if glair was not well beaten it would behave as if it was glue, so pigments would not run well from the pen of the scribe and the colour would appear unsightly on parchment (Thompson 1956: 19). The proof that glair was well whipped was that foam could remain adhered to the container without running. Then glair was left to rest with the container tilted, so when the

1. At the *De clarea* treatise we have a very good description and even a drawing of this wooden whisk (f. 2r). At the De *arte illuminandi* a brush (*pinzellum situlare*) was also used to whip egg (Brunello 1992: 89). An anecdotic case is described in an Italian recipe from the XIII century where glair was the binding media for vermilion applied with quill «bene rocta con la spongna o con la scopa et con l´artifiggio delfico» (Tossati Soldano 1978: 142).

2. Current research considers that the treatise is a composite text and the author (or authors) was a compilation; see Clarke, M. (2011) «Reworking Theophilus: adaptation and use in workshop texts», in: A. Speer *et al.*(eds.) Die *«Schedula diversarum artium» – ein Handbuch mittelalterlicher Kunst?* (in series *Miscellanea Mediaevalia*). Berlin–New York: W. de Gruyter.

3. For example, *Experimenta de coloribus* (Merrifield 1967: 56); *De coloribus diversis modis* (Merrifield 1967: 265); *Liber diversarum arcium* (Libri 1849: 765; Clarke 2011 §1.22.1); *Libro secondo de diversi colori* where the author recommends to use four sponges bound together (Wallert 1995: 40, 42); or the fifteenth century *Bolognese manuscript* (Merrifield 1967: 466).

foam would become liquid it could be easily collected. In that moment it was really important to control environmental conditions as low temperatures could freeze glair and high ones could dry it. Finally, glair was kept in a glazed clay pot or even in the shell of the egg because according to a widespread medieval belief, the natural container of substances was the best to conserve them. It seems that old glair was more appreciated than the new one. The author of *De coloribus faciendis* recommends to use a three or four days old glair as a binder for the mixture of red lead and vermilion, because colour would look shine with a short of varnish brilliancy (Merrifield 1967: 142) and the author of *De coloribus naturalia* used old putrefied glair to give shine and strength to blue pigments (Thompson, 1935: 139). Glair could be modified with water to improve pigment's fluidity, once tempered. Theophilus in his treatise recommends beating egg white with water in summer and without it in winter, so it would never become too dry or too aqueous (Hawthorne and Smith, 1979: 36). Glair was an optimal medium for miniature painting, free flowing and easily applicable, but there were also some inconveniences in its use as a binding media, besides the above-mentioned difficulties. The main disadvantage was the formation of bubbles while pigments were tempered (*spumositates de coloribus*), which was really annoying to illuminators. The recommendation of almost all authors to avoid this problem was to add earwax (*ceroti auricule*) in the mixture, especially if it was going to be used with azurite blue and vermillion (*Liber diversarum arcium*, Libri 1849: 747; Clarke 2011 §1.3.19). Another problem was the fact that if glair stayed too long mixed with pigments it could damage them. It seems that, again, blue pigments were the problem, as many authors warn not to work more than a day with the pigment tempered with glair, because becomes darker and its beauty gets spoiled (*Livro de como se fazen as cores*, Blondheim 1930-1: 82; *De coloribus faciendis*, Merrifield 1967: 134; *Bolognese manuscript*, Merrifield 1967: 410). As glair reduces the natural saturation of colours, sometimes pigments had to be varnished after drying [4]. Another inconvenience is that, unlike egg yolk and gums that can be used more or less immediately, glair needs to be prepared a few hours before it can be used, as it has to sit and the older it is, the better it gets. Many of these difficulties were resolved with the mixture of adhesives. For example, as glair dries fast, yolk was added and, at the same time, the intensity and brilliancy of yolk was combined with the durability of glair (*Bolognese manuscript*, Merrifield 1967: 410).

4. Old glair was a very common varnish in manuscript illumination and bookbinding as it forms resistant and elastic films, although its permeability and solubility decreases with ageing (Colombini and Modugno 2009: 238). For example, Theophilus recommends old glair to varnish gilded areas (Hawthorne and Smith 1979: 37).

