

Note from the Making and Knowing Project:

This essay was written for “The Art Technological Source,” an 8-week graduate course at the University of Amsterdam offered by Dr. Marjolijn Bol in 2015 and 2016 to students enrolled in an MA program in either Technical Art History or Conservation and Restoration. Students worked on various recipes from BnF Ms. Fr. 640 on the following five topics: 1) tracing and painting on glass, 2) yellow dyes and their applications, 3) dragon’s blood, 4) painters’ varnishes, and 5) sieves.

This is an un-edited student paper that relies on an earlier state of the Making and Knowing Project’s transcription and translation of Ms. Fr. 640. For an updated version of the text, see:

Making and Knowing Project, Pamela H. Smith, Naomi Rosenkranz, Tianna Helena Uchacz, Tillmann Taape, Clément Godborge, Sophie Pitman, Jenny Boulboulle, Joel Klein, Donna Bilak, Marc Smith, and Terry Catapano, eds., *Secrets of Craft and Nature in Renaissance France. A Digital Critical Edition and English Translation of BnF Ms. Fr. 640* (New York: Making and Knowing Project, 2020), <https://edition640.makingandknowing.org>. DOI: <https://doi.org/10.7916/78yt-2v41>.

The Art Technological Source
Spring 2016
Prof. Marjolijn Bol

BnF Ms. Fr. 640, fol. 29v: “Gold without Gold”

Fol. 29v

Transcription

Couleur d’or sans or sur l’argent

Colore ton argent de foeille apliqué avecq de la terre emerita, et estant sec donne une main de vernis d’aspic et de sandaraque. Et il sera plus beau qu’or bel

Translation

Color of gold without gold on silver

Color your applied silver leaf with some terra emerita and once dry, spread a handful of varnish of aspic and sandarac and it will be more beautiful than fine gold.

Introduction

Gold has always been one of mankind’s noblest and most valued materials, a signal of power and success. Yet a large part of its charm is its rarity and cost, which limit its use to the highest echelons of most societies. For the man without means, substitutes had to be found. Following a medieval tradition, the sixteenth-century author-practitioner of BnF Ms. Fr 640 offers his readers some recipes for this golden simulation—by following his instructions one can create “gold without gold” by simply spreading a “handful” of yellow colorant and varnish on silver or tin, and the product of this may be “more beautiful than fine gold.” One may wonder why, if this recipe and the many like it were so simple and the results so lovely, we do not have more examples of its rendition? The answer likely lies in the very reason we must reconstruct this process to the best of our abilities—the fugitive nature of this “gold” has left us with little to

no surviving examples of what, according to sources dating back to the middle ages, was a fairly common and accepted practice. Some recipes in Ms. Fr. 640 are of further interest in that they do not follow the typical formula for imitation gold found most famously in sources like Theophilus and Cennini's recipe books.¹ Rather than using saffron to obtain the golden color, the author-practitioner recommends “terra emerita,” which we know to be commonly called “curcuma” or “turmeric.”² Since in fol. 41 he does recommend using saffron mixed with massicot to achieve a similar imitation gold, his use in our fol. 29 of terra emerita is a strange alteration to a practice he was obviously aware of. This choice is baffling not only in its originality, as a quick look through major historical sources yields no mention of turmeric's use in this fashion, but also in its pairing with silver. Before our reconstruction began, we questioned why the author-practitioner would choose silver, a metal widely known since antiquity to tarnish, which is also far more expensive than the more durable and typically used tin. Despite the usefulness of our reconstruction to visualize such an intriguing process, we could not find conclusive answers and remain puzzled over his decisions. In an attempt to discover why and how any version of imitation gold was used, this annotation will briefly outline our experiments before exploring the material and economic factors that might have contributed to the use of imitation gold leaf on silver and tin despite its impermanence.

Part I: Reconstruction

We began our reconstruction with a thorough reading of the recipe, which, although merely a sentence in length, contains far more information than one may first think. Looking

¹ See Theophilus, Hawthorne, and Smith, 1963, and Cennini and Broecke, 2015.

