Zeitschrift: Kunstmaterial

Herausgeber: Schweizerisches Institut für Kunstwissenschaft

Band: 4 (2017)

Artikel: Photographic layer and paint layer: approaches to tempera beyond tradition

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DOI: https://doi.org/10.5169/seals-882604

Photographic layer and paint layer: approaches to tempera beyond tradition

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THE INVENTION OF '*ERBSWURST*'

In 1867 the Berlin-based chef Heinrich Grueneberg invented '*Erbswurst*' (pea sausage). Despite its name, *Erbswurst* was not a true sausage but one of the very first instant food products. Composed of dried bacon and flour made from ground peas enveloped in a natural sausage casing, when the filling was squeezed out and dissolved in hot water it produced a nourishing soup. In 1870–1871, during the German–French war, *Erbswurst* was selected as one of the best products for feeding the German troops: it was tasty, kept well even under the worst conditions and was thought to be easily mass-producible. The only problem with this plan was the casings, as sufficient supplies of animal instestines were not available. Parchment paper was chosen instead, but for holding the paper together it seemed impossible that a glue could be found that would not dissolve later in the production process, as *Erbswurst* had to be cooked in boiling water. The problem was solved by the Berlin-based chemist Emil Jacobsen (1836–1911).[1] He mixed hide glue with potassium bichromate and then cured the glued parchment paper joints with light, which rendered them insoluble in water (Jacobsen 1871; Vogel 1874, pp. 254–255).

The light sensitivity of bichromates had been discovered by the Scottish researcher Mungo Ponton (1801–1880) in 1839 (Eder 1932, p. 356). Subsequently, in 1852, Henry Fox Talbot (1800–1877), one of the inventors of photography, had found that a combination of gelatin and potassium bichromate becomes insoluble in water after exposure to light and had used this formulation for the production of printing plates. The fact that the light-exposed areas of such mixtures could be swollen was first exploited in 1855 by Louis-Alphonse Poitevin (1890–1882) when he invented the collotype; further exploitation of the same property later led to the invention of carbon and pigment printing (Eder 1932, pp. 773–775).

Jacobsen was the scientific advisor of the pharmacy Grüne Apotheke in Berlin, which later became the well-known chemical company Schering AG. He also had a great sense of humour: he wrote a chemical textbook in rhymes, called *Der Reaktionär in der Westentasche* (*The Radical in the Waistcoat Pocket*), the title of which is a pun referring to political tendencies in Germany in his time. Jacobsen was a friend of Hermann Wilhelm Vogel (1834–1898) who, in 1873, had discovered the sensitisation of the photographic layer for all wavelengths of the visible spectrum. This led to a great improvement in the technology of black and white photography, and later formed the basis for almost all processes of colour photography. To sensitise the photographic layer, Vogel added small amounts of synthetic dyestuffs to the photographic 'emulsion' (see below). His friend Jacobsen, who had discovered some of these first dyestuffs, had also conducted research on dyes specifically to be used for this purpose (Röll 1939).

It was left to the famous scientist Wilhelm Ostwald (1853–1932), one of the pioneers of physical chemistry and winner of the 1909 Nobel Prize, to propose a tempera medium for painting that was based on the effect of hardening under the action of light.[2] In 1904, in his *Letters to a Painter*, Ostwald wrote (here, from the historical translation by Ostwald's pupil H.W. Morse):

> At the present time we understand by tempera those media which can be diluted to any degree with water while they are in the fresh state, but which become insoluble in water when once dry [...]. Chemistry offers a whole series of means for solving this problem. The principle of the oil process might be used, and a substance chosen which becomes insoluble by oxidation; or the action of light in making certain combinations of substances insoluble might be used; or one might apply to the finished painting a substance which will make the medium insoluble (Ostwald 1907, pp. 139–140).

As an example for use of the action of light Ostwald continued:

> [...] one might paint with gelatin to which is added a very small amount of any soluble chromate. The

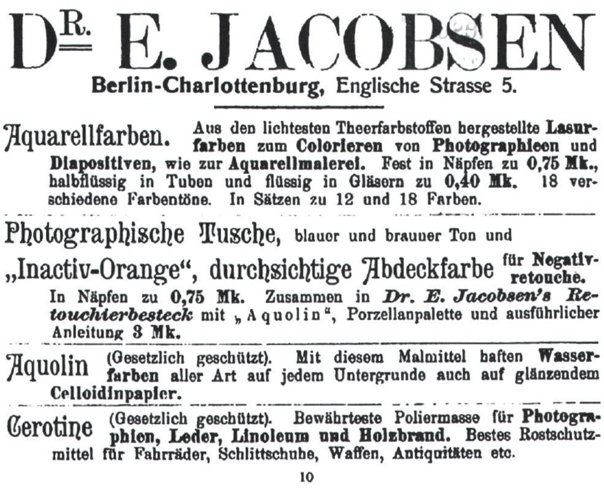

Fig. 1 Advertisement for products from E. Jacobsen's laboratory. (Reproduced from Schmidt 1906, p. 336.)