Egg yolk

Egg yolk (*vitello ovi*) was the foremost medium for panel painting in late medieval and early Renaissance Europe. But, according medieval treatises on art technology, it was rarely used alone as a binder in manuscript illumination. As the author of *De clarea* stated, the reasons was that it had not a good adhesive power, as it is more greasy than glair, pigment surface cracked and made spots (Thompson 1932: 73). But as egg yolk left pigments brighter, he also recommended mixing it with glair and taking advantage of the characteristics of both media. The use of this mixture is also found in the *Marciana manuscript*, where putrefied glair and yolk is specially recom-

mended for «colours which have no body» (Merrifield 1967: 610). The anonymous author of the twelfth century *Hi sunt omnes colores* also quotes the use of yolk as a binding media for illumination, together with glair and cherry gum (Novák 1996: 77). Finally, pigments tempered only with yolk clot on the brush, so only a small amount could be applied each time. Therefore, the amount of water in the tempering process would be really important, as it could influence the transparency of the colour. The preparation process was really easy: egg yolk was removed from its sac by making a hole very carefully with a thorn or a needle and it was mixed with a drop of water (*De coloribus et artibus romanorum*, Merrifield 1967: 235).

Gums

Gum arabic was one of the most common binding media for pigments in manuscript illumination and the exclusive medum in writing inks. As the author of the *Liber diversarum arcium states* (Libri 1849: 766; Clarke 2011 §1.23.1), this gum was imported from Arabia and there were commercially available three kinds, according colour: the best quality was the white one (*albam* [5]) and of a lower quality was the yellow (*citrinum*) and the pink (*subrussum*). The gum was very easy to prepare and use: it was commercialized in solid lumps, which were powdered or soaked in water, until they were completely dissolved. Then it was tested with fingers: if they stuck together tightly, then it was well done, if not, more gum should be added. Finally, it was filtered with a linen cloth and mixed with pigments. The main advantages of gum arabic are its high solubility in water, its good adhesive power, and the fact that gives intensity to colours, as it saturates pigments. The disadvantage is its brittleness, and normally it had to be emulsified with natural plasticizers like honey.

However, we must take into account that during Middle Ages «*gum arabic*» was also a generic term to refer to any kind of gum used as a binding medium in painting techniques. In the case of manuscript illumination cherry and plum gums (the «local» ones [6]) were frequently used. It is obvious that access to true gum arabic depended on commercial routes to and from Northeast Africa (Senegal still is the main gum Arabic producing country), something that not always was possible. Yet in the sixteenth century the famous Spanish physician Andrés Laguna, stated that in his time «the ordinary gum arabic in drugstores unworthily have such a name [...] as it was born here, among us, from plums, pear, cherry and almond trees» (Laguna 1556: 87). That is why, in this case, the commercial aspect was very important as, according Prosperus Alpini, the fact that the gum came directly «from Egypt or Arabia then was the original, as they don´t have plum, cherry or other gum trees» (Alpini 1592: f. 5r). But the fact that it was very common to commercialize local fruit trees gums under the name of gum arabic does not mean necessarily that artists were tricked into using a gum of lower quality. It is well known that in Middle Ages the appearance of a substance prevailed over any other property and a gum that was a good binder in manuscript illumination could be perfectly considered as «gum arabic». For example, in the text *Hi sunt omnes colores* we read that pigments for books were tempered with cherry gum, because it could be used either with water or wine and it could maintain

5. The term *albam* here is not used in the sense of something opaque white, but in the sense of something bright and transparent; for example, a common adjective for water is also *albam*. That is why the author of *De Arte Illuminandi* recommends to chose always a gum that is *lucidisima or albam et claram* (Brunello 1992: 99).

6. It seems that Theophilus´ recommendation to use local products, equally good and less expensive, rather than imported ones is quite applicable in this case (Hawthorne and Smith 1979: 12).

its strength even for a year (Novák 1996: 77). A century later, the author of the treatise *De coloribus naturalia exscripta et collecta*, gives a recipe to prepare an artificial gum arabic, using also cherry gum (Thompson 1935: 143). In the *Liber de coloribus illuminatorum sive pictorum* the author tells us that the gum from plum tree was also a good binder (Thompson 1926: 287). Cherry gum gives great transparency and brightness to colours, but it is only partially soluble in water (60% soluble fraction and 40% insoluble one; Perego 2005: 338). In the above mentioned text *Hi sunt omnes colores* cherry gum was prepared either by softened in water a whole night or by boiling it with water or with wine (Novák 1996: 77). Also Theophilus recommendation that cherry and plum gums should be left in sun, during summer, or close to fire, during winter, is probably due to this low solubility of both gums (Hawthorne and Smith 1979: 33). A prolonged boiling can transform them into a substance similar to gum arabic (Perego 2005: 340). The advantage of using cherry gum in tempering pigments for illumination is that it is less viscous than gum arabic, although cherry gum films chips easily if used alone and for that reason it has to be emulsified also with honey or fig tree sap.