² See CAMEO database from the MFA Boston for entries on “turmeric” and “curcuma”

through other recipes in Ms. Fr. 640, we decided to interpret the term “color” as “paint” and proceeded to create various mixtures of turmeric with water or linseed oil.³ (Fig. 1: turmeric tests on sample boards, Fig. 2: mixtures of turmeric with oil and water) The next part of the recipe refers to “applied silver leaf,” which meant we needed knowledge of gilding and had to prepare a ground of red bole, apply the silver leaf, and burnish it.⁴ (Fig. 3: red bole ground, Fig. 4: applied silver leaf) Before applying our colorant we tested different formulations of turmeric with water and oil, and tried different methods of application—thin versus thick coats, applying a layer and then removing the grainy top with a cloth, dabbing, brushing, etc. After a few trials we decided that the best result was achieved in formulation 7A—2 grams of turmeric mulled with 2.5 mL of linseed oil. (Fig. 5: Turmeric 7A, rubbed and untouched) We proceeded to use this sample in all further tests. As for the varnish, we used another recipe from Ms. Fr. 640 for the aspic and sandarac varnish the author-practitioner calls for here.⁵ For our first trial, we tried mixing the aspic oil and crushed sandarac and then heating it up to a temperature of 50 degrees C. (Fig. 6: grinding sandarac gum, Fig. 7: heating apparatus) This was unsuccessful and yielded a yellowish and lumpy result. (Fig. 8: varnish trial #1) For the second two trials, we heated the lavender oil

³ See Table 2: tests with terra emerita and varnish on a white canvas board, in digital [logbook](#)

⁴ We also silver-gilded some frames that had already been partially gilded with gold, so we could see the imitation directly beside its model. Fig 4b: silver leaf on gilded frame

⁵ We used the recipe for aspic oil varnish found in BnF Ms. 640, which is translated in part as follows: p004r_1 Aspic oil varnish

“One must heat lavender spike oil and, as it begins to simmer, put in powdered sandarac gum so that it soon melts. And stir continuously over a charcoal fire until the sandarac is well melted, which you will know by taking a little of the said varnish on a plate and, if it is fat enough when you handle it with a finger, it is ready. And for one pound of lavender spike oil, you should put five ounces of ground sandarac. Some only put in four ounces but this is not as good, nor as fat. The former dries promptly.”

first and then added the powdered sandarac gum.⁶ The third trial was the most successful, as a smooth and relatively clear varnish. (Fig. 9: stirring Varnish #3) However, it did not, as the author-practitioner wrote, become “fat enough [to] handle it with a finger” and I believe this is because we could not safely bring the aspic oil to a “simmer” (as it is an essential oil with a low flash point). (Fig. 10: three varnish trials) We proceeded to use Varnish #3 for all further tests.⁷

We applied the 7A turmeric in oil and a mixture of turmeric in Varnish #3 to the sample boards and while we achieved a shiny and yellow result, when compared to the real gold on the gilded frame, the Ms. Fr. 640 “gold” was not convincing. (Fig. 11: all turmeric tests, Fig. 12: turmeric with varnish and oil on frame, Fig. 13: video of test panel in shifting light) We also ran into problems when we tried to layer the turmeric and the varnish. The author-practitioner writes that one should apply the varnish over the turmeric “once dry.” However, the turmeric and oil mixture simply did not dry quickly enough, and when we came back almost a week later, almost all of the color had faded or disappeared. (Fig. 14: turmeric test panel 2/25) We do not know if this is because there was no protective layer of varnish, but this seems to be a catch-22, since the turmeric and oil was still not dry even faded, and so there would be no color to protect by the time it was dry and ready for the varnish. We tried once more to apply a very thick layer of turmeric to see if that might better retain the color, and over the edge we tried to apply some

⁶ We calculated the ration of “one pound of lavender spike oil” to “five ounces of ground sandarac” and then calculated our lavender oil needs to match the sandarac we had already ground and divided for three trials. This ratio became approximately 2.4 g sandarac to 7.68 g lavender oil.