> action of light is then sufficient to produce an insoluble compound from the salt and the gelatin. Here [...] the yellow color of the chromium compound is somewhat inconvenient, but this disappears under the influence of light, being replaced by a more neutral tint (Ostwald 1907, p. 140).

Although it is not known for certain if Ostwald was aware of Jacobsen's invention, it seems highly likely as Ostwald took pains to be thoroughly up to date with the contemporary chemical literature. It does not appear, however, that his suggestion for a tempera medium was ever put into practice. This was probably due to two serious drawbacks: firstly, the yellow colour of the medium made it unsuitable for bright tints, and secondly, the shortness of the time span (between one minute and several minutes) sufficient for light to harden gelatin would also have rendered its usage highly impractical.[3]

A DIFFERENT APPROACH

We tend to view the so-called 'tempera revival' around 1900 throughout Western Europe as an exploration of the techniques employed by medieval and Early Renaissance painters. Much time was spent on the careful study of technological sources: the new editions of Cennino Cennini and the *Schedula diversarum artium* were ground breaking, as was Ernst Berger's (1857–1919) comprehensive source research. However, at the same time we also find a different, very modern tendency in tempera studies. Remarkably, its protagonists did not employ the rhetoric otherwise characteristic of the period, which involved constant invocations of the 'Old Masters' followed by promises to regain the fabulous advantages and qualities of their media. Among the proponents of this alternative approach was a small group of artists and inventors inspired by modern methods derived from the processes employed in contemporary photography.

As is widely known in technological circles, the so-called photographic 'emulsion' is not an emulsion at all, but rather, a suspension: it consists of gelatin or some other organic binding medium in which silver salt particles are dispersed. Today we understand the combination of gelatin – or some other colloid – and silver salts as a photosensitive unity, where gelatin components enhance the light sensitivity of the silver halides.[4] However, the first colloids used in photography were considered merely as simple glues or binders for attaching the photosensitive substances to glass plates or papers. Only a few years after the invention of the daguerreotype, the question of the 'binding media' of the photosensitive layer became crucial for the further development of photography. In addition to gelatin, the predominant medium in photography since around 1880, researchers and inventors experimented with many other colloids, among them genuine emulsions such as casein (considered in more detail below). In 1847, Niépce de Saint Victor (1805–1870) attempted to fix iodine salts onto glass plates variously with starch, gelatin and egg white (albumen) (Eder 1932, p. 471). In 1850, Poitevin experimented with gelatin as a binding medium for the silver salts he preferred (Eder 1932, pp. 472, 589). Ultimately, the first researcher to produce a photographic 'emulsion' with gelatin seems to have been Marc-Antoine Gaudin (1804–1888) in 1853 (Eder 1932, pp. 525, 589). Not only was the function of these colloids analogous to that of the binding medium in paints, but the colloids themselves were identical to the media found in watercolour, gouache, distemper and tempera painting, and in the secco techniques employed in wall painting.

The wet collodion process, used between 1860 and 1880, was an important improvement in its time, but remained a brief episode in the history of photography. As the wet process was complicated, photographers sought to develop a dry process to replace it. But in a dry state, the collodion layer loses its high sensitivity. In 1871, Richard Leach Maddox (1816–1902) invented the silver bromide/gelatin process (Eder 1932, pp. 517–520). Shortly thereafter, in the early 1880s, the use of dry gelatin plates finally replaced the wet collodion process (Eder 1932, pp. 591–593, 600).