It seems that also almond tree gum was used a binder, but less frequent than cherry or plum tree gums. For example, in the text *Tractatus qualiter quilibet artificialis color fieri possit* almond gum was mixed with glair in a gilding process with gold leaves (Thompson 1934-5: 467-8).

Gum tragacanth (*adragante, draganto*) appears in *De arte illuminandi* as a binder in manuscript illumination but its use is anecdotic (its adhesive power is less than other gums) and only as an additive to other gums or glair (probably as an emulsifier) for the tempering of blue pigments (*Bolognese manuscript*, Merrifield 1967: 410) or in parchment gilding (*De arte illuminandi*, Brunello 1992: 45). The use of tragacanth gum is problematic due to, first, the fact that it is only partially soluble in water and it is one of the most viscous vegetables gums; and, second, it gives mat pictorial films (Perego 2005: 334-335).

Glues

Glues of animal origin were used since Antiquity in art techniques (Pliny, *Historia Naturalis*: 28.236), particularly in woodworks, sculpture, panel or wall painting, textiles. Animal glues derive from collagen, a protein present in skins, bones, and connective tissue. Various types of animal glues are available, according to animal or the part used. In illumination techniques parchment size (*cola pergamena*) and fish glue (*cola piscium, ichtyocola*) are the ones that most often appear in medieval treatises on art technology, mainly in gilding, chrysography, tempering certain colours or as additives to glair or gum arabic. Recipes for its preparations are very common in medieval treatises like *De arte illuminandi* (Brunello 1992: 93), *Livro de como se fazen as cores* (Blondheim 1930-1: 82) or *De coloribus faciendis* (Van Acker 1972: 190). Parchment size was considered as the highest quality of all animal glues and it was prepared by boiling parchment clippings, until broth got concentrated (*Heraclius treatise*, Merrifield 1967: 230); then it was strained through a piece of cloth and allowed to cool. Parchment size was used mostly in gilding on parchment. Parchment size does not

spread so easily as gums or glair, so they are easier to use when precision is needed but shrinkage is considerable and plasticizers should be used (Horie 2005: 143). Fish glue (or «isinglass» when it was prepared from swim bladders) was prepared in a similar way, by boiling skins or bones in water, although for the purest form the swim bladders were used. The most famous fish glue was the one made from the sturgeon fish (*Heraclius treatise*, Merrifield 1967: 192), but other fishes were also used, like pike or eels (*Il libro del arte*, Brunello 2002: 148-9; Schedula of Theophilus, Dodwell 1961: 29). It seems that fish glue was a common binder in manuscript illumination on parchment, as the eighth century manuscript *Compositiones ad tingenda* quotes (Hedfors 1932: 33), although in latter treatises fish glue was used normally in gilding techniques, chrysography and argyrography (*Experimenta de coloribus*, Merrifield 1967: 56). Fish glue is transparent, with good adhesive power and it does not darken as do other animal glues (Colombini and Modugno 2009: 168) and its solutions resist gelling in room temperature (it can melt even at 6º C while parchment size has to be kept warm during use, as it needs 30-50º C; Horie 2005: 143). Fish glue is too sensible in the presence of salt (Perego 2005: 220), so it is incompatible with pigments like salt verdigris.

Cheese glue (or casein glue) was another animal protein glue based on casein and obtained from milk or cheese, mixed with an alkali [7] (Horie 2005: 144). If the alkali is lime the adhesive is highly water resistant (Gettens and Stout 1966: 8).