⁷ We got this idea from Emilie Foyer’s annotation of our recipe as part of the Making and Knowing Project, Fall 2015. She used our fol. 29v but also attempted to follow fol. 57r, which mixes the turmeric with a turpentine varnish. Unfortunately, our aspic and sandarac varnish mixed with the turmeric did not yield satisfactory results, although she claims her turpentine mixture was her most successful.

varnish without waiting, but this did not work well. (Fig. 15: applying thicker turmeric, Fig. 16: varnish on wet turmeric) We concluded that some of our issues stemmed from perhaps choosing to use oil to apply the turmeric, which we thought got the best result but was not specified in the recipe and caused problems with drying, and the inability to heat the varnish to a “simmer” as recommended. I believe that the problems with drying in this recipe may be the reason the author-practitioner included a similar recipe in the manuscript on fol. 57r, which specifically claims to “dr[y] within a quarter of an hour.”⁸ Our conclusions were that the choice of mulling the turmeric with oil to get the smallest particles, while most visually pleasing, caused practical problems, and that the varnish was not as not as viscous as recommended.⁹ We were also left with questions of why the author-practitioner would choose to use grainy turmeric and tarnishing silver when historical recipes for this kind of “gold without gold” overwhelmingly employ saffron and tin to apparently successful result.

Part II: Historical context

The product of this turmeric and silver reconstruction was so unconvincing as gold and took so much time and effort that it seemed baffling that one should attempt it despite the lower cost. However, as Daniel Thompson wrote of medieval attitudes toward imitation gold: “We must suppose that medieval eyes were very easily deceived, for most of these substitutes are very

⁸ Translation of fol. 57r: “White turpentine varnish or aspic oil and turpentine is colored with powdered turmeric boiled together with it. It gives a gold color on silver which is even more beautiful when burnished. It dries within a quarter of an hour. Aloes would made an even brighter color but it takes time to dry whereas the other one dries within a quarter of an hour in winter as well as in summer.”

⁹ Emilie Foyer also concluded this, as she chose to use an nineteenth century method of extracting the pigment with ethyl alcohol to get smaller particles. We did not think this was historically accurate for our reconstruction.

weakly like real gold. If they were yellow and shiny, and particularly if they had any sort of metallic sparkle, they were acceptable.”¹⁰ In the service of deeper inquiry, let us thus proceed by supposing that the imitations that artists and workshops may have created from similar recipes to Ms. Fr. 640 were either more successful than our own reconstruction or that the visual differences did not bother the “medieval eye.”

The true mystery of the Ms. Fr. 640 recipe for “gold without gold” is one that unfortunately has no answer here—the use of turmeric as a colorant. It is not even mentioned in most historical sources, and when it is, it is simply referred to as a yellow rhizome of *curcuma longa* that can be sliced, dried, and ground to create a pigment or dye and was mostly used in India and other parts of Asia to dye textiles or for medicinal purposes.¹¹ One brief mention of it in a European trade context gives its price in a table of “Artist’s materials in the Liegnitz Taxa of 1662” as 9 *Heller* per *Loth*, in comparison to 18 *Heller* for a *Loth* of sandarac, 54 *Heller* for a booklet of silver leaf, and 144 for a booklet of gold.¹² Looking at these 17th century prices, which of course may not be representative of the author-practitioner’s time but nevertheless offer some insight into the cost of this project, the materials for this recipe cost over half of the price for gold and required far more labor for their result. Furthermore, as we saw in the reconstruction, the color of our turmeric faded immensely after only one week, and silver is famous for tarnishing—so were the savings in cost worth the ephemerality of the product? While

¹⁰ Thompson, Daniel V. *The Materials and Techniques of Medieval Painting*. New York: Dover Publications, 1956. 181.

¹¹ Eastaugh, Nicholas, Valentine Walsh, Tracey Chaplin, and Ruth Siddall. *Pigment Compendium: A Dictionary and Optical Microscopy of Historical Pigments*. Oxford: Butterworth-Heinemann, 2008. 757.