JACOBSEN'S 'AQUOLIN'

Emil Jacobsen, who had solved the *Erbswurst* problem, later invented a vehicle for tempera painting which was subsequently produced commercially. He called it 'Aquolin', a name derived from the Latin for water (*aqua*) and oil (*oleum*). Its main advantage was that any category of paint mixed with the Aquolin medium could be applied on nearly all types of surfaces, regardless of whether they were rough or smooth, lean or greasy. To set the paint layer and to make it water resistant, for the finishing step a wax/resin fixative was applied over it with a brush. Jacobsen himself described his medium as 'a composition of albumen-like and soap-like substances with emulsified fats' (Anonymous 1893a; see also the contribution by Pohlmann *et al.*, in this volume). Painting with Aquolin was similar to painting with the so-called *Weimarfarbe* (Weimar paint), an artists' paint based on an oil/resin medium which could be transformed into water-miscible soaps during the painting process (Feuchter-Schawelka 2005; Pohlmann 2012a, pp. 186–187) by adding the vehicle *Feigenmilch* ('fig milk'), which was not natural fig latex at all, but rather an artificial composition of several substances, mainly soaps (Fig. 1; see also the contribution by Pohlmann *et al.*, in this volume). Like most of the new tempera systems that were invented around 1900, painting with Aquolin was said to combine the advantages of aqueous techniques, such as watercolour or gouache, with those of oil painting without having any of their disadvantages (Anonymous 1893b).

Fig. 2 Colour chart with Bössenroth paints. (Reproduced from Trillich 1925, after p. 96.)

Aquolin was patented in 1892 (Patent DE71444, 11 November 1892), and surprisingly soon gained importance for many photographical uses to a far greater degree to that which it had gained for painting. Only

Fig. 3 Advertisement for *Tempera-Pastell Bössenroth*, 1922. (Reproduced from *Photographische Chronik* 29(45), 1922, p. 45.)

two years after the patent, Aquolin was first mentioned as an aid for colourising silver bromide prints on paper, and from then on it appeared in the context of many of the photographic uses described in the various contemporary photography magazines and textbooks (Jacobsen 1894). It was frequently recommended as a coating for photographic prints that were later overpainted with aqueous media such as watercolours or gouache.

OTTO BUSS: EXPERIENCE IN MANUFACTURING PHOTOGRAPHIC PAPERS

Otto Buss (1871–1906),[5] a Swiss chemist with an affinity for the practical application of paints and pigments in all forms of contemporary imaging techniques, worked in a different direction. He wrote his doctoral thesis on the spectral analysis of synthetic organic dyestuffs (Buss 1896) and dedicated his research to the problems of early colour photography, especially the so-called Lippmann process, where the colours on the photographic plate were generated by interference.[6] In the 1890s, Buss headed the photochemical department of the company Schering AG in Berlin.

One of Buss' particular interests involved research into the improvement of 'gum printing' – a photographic printing process based on the light sensitivity of bichromates in gelatin. For the printing itself, real pigments or, more frequently, paints were used. Buss' company manufactured *Gummidruckfarben* (gum-based printing paints) in tubes that were exclusively used in the making of gum prints (Oettel 1913, p. 70). Gum printing is perhaps the photographic printing process that is closest to the process of tempera painting and, in a sense, the photographic equivalent of Ostwald's concept.

In 1903, Buss founded a factory for photographic materials in Rüschlikon near Zurich. One of his better-known inventions was the so-called Casoïdin paper, a photographic paper prepared with a photosensitive layer that contained casein (Patent GB190122040, 1 November 1901; Patent US705643, 29 July 1902). Casoïdin is first

Fig. 4 Advertisement of Vereinigte Farben- und Lackfabriken vormals Finster und Meisner (The Unified Paint and Enamel Factories formerly Finster and Meisner), 1927. (Reproduced from *Technische Mitteilungen für Malerei* 43(1), 1927, p. 11.)

mentioned in the photographic literature around 1905. Unlike many earlier inventors, Buss made strict distinctions between the function of a binding medium and that of a photosensitive layer. He worked out a method to prepare only the binding medium, a casein (a natural emulsion of milk fat in water) layer, which was described in an article in the *Journal of the Society of Chemical Industry* as follows:

> Casein is dissolved in citric acid solution, glycerine is added (to make the film ultimately formed flexible) and the liquid is filtered while warm. Paper is coated with this liquid at a temperature of 35° to 50° C, then dried, and drawn slowly over or through a dilute solution of sodium or ammonium chloride, which renders the film insoluble. The dried or still damp paper is then sensitised by being floated upon a silver solution (Anonymous 1902).

In 1916, independently of Buss, the Russian chemist Maklakoff proposed the use of a milk-based emulsion, sensitised by silver bromide, for photographic purposes (Plotnikow 1920, pp. 643–644).