Additives

Additives to modify the properties of binding media and facilitate their preservation were two very important aspects in medieval workshop praxis. That is why a series of substances were added in the tempering mixture. Increase the flexibility of the adhesive film once dried was a key point, as the turning of book pages could deteriorate pigments. Honey and sugar was the most employed additives to prevent binders becoming brittle (Borradaile 1966: 59). According the author of *De arte illuminandi* an illuminator should have always prepared a «water of honey» or a «water of sugar» as an additive to glue or glair (Brunello 1992: 100-103). But the same author also warn not to put too much honey otherwise pigments will get spoiled as they will not dry easily (Brunello 1992: 81). Fig tree sap also provided flexibility and, moreover, due to latex, could increase adhesive power and water-proof the painting film [8] (Blondheim 1930-1: 80; Libri 1849: 765; Clarke 2011 §1.22.1B; Pomaro 1991: 120, Merrifield 1967: 475). Only rarely fig tree sap was used alone as a binder, as in a case of yellow colour made by orpiment and sulfur (*Experimenta de coloribus*, Merrifield 1967: 96). In animal glues wine and vinegar (alcohol) could prevent the formation of a gel at room temperature. Vinegar was added to gum arabic (*aceto gumato*) when used with colorants in order to control pH and consequently the tone of the colour (Pomaro 1991: 115). Small quantities of vinegar added to animal glues facilitate their solubility as an agent against gelification (Perego 2005: 216-7). Finally to prevent from mould and insects, arsenic, camphor, clove, myrrh or even orpiment (in glair) were added (Brunello 1992: 97; Wallert 1995: 42; Borradaile 1966: 29; Merrifield 1967: 676).

7. See for example the recipe for cheese glue in *De coloribus faciendis* (Van Acker 1972: 180) or in *Il libro dell' arte* de Cennino Cennini (Brunello 2002: 151-2).

8. Francisco Pacheco and Antonio Palomino, the well known Spanish painter and writer, quotes that by adding branches and leaves of fig tree to parchment size, the glue remained liquid and did not need heating (Pacheco 2001: 451-2; Palomino 1724: 80). However, still it is not very clear the purpose of the use of fig tree sap and alternative explanations can be found like fungicide replacing the use of vinegar or because it clots and holds together egg temple (Villarquide Jevenois 2004: 392).

The tempering of pigments

The basic technical principle that always should be followed in the tempering of pigments and colorants was that for illumination they should be prepared in order to be applied more than one time, in order to create light and shadows effects. *Theophilus* in his treatise *De diveris artibus* made it quite clear in stating that «in a book all pigments should be applied twice, first very thinly, then more thickly; but only once for letters» (Hawthorne and Smith 1979: 38). In this regard it is understandable the choice of gum Arabic as the only ink binder: an adhesive that technically is stronger than glair (good covering) but weaker than animal glues (less crackling possibilities) and, moreover, saturates pigments increasing their intensity. On the contrary, in the illumination of manuscripts technical aspects such as the necessary drying time of the pigment or its opacity were more important. The same Theophilus argues that if someone wanted to spread up his work, then he had to use cherry or plum tree gum, as it dries faster than the others (Hawthorne and Smith 1979: 33). And Heraclius in his *De coloribus et artibus romanorum* recommends to use instead of oil yolk, otherwise orpiment will never dry (Merrifield 1967: 235). Cherry or plum gums were added to other binders to control fluidity, as we see in *Mappae clavicula* (Phillipps 1846: 223) or in *De coloribus faciendis* (Van Acker 1972: 195). The technique where both glair and gum Arabic were used as binding medium allowed a slow and careful work, as the pigment could run easily from the pen (*Liber diversarum arcium*, Libri 1849: 746; Clarke 2011 §1.3.17A) and tiny strokes could be employed for details, as colour would be bright and opaque enough. Finally, the anonymous author of the *Strasbourg manuscript* warns about the necessity to control the relationship between binding media (glue) and pigment (vermilion) for a satisfactory result (Borradaile 1966: 23-24). Manuscript illumination was a sumptuary art, thus aesthetic criteria had also to be taken into account. Probably the most important aesthetic aspect was the fact that intense and brilliant colours were synonymous with richness and beauty. We can see this in several medieval illuminated manuscripts where scenes were developed in intense gold or blue backgrounds, with detailed representations of clothing, jewellery, furniture, etc. Technically this means that the artist had to work with pigments and binders that give intensity and lustre with opaque or semi-opaque pictorial layers. In this sense it should be interpreted the reference in the small treatise on book illumination that precedes the main text of *Mappae clavicula* (a later addition commonly referred to as *De coloribus et mixtionibus*) that all colours on parchment should be «spissi et clari» (Phillipps 1846: 188). Such a preoccupation is very common in treatises on art technology. For example, the author of *De clarea* states that vermilion tempered with yolk will be very bright and that it could be used to dye low quality parchments, so it looked like purple has been employed (Thompson 1932: 71). Centuries later, painter Pierre Lebrun and author of the so called *Brussels manuscript* (1635 AD) quotes that gum is used in illumination because gives lustre and brilliancy to colours (Merrifield 1967: 784). Some technically interesting results of a survey on medieval treatises on art technology regarding pigments and their binders in manuscript illumination will now be detailed.