¹² Kirby, Jo, Susie Nash, and Joanna Cannon, eds. *Trade in Artists' Materials: Markets and Commerce in Europe to 1700*. London: Archetype Publications, 2010. 319-322.

gold will never tarnish or grow dull, Cennini specifically wrote of silver: “And note above all: do it with as little silver as possible, because it does not last and turns black.”¹³ In writing about medieval conceptions of materials, Spike Bucklow muses that “the act of trying to stop silver from tarnishing is like trying to stop death. It is not easy.”¹⁴ Having concluded that both turmeric and silver are extremely impermanent in nature and poor choices to replace a material renowned for its longevity, it is not surprising to see that almost all of the recipes for imitation gold recommend saffron and tin instead.

Tin is the other “white metal” to silver and is both cheaper and not prone to tarnish. There is even a recipe for turmeric on tin on fol. 76v of Ms. Fr. 640.¹⁵ In his twelfth-century compendium *On Divers Arts* Theophilus Presbyter actually recommends tin as a substitute for both gold and silver, advising that one lay down the tin and then cover the “golden” parts with a mixture of saffron and glair and “leave the rest [of the tin bare] to take the place of silver.”¹⁶ Tin was also recommended by Cennini as the ideal material for creating imitation gold, and also as a

¹³ Taken from Lara Broecke’s new translation of *Il libro dell’arte*: “Chapter 95: The way to decorate walls with gold or with tin. “Now that I have explained to you the way to work in secco, in fresco and with oil, I want to explain to you how you should decorate the wall with gold-tinted tin, in plain, and with gold leaf. And note above all: do it with as little silver as possible, because it does not last and turns black on walls, on wood, but fails more immediately on walls. In future, use beaten tin, or rather tin foil, in its place. Also, watch out for part gold, which turns black straight away.” (Cennini, 130)

¹⁴ Bucklow adds that people in the middle ages thought silver tarnished from sulphur, whether from direct contact or the invisible sulphur in the air. Artists also knew of airtight seals, using linseed oil and lead white putty to protect silver from exposure to air. (Bucklow 2014, 194-195)

¹⁵ There are ten recipes for various sorts of gold without gold on fols. 29v, 41v, 57r, 73r, 76v, 78v, 100r and 104r. 29v, 57r, and 76v are the only ones that mention turmeric over silver or tin and 41v mentions saffron.

¹⁶ Theophilus, John G. Hawthorne, and Cyril Stanley Smith. *On Divers Arts; the Treatise of Theophilus*. Chicago: University of Chicago Press, 1963. 37.

substrate for gold leaf itself, since tin could be applied to walls and stones as well as panels and gold could then safely rest on top of it. He gives recipes for gilded tin, as well as gold-tinted tin, although he does not give a specific recipe for the “gold size” needed to color the tin.¹⁷ In her new annotation of Cennini, Lara Broecke points out that Theophilus and the *Montpellier liber diversarium arcium* are the most likely sources for the gold size recipe Cennini does not include.¹⁸ Both of them, dating respectively from the twelfth and fourteenth centuries, recommend saffron as the golden colorant and specifically mention tin as the substrate.¹⁹

Saffron is made from the dried and powdered stigmas of the *Crocus sativus* plant, cultivated throughout the Mediterranean and later in medieval Europe. There were three major types—field, garden, and oriental (Cilician), which was the most favored, and it was used in cooking, as a dye, as a golden-yellow pigment in manuscripts, and of course as a colorant in many recipes for golden tin.²⁰ As Thompson writes of medieval materials: “One of the most

¹⁷ The two recipes for both gilded tin and gold tinted tin become conflated in several instances. Broecke makes the observation in one of her notes that “perhaps he was not writing from personal experience here and left out the end of the instructions for making gold-tinted tin because he was not thinking through the process as he wrote.” (Cennini, 134)

¹⁸ The *Liber diversarium arcium* has two recipes for a gold colour that can be applied over tin leaf, the first consisting of aloe vera, linseed oil, and saffron and the second of aloe vera, linseed oil, pine resin, and dragon’s blood. There is also a recipe (2.12.1A) as follows: “Also is made a certain painting, which is called ‘translucent’ or ‘golden,’ which is made in this way on top of polished material [note 145—tin foil]: and thereupon cover whatever you want to paint with saffron.” (Clarke 2011, 132-148)