His experience with the use of casein probably inspired Buss to create a new tempera medium for painting based on this material. Buss was probably encouraged by his friend, the Munich painter and scholar Ernst Berger. After Buss' death, Berger published excerpts of a treatise on tempera Buss had been planning to publish, which contained a general survey on all substances then used in contemporary tempera painting, but which did not explain the principle of Buss' own tempera medium (Buss 1908). According to a newspaper article of 1904, it could be used as a watercolour, but could also be mixed with three different media that contained beeswax. Among the special properties of Buss' tempera the article mentions its extraordinary brightness, the tinting strength of the pigments it contained, and its suitability for impasto painting (Berger 1905a). After Buss' death in 1906, Berger published reports by the Swiss painters Hermann Gattiker (1865–1950), Ernst Würtenberger (1868–1934), Fritz Widmann (1869–1937) and Christian Fürchtegott Brunnschweiler (1874–1960) (Berger 1912b; Beltinger 2015, p. 46).

It is not known whether or not Buss' tempera actually did contain casein, but it seems likely given his extensive experience working with casein as a binding medium for photographic papers. His description of the manufacture of Casoïdin paper from 1902 (described above) is very similar to his remarks on the dissolution of casein in dilute acids for tempera painting, which were published posthumously by Berger (Buss 1908).

CARL BÖSSENROTH AND GELATINE-BASED DRY PLATES

Since 1905, the painter Carl Bössenroth (Beitz 2000) had been known for his new painting materials, which he produced in his little factory in the artists' colony of

Dachau near Munich. An egg tempera that he improved several times in the following years may be counted among his inventions (see the contribution by Pohlmann *et al.*, in this volume). Used in combination with a special *Tempera-Emulsionsgrund* (tempera-emulsion ground) and additional painting vehicles, his tempera was one component of a larger set of tempera painting materials (Pohlmann 2010b).

In 1912, Bössenroth obtained a patent for a completely new system of artists' paints: the so-called '*Tempera-Pastell Bössenroth*' (tempera pastels) (Patent AT63368, 31 December 1912). In fact, it was a hybrid of pastel and tempera: the pigments were manufactured in stick form (Fig. 5). Unlike common pastels, where a small amount of medium is needed just for binding the pigment grains, in his pigment sticks Bössenroth mixed the pigments together with enough binding medium so that the pigments would fix onto the ground (Fig. 2). The main component of the binder was the blood protein fibrin, which was derived from ox blood. Once the pigment material was applied to the ground, it could be further worked on with water, like paint. The paint layer was made water resistant as the final step when sprayed with a solution of formaldehyde (Bössenroth 1915; Bössenroth 1921; see also the contribution by Pohlmann *et al.*, in this volume).

Discovered in 1855 by the Russian chemist Alexander M. Butlerow (1828–1886) and synthesised in 1867 by his German colleague August W. von Hofmann (1818–1892), formaldehyde was for a long time regarded merely as an intermediate product in the still mysterious process of photosynthesis. Only in 1894 did Schering AG, possibly prompted by its scientific advisor Jacobsen, obtain a patent for the hardening of gelatin by using a solution of formaldehyde to give the photographic layer improved resistance to water (Patent DE107637, 5 October 1894; Eder 1902, pp. 46–47). Bössenroth mentioned this invention as an example of his own method of rendering his pastel paints insoluble, and that he took the chemical principle for his *Tempera-Pastell* from the hardening of photographic gelatin dry plates with an aqueous formaldehyde solution (Fig. 3). Also interesting is that in the photographic literature of the time, *Tempera-Pastell* was recommended as a very suitable artists' paint for colourising photographs because the proteins of the binding medium were highly compatible with the proteins of the photosensitive gelatin layer (F. & M. 1922).

In the last decade of the 19th century, many scientific articles appeared concerning the action of formaldehyde on gelatin and proteins. Some of these processes soon became useful for medical or commercial purposes: for disinfection, the tanning of leather, the production of early plastics such as Galalith and for the hardening of photographic layers. Ostwald also proposed formaldehyde as a hardening agent when he commented on the tempera problem in his *Letters to a Painter* from 1904 (again from the 1907 translation):

> Finally, you might paint with gelatine, and spray with a solution of formalin [an aqueous formaldehyde solution] after each coat is dry. This combines with the gelatine to form an insoluble compound, and the desired end is attained, for the excess of formalin evaporates, escaping without any further effect on the picture (Ostwald 1907, pp. 140–141).