Casein glue was used traditionally for woodwork (Hawthorne and Smith 1979: 26) or as an additive to earth plasters or as binding media in the «a secco» wall painting technique. In manuscript illumination its use in not so frequent and appears almost exclusively in the preparation of the pigment *folium* on parchment (*De coloribus faciendis*, Van Acker 1972: 180; *Liber diversarum arcium*, Libri 1849: 757; Clarke 2011 §1.13.3-4), probably because *folium* changed colour according to acidity or alkalinity of its environment (*rubeum, purpureum* or *saphireum*) and casein does not denature in strong alkaline solutions. Theophilus used *folium purpureum* without any tempering, but he warned that once illumination was finished, the whole area had to be varnished with old glair (Hawthorne and Smith 1979: 40). Casein glue of a high pH values is incompatible with pigments that contain aluminium (Perego 2005: 166) so it could not be a binding media for any lake pigment.

Normally lead white and verdigris were used on parchment diluted with wine or vinegar (*Liber de coloribus illuminatorum sive pictorum*, Thompson 1926: 293; *Mappae clavicula*, Phillipps 1846: 189). But, as master Peter of St. Omer stated in his *De coloribus faciendis*, this was right only for artificial greens and whites prepared without salt [9] (Van Acker 1972: 177). Well known is Theophilus´ recommendation not to use salt verdigris on books (Hawthorne and Smith 1979: 38) because it is too reactive, and probably this is the reason of master Peter´s previous recommendation. Nevertheless, it is also equally common to find recipes where lead white and verdigris were tempered with glair or egg yolk (*Liber de coloribus illuminatorum sive pictorum*, Thompson 1926: 289; *De diveris artibus*, Hawthorne and Smith 1979: 38; *De arte illuminandi*, Brunello 1992: 105; *Il libro del arte*, Brunello 2002: 101) [10]. The reason of this could be the fact that yolk is a fat medium and glair, once dry, is impermeable to air and humidity; therefore, they would be good binders for reactive or artificial pigments like the above mentioned lead white and verdigris or orpiment and vermilion (*Experimenta de coloribus*, Merrifield 1967: 234; *Liber diversarum arcium* Libri 1849: 752; Clarke 2011 §1.7; *Bolognese manuscript*, Merrifield 1967: 502) that could interact easily both with their environment or with nearby pigments. Gum arabic was used as a binder for verdigris on parchment or paper mostly in the «not corrosive» version, where the pigment was mixed with the juice of gladiolus (*De coloribus diversis*, Merrifield 1967: 286). It has already been mentioned that yolk gives intensity to colours, that is why azurite and vermilion were also tempered like this. However Vasari in his *Introduzione alle tre arti* (*Pittura*, cap. V) comments that earlier painters were tempering blues with animal glue because yolk turned colour to greenish hues (Brunello 2002: 151). Another reason is given by the author of the *Liber diversarum arcium* who explains that colours tempered with a mixture of egg yolk and glair would flow better from pen or quill (Libri 1849: 746; Clarke 2011 §1.3.17A). It seems that there was also a tendency to temper some vegetable colorants, like indigo or saffron, and lake pigments (like brazil) with glair (*De coloribus faciendis*, Van Acker 1972: 181; *Experimenta de coloribus* of J. Le Begue, Merrifield 1967: 54; *De arte illuminandi*, Brunello 1992: 113, 127). A possible reason could be the fact that normally alum was used in their preparation. Technologically there is a certain af-

9. But the fact is that the same author contradicts himself as in the first recipe on salt verdigris he recommends the use of wine or vinegar.

10. Copper salt-based pigments like verdigris can react with proteinaceous material, as egg yolk and animal glues (Easteaugh et al 2004: 135).

finity in the use of alum and glair, as both were the principal ingredients for *alumine zuccarino*, a base for lake pigments and, moreover, alum was distempered always with glair (Easteaugh et al 2004: 12). Alum can form a complex with egg white, presenting a neutral pH and stabilizing it (Cunningham 1995: 298). Another reason could be the fact that pH of glair close to neutral (around 7,4; Perego 2005: 511) and it could not alter the tone in animal or vegetable colorants sensitive to pH changes.