¹⁹ Theophilus writes: “Take some shoots of alder buckthorn, cut and dried, and scrape out the yellow inner portion, adding a fifth part of saffron to it. Pour old wine or beer over it and let it stand for the night, then the next morning heat over a fire until warm. Put the sheets of tin into this mixture one by one, lift them out frequently until you see that they have taken enough golden color. Then stick them again to the wooden board, smear the gluten on them again, and let them dry.” (Theophilus, 31-32)

²⁰ Kirby, 457.

important services required of [yellow pigments] was to imitate the appearance of gold.”²¹ The most common yellows available were yellow ochres, orpiment, realgar, *giallorino* (massicot), bile yellows, mosaic gold (tin sulfide, *porporina*), weld and buckthorn, and saffron. In the fourteenth century Master Peter of St. Omer in Northern France wrote: “A great deal of the best saffron comes from there [Corycian] more fragrant in aroma and in colour more beautiful than gold.”²² It must be noted that saffron is not necessarily much more long-lasting than turmeric, and was primarily used for medieval books and manuscripts where it was protected from the elements.²³ Saffron was costly, rare, and extremely laborious to harvest, so the fact that it appears so many times in various recipes for gold or golden colors must indicate its merits despite its fugitive nature.

Considering the ephemerality of imitation gold leaf, one questions whether recipes for it were actually used and what the market for it could be. Cennini admonishes his reader, saying, “Most people habitually decorate walls with gold-tinted tin because it is less expensive. But I urge you to take this advice: force yourself always to do your decorations with gold leaf and with good pigments, especially on the figure of Our Lady.”²⁴ Yet gold was expensive, the gilding and polychromy of an altarpiece frame could absorb almost 40% of the total cost of the work, and so often compromises had to be made.²⁵ Despite Alberti criticizing “those who make excessive use of gold, because they think it lends a certain majesty to painting” and Leonardo complaining of

²¹ Thompson, 174.

²² Thompson, 185.

²³ Ibid. 186.

²⁴ Cennini, 131.

²⁵ Kemp, Martin. *Behind the Picture: Art and Evidence in the Italian Renaissance*. New Haven: Yale University Press, 1997. 37.

“a certain breed of painter who, having studied little, must spend their working lives in thrall to the beauty of gold and azure,” gilded works were ubiquitous.²⁶ The popularity of this material did not come cheaply—the mean price of Venetian altarpieces between 1470-1530 was around 80-100 ducats, with additional stipends for housing and materials.²⁷ To put this in perspective, it was reported that in 1480 a family of five could live reasonably in Florence for 70 florins per year.²⁸ Michelle O’Malley did extensive research into the commissioning practices of Renaissance art and discovered that pure gold was commonly stipulated in contracts but occasionally other types of leaf were required to enliven the surface or simulate gold. Contracting parties might choose to use beaten silver or tin, or silver or tin that was lacquered to appear golden, all of which was cheaper than gold and mostly used by less wealthy clients and patrons looking to cut corners in less important areas of a large work. For example, in 1347 the painter Chiozzo agreed with the Florentine confraternity of the Gesù “to use fine gold on the altarpiece panel and on the predella, and another gold, not fine, on the columns of the wooden

²⁶ Ibid. 153.

²⁷ The Florentine florin, the Genoese genovino and the Venetian ducato were gold coins of basically equal exchange throughout Europe. O’Malley uses the following exchange rate: 240 *denari* = 20 *soldi* = 1 *lira* and about 6 *lira* were equivalent to a *florin* (*soldi* and *lira* were monies of account and did not really exist as actual coins). (O’Malley, 280)

²⁸ Estimated that a working man in the 15th century would require about 36 lire annually for food, 20 for rent, and 20 for clothing. An unskilled worker could expect around 130 lire in income for a year, and so might be able to meagerly support two adults at “the margin of decency.” Civic officials could expect over 150 florins. The most reasonably successful artists around 1450 could expect to live at a level towards the top of most skilled workers but below lawyers and civil officials (Kemp, 125-126)

surround.”²⁹ In Siena, Martino di Bartolomeo agreed with the officials of the Sienese Palazzo Pubblico, when he was hired to paint the ceiling of the Sala di Balia, that he should “not use gold in the places where he would normally put it, but instead use tin.”³⁰ Perhaps some clients were more interested in the immediate glittering results and low cost of imitations than the longevity of their commission, but detailed accounts of exactly where certain grades of gold and tinted tin were to be placed shows a shrewd mind for cost-effective dazzle.