In 1906, the pharmacist Ernst Friedlein (1841–1919) recommended the application of an aqueous formaldehyde solution in his book *Tempera und Tempera-Technik* (*Tempera and Tempera Technique*) as a means to harden the size in chalk or gesso grounds. Subsequently, Ostwald invented a method to use pastel sticks for wall painting, which he named '*monumentales Pastell*' (monumental pastel). To render the pastel (whose fixative was based on casein) waterproof, he recommended spraying it with a formaldehyde solution. The German painter Sascha Schneider (1870–1927) was the first to apply this method. To demonstrate its resistance against water with dramatic flair, Schneider would throw a soaking wet sponge against the surface of his 'monumental pastels' before audiences (Ostwald 1912).

Fig. 5 Box with *Tempera-Bössenroth* pastel sticks, assortment 'Portrait'. (Courtesy of Carl Bössenroth-Archiv, Museum Eckernförde, Germany.)

Unlike other formulations, Bössenroth's invention was a success. The manufacture of *Tempera-Pastell* was carried out by the Munich-based company Vereinigte Farben- und Lackfabriken vormals Finster und Meisner (The Unified Paint and Varnish Factories formerly Finster and Meisner) (Fig. 4). It was advertised as one of their main products until 1943; the last known advertisement for *Tempera-Pastell* appeared in a catalogue from the Haus der Deutschen Kunst (House of German Art) from that year (Munich 1943). Bössenroth himself seems to have used his pastel sticks only infrequently; most of his paintings appear to be ordinary oil paintings. In the museum of Eckernförde, which owns a large collection of Bössenroth works, there is only one that seems to have been painted with his *Tempera-Pastell* (Beitz 2000, p. 22): the *Portrait of a Little Girl*[7] does not have the appearance of a pastel drawing, but rather looks as if it was created with fluid gouache, tempera or oil paints.

ERNST FRIEDLEIN

Finally, the name of Ernst Friedlein must be mentioned in the discussion of modern tempera formulations of the early 20th century. The chemist, who ran a pharmacy in Würzburg from 1888 (Röder 1888, p. 295), was a member of the Deutsche Gesellschaft zur Beförderung rationeller Malverfahren (German Society for the Promotion of Rational Painting Methods), and who participated in the congress for painting technique in 1893 in Munich and published the well-known book on tempera technique in 1906 (Friedlein 1906), is the Ernst Friedlein most familiar to scholars of painting technique. However, in 1866, a chemist of the same name from Nuremburg obtained a patent for *Weingeist-Tuschfarben* (spirits of wine paints) (*Bayerische Zeitung* 1866), a paint for artists based on natural resins including copal, mastic and sandarac, which could be used on prints or photographs (Anonymous 1869). A decade later, in 1876, 'Ernst Friedlein' published a brochure on the practice of pigment or gum printing, which enjoyed some attention, as it was quoted in several contemporary photographic periodicals (Friedlein 1876). It is unclear whether or not the Friedlein who had conducted research in the photographic domain should be identified with the well-known pharmacist Friedlein who focused on tempera paints for painting some years later. If this was the case, we would have a fifth example for a direct connection between the two fields of research: photography and tempera painting.

CONCLUSION

Among those discussed in this study, only Ostwald – and, in a sense, Jacobsen, not with his Aquolin medium, but with his glue for *Erbswurst* – took a genuinely photochemical approach to tempera painting. The others used processes other than actual photochemical reactions: processes and materials to fix the photosensitive substances onto a support (at that time mostly glass or paper) or to harden the gelatin, so that it could resist aqueous exposure.

As has been shown, the tempera revival around 1900 not only comprised study of the historical past, but also modern technical knowledge of contemporary artists and inventors in the field of photography, an inventive cross-fertilisation that has heretofore received little attention.

1 For Jacobsen's biography see Jacobsen 2011, pp. 5–7.

2 For Ostwald's colour theory and art-technological research see Pohlmann 2010a.

3 '*Chromleimfarbe*' (chrome glue paint) was used in the first decades of the 20th century for a very short time and only as a house paint (Wenzel 1912, p. 136; Koch 1931, p. 507).

4 In 1925, S.E. Sheppard published the results of his research concerning the photochemical active substances in different gelatins used for photosensitive layers (Sheppard 1925). For the modern scientific approach see Fujita 2004, pp. 52–54.

5 For his professional biography see Baur 1989, pp. 20–21.

6 This is the principle of the imaging process we today call 'holography'.

7 Inv. no. 1996/167.