Gilding media

Gilding was one of the most important techniques in manuscript illumination [11]. Gold was applied in fine gold leaf or in powder and, according to the desired results, the surface was polished or not. In this case, workshop practises are more clear. For example, Theophilus in *Schedula*, or the anonymous compiler of *Compositiones ad tingenda*, write that when gold leaves were applied directly on the parchment glair should be used (Hawthorne and Smith 1979: 31; Hedfors 1932: 23, 31), as does the anonymous author of the *Bolognese manuscript*, but in this case fig tree sap is added (Merrifield 1967: 462); whereas Alcherius in his treatise *De coloribus diverisis modis* not only recommends parchment size, but also quotes that glair is more rigid and less flexible and that gilding could fall off from parchment or paper (Merrifield 1967: 269). For gesso mordants, gum or glue was used more frequently, because as the author of the *Bolognese manuscript* writes, glair can crack it; but he also gives a recipe «according to the German manner» where gesso and white clay were tempered with glair and fig tree sap (Merrifield 1967: 446, 474). Cennini also tempers gesso mordant in gilding on parchment or on paper with «well beaten glair» (Brunello 2002: 196-7). To apply gold powder Theophilus recommends parchment size or fish glue for gold powder either for writing (*chrisographia*) for use in gilding of illuminated manuscripts. But he warns, firstly to pay special attention in fish glue preparation as if it is left too thick during boiling gold will flake, and secondly to apply glue moderately otherwise gold leaf will lose brilliance and it will be spoiled (Hawthorne and Smith, 1979: 36). On the contrary, master Peter of St. Omer in his treatise *De coloribus faciendis* writes that gum arabic is excellent for gilding on parchment (Van Acker 1972: 192). In this binding media selection process other technical criteria were also taking into account, such as the type of parchment to be gilded: for parchment made of sheep´s skin several a mixture of glair and plum tree gum or gum arabic was specially recommend, as this type of parchment is too fat and a stronger binding media might be needed (*De coloribus faciendis*, Van Acker 1972: 192). The anonymous author of the *Liber illuminatorum sive pictorum* adds also that such gilding method should be carried out in a damp place, especially in warm weather, otherwise burnished gold will get spoiled (Thompson 1926: 305).

Incompatibilities

The presence of tannins in the tempering process could be a great inconvenience. As was mentioned earlier, most authors when referring to gum arabic advised to use

11. Although we will only refer to binding media for parchment gilding, the same materials were also used to gild other surfaces (silver, tin, copper, wood, leather) and in other techniques (silver writing, gold leaf imitations, etc.).

the most transparent one. This was really an important aspect as the most coloured gums contain tannins, due to long contact with bark (Perego 2005: 336) and tannins can react with iron ions (iron based pigments or pigments where iron can be present as impurity) and the result is a dark coloration that could easily spoil the final colour. Moreover, parchment size and fish glue in the presence of tannins become insoluble (Perego 2005: 217).
Gum Arabic is also incompatible with gelatin, mostly is presence of salt (Perego 2005: 336) and probably this is the reason why the mixture of parchment size with gum Arabic is not so frequent in the tempering of pigments.

Conclusions

Glair and gum Arabic were the main binders for pigments in medieval illumination techniques and they were used continuously throughout Middle Ages and it is imposible to establish any chronological criteria for their use. For example, there is a very common assertion that until the fourteenth century the widely used binding medium for illumination was glair and after was replaced with gum Arabic, due to aesthetic criteria, like the preference for bright and vivid colours since that century. However, medieval treatises on art technology do not corroborate such a hypothesis, as parchment size, glair and gum Arabic are mentioned constantly in texts from XV, XVI and even XVII century[12] (*Bolognese, Marciana, Paduan or Brussels manuscripts*, Merrifield 1967: 408, 610, 664, 786).
In short, the use of glair or gum in the tempering process is a technical aspect that, together with the nature of pigments, determines the election of the two possible – *grosso modo* – illumination techniques as described by the Spanish painter and writer Pacheco in his *Arte de la Pintura* (1649). The author states that in his days in manuscript illumination the colour of parchment was used as «light» with transparent pigments and subtle tones (so gum arabic or one of its mixtures should be used), unlike what happened with what he calls «the old temple» where opaque and intense colours were used, «closer to oil painting» (so glair or one of its mixture were more suitable) (Pacheco 2001: 454-5).
This optical behaviour of binders once tempered with pigments was well known and much employed by medieval illuminators as a technique to achieve different tones and hues in the same work. We have several examples of this use. The anonymous author of *De clarea* quotes that to control glair and water in the tempering process was very important as the artists could do things as he wished, glossy or mat (Thompson 1932: 75). In the Bolognese manuscript we read that for body colours blue should be tempered with animal glue or parchment size and vermilion with glair and fig tree sap; but if they supposed to be used in capital letters or decorative motives, for blue gum arabic or glair was more appropriate and for vermilion glair and yolk (Merrifield 1967: 408, 500). In the same way, the author of the *Livro de como se fazen as cores* advises to use gum for a dark tone in blue, or glair for lighter one (Blondheim 1930-1: 75). In this sense we have to interpret also the fact that there is no clear criterion on the