Many of these examples come from the well-documented Italian Renaissance, but the use of colored tin and silver can also be traced back to the time and location of the Ms. Fr. 640 author-practitioner. Sixteenth-century guild records from Paris show that the business of selling imitation gold tin was a profitable one. The guild regulations of the Parisian tin beaters (*batteurs d’etain*) guild specifically state that they could color their work: “tindre son estain de toutes maniers de couleurs.”³¹ They would sell their tin leaves as white, green, or gold, in dozens or gross dozens and the provision of ready-coated leaves indicates a fairly specialized and developed trade. Perhaps this was what prompted the author-practitioner to include a few similar

²⁹ O’Malley makes an important note that I will quote here in its entirety for accuracy: “There also seems to have been a leaf made of tin with a veneer of gold, which was equal to or higher than the average cost of gold leaf. The *stagnio dorato*, or gilded tin, used by Jacopo Cione in 1366, in the guild hall of the judges and notaries in Florence cost 330 soldi or 16.5 lire for one hundred leaves; it was much more expensive than the pure gold leaf that Jacopo bought at 3 lire 7 soldi for the same quantity. Kirby in Neher and Shepherd 2000, p. 34, notes that in 1472 Baldinovetti bought ‘yellow tin’ to be gilded at a price that can be calculated as 9 lire 4 soldi for 100 leaves. Eve Borsook postulates that it may have been more labour-intensive to gild tin than to beat gold into leaf, and that gilded tin was used when a leaf more durable than gold was wanted.” This seems in line with Cennini’s gilded versus golden tin, and may explain some confusion in written accounts. (O’Malley, 288)

³⁰ Tintori, Leonetto. “‘Golden tin’ in Sienese Murals of the Early Trecento.” *The Burlington Magazine* 124 (1982): 92-95.

³¹ Nash, 137.

recipes, for his readers to achieve a similar result at home. This would have been smart of him, since at their highest price of 8 *denari* per foil for gold and green tin foils, colored tin leaves cost more than double the price of standard gold leaf.³² This seems to present a small mystery—why would tin leaves cost the same as or more than gold leaf? That would completely remove the reasoning for choosing the imitation. Our answer may lie in an examination of gilded objects from the period. Although gilded areas seem uniform at first, it is not difficult to find the edges of individual leaves, and the average sheet size for gold appears to be around 8-9 square cm, while single tin foil sheets could be up to 30 x 30 cm. And while gold can be and was beaten to a thickness of 0.2-5 μm , tin measured at 6-85 μm thick.³³ Thus the records can be a bit misleading, and if one calculates total cost, it was indeed much cheaper to use colored tin to cover an area. As Jo Kirby wrote, the concern of the patron, in choosing which materials were used, was that his money should be well spent and that it should be evident now and in the future. Budget concerns forced certain compromises and decisions, but the overarching aim was always beauty. The aim of “future” evidence seems to have been more flexible.

³² See also Jo Kirby’s price tables in *Revaluing Renaissance Art*. In summary, Florence, 1460-72

100 leaves of gold = 68 soldi

100 leaves of yellow tin = 183 soldi (approx)

England, 1481-82

100 leaves of gold = 6 soldi, 7 denari

100 leaves gold foil (tinted tin) = 7 soldi, 7 denari (approx)

These prices do not make sense—tinted tin is either the same price or more expensive than gold. (Kirby 2000, 19-20)

³³ Cennini gives a major hint to this, saying that to cut tin foil, the tin should be laid out on a wooden board the size of a royal folio (41.5x61.5 cm) and for gold leaf he recommends a cushioned pad the size of a tile or a brick. (Nash, 139) Theophilus also mentions a wooden board for beating tin, but does not specify size. He also says that each sheet of gold leaf should be about ‘four finger’ wide and square (Theophilus, 31).

Conclusion

To quote Daniel Thompson once again, “We deplore deceptions in the arts. We have rejected the ingenuities of a generation back in making one material look like another.”³⁴ One must not discount the innovation and creativity of those who sought to expand the limits of materials for practicality and financial benefit. The aim of our reconstruction was to visualize an ephemeral material, and although ours did not seem to be convincing as real gold, we at least gained an insight into the possibilities of manipulating materials for imitation. Despite the author-practitioner’s use of unorthodox ingredients in the recipe we chose to study, the contents of Ms. Fr. 640 are not unprecedented. The desire for imitation gold is well documented, and by comparing the work of our anonymous author-practitioner to known historical sources and records of formulation and use, we can begin to imagine how and why this useful but short-lived technique was used.

³⁴ Thompson, 216.

Bibliography

- Borsook, Eve. “Jacopo di Cione and the Guild Hall of the Judges and Notaries in Florence.” *The Burlington Magazine* 124 (1982): 86-88.
- Bucklow, Spike. *The Riddle of the Image: The Secret Science of Medieval Art*. London: Reaktion Books, 2014.
- Bucklow, Spike. *The Alchemy of Paint: Art, Science, and Secrets from the Middle Ages*. London: Marion Boyars Publishers, 2009.
- Carlyle, Leslie. *The Artist's Assistant: Oil Painting Instruction Manuals and Handbooks in Britain, 1800-1900*. London: Archetype Publications, 2001.
- Cennini, Cennino, and Lara Broecke. *Il Libro dell'Arte: A New English Language Translation and Commentary with Italian Transcription*. London: Archetype Publications Ltd, 2015.
- Clarke, Mark. *Mediaeval Painters' Materials and Techniques: The Montpellier Liber Diversarum Arcium*. London: Archetype, 2011.
- Foyer, Emilie. “BnF Ms. Fr. 640, fol. 29v and 57r: “Gold Without Gold” *The Making and Knowing Project*. New York: Columbia University. Fall 2015.
- Kemp, Martin. *Behind the Picture: Art and Evidence in the Italian Renaissance*. New Haven: Yale University Press, 1997.
- Kirby, Jo, Susie Nash, and Joanna Cannon, eds. *Trade in Artists' Materials: Markets and Commerce in Europe to 1700*. London: Archetype Publications, 2010.
- Kirby, Jo. “The Price of Quality: Factors Influencing the Cost of Pigments during the Renaissance.” In *Revaluing Renaissance Art*, edited by Gabriele Neher and Rupert Shepherd, 19-42. Hampshire: Ashgate, 2000.
- Nash, Susie. ““Pour couleurs et autres choses prise de lui...”: The Supply, Acquisition, Cost, and Employment of Painters' Materials at the Burgundian Court, c. 1375-1419.” In *Trade in Artists' Materials: Markets and Commerce in Europe to 1700*. edited by Jo Kirby, Susie Nash, and Joanna Cannon. London: Archetype Publications, 2010.
- O'Malley, Michelle. *The Business of Art: Contracts and the Commissioning Process in Renaissance Italy*. New Haven: Yale University Press, 2005.
- Tavares da Silva, Alice. “Reconstruction of the Tin Relief Decoration on the Thornham Parva Retable.” In *In the Artists' Footsteps: The Reconstruction of Pigments and Paintings*,

edited by Lucy Wrapson, Jenny Rose, Rose Miller and Spike Bucklow. London: Archetype, 2012.

Theophilus, John G. Hawthorne, and Cyril Stanley Smith. *On Divers Arts; the Treatise of Theophilus*. Chicago: University of Chicago Press, 1963.

Thompson, Daniel V. *The Materials and Techniques of Medieval Painting*. New York: Dover Publications, 1956.

Tintori, Leonetto. “‘Golden tin’ in Sienese Murals of the Early Trecento.” *The Burlington Magazine* 124 (1982): 92-95.