12. The fact that these texts were written by practising artists indicates more a traditionalism of workshop practices than a mere copy of old contents.

use of a specific binder with each pigment, as most of them were tempered one way or another depending on the necessities of the illuminator or even on workshop (or school) traditions: Egg yolk increase intensity and gives depth; glair without varnish gives a flat mat finish; gum Arabic gives a glossy appearance; cherry gum makes colours brighter. That is why the binder should be the last ingredient to add in order to control the development of the tone, and when a gum or glue was used in the grinding process normally the pigment was washed to remove the excess of adhesive, and then it was tempered. Cennino Cennini makes a very interesting comment when he writes that for illumination on paper only gum arabic should be used (Brunello 2002: 198). Such an observation shows that technical limitations were equally (or even more) important in artistic praxis: paper is more flexible and absorbent than parchment, thus washing techniques and gum arabic as binder are more appropriate. The progressive use of paper as support for writing and illumination meant that, since the sixteenth century onwards, gum arabic appeared almost exclusively in printed treatises of painting techniques [13]. And consequently it was felt that the gum arabic was the binding media par excellence even in medieval illumination.

Probably the only valid conclusion we can draw is that artistic praxis was strongly influenced by traditions (local or international) and workshop experience. Distempering of pigments is a good example, as it is very common to find in medieval treatises expression like «do what from your experience seems better to you» (*De arte illuminandi*, Brunello, 1992: 105) or «according to the choice of the artist and the nature of the work which is to be done» (*Experimenta de coloribus*, Merrifield 1967: 110). A representative case is the use of fish glue as a binder for all pigments, recommended in the oldest treatises on art technology in the Occident such as the *Compositiones ad tingenda* (Hedfors, 1932: 33) and *Mappae clavicula* (Phillipps 1846: 218). Both works show a strong Byzantine influence and it seems that the use of fish glue can also relate to this tradition, as animal glues were very common in icon painting. Two centuries later things changed as in the small treatise on book illumination that precedes the main text of *Mappae clavicula* (the *De coloribus et mixtionibus*) where we read that all colours on parchment should be tempered with glair (Phillipps 1846: 188). As we have seen, medieval illuminators used binding media and pigments according to their specific characteristics and properties and according the illumination technique they thought appropriate in order to carry out their work. Moreover, illuminator's guild rules obliged the use of specific pigments in different parts of illumination as, for example, azurite in pictures and only lapis lazuli in capital letters. This technical and historic aspects should be always taken into account, first, because many aesthetic studies and laboratory analysis dedicated to medieval illumination, are based on exceptional pieces, luxury books for wealthy patrons, that by no means could be representative of the common practise in manuscript illumination; and second, because the place where a sample was taken for analysis becomes really important as results can vary (different binders and pigments in capital letters, backgrounds, foliage, etc.) and conclusions might be wrong or over generalized. ●

13. Francisco Pacheco (1649) and Vicente Carducho (1633) describe the «aguadas de colores» as the appropriate type of painting executed on paper (Pacheco 2001: 452; Carducho 1633: 132). The almost exclusive use of gum arabic is also found in Salmon´s *Polygraphice* (1685: 95, 447); Jenner`s *A Book of Drawing, Limning, Washing or Colouring of Maps and Prints* (1652: 20-1); and Félibien´s *Des principes de l'architecture, de la sculpture, de la peinture*. (1690: 621).

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Acknowledgments

I would like to thank Mark Clarke for his comments and his open-handed exchange of knowledge.

Biography

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