Figure 3 Ernst Berger, study painting in the technique of Cennino Cennini after Sandro Botticelli, *Primavera* (detail), Uffizi Gallery, Florence, Deutsches Museum inv. No. 11564 (Berger 1897: 114). (Photo: Bayerische Staatsgemäldesammlungen © Deutsches Museum.)

Figure 4 Alexander Eibner (first row in the middle) at the Versuchsanstalt- und Auskunftsstelle für Maltechnik (Research Institute and Information Centre for Painting Technology) at the Technical University of Munich. The person on his left is probably presenting Eibner's book *Malmaterialienkunde als Grundlage der Maltechnik*. (Photo: estate of Prof. Anton Dietl, made available by Ingo Rogner, Akademische Chemiker Verbindung.)

some varnish recipes. A comparison between the 1916 and 1920 editions of *Technik der Malerei nebst kurzgefaßter Farbenlehre* and the 1928 edition revised by Max Doerner after Wirth's death, reveals several changes in the tempera recipes. For example, Doerner removed glycerine, vinegar and honey previously used by Wirth and recommends egg and casein instead of gum arabic (see Table 2).

Ernst Täuber

Contributions in *Technische Mitteilungen für Malerei* and *Münchner kunsttechnische Blätter* (*Munich Art Technology Newssheets*) by Ernst Täuber (1861–1944) evidence a deep research interest in oils, resins, wax and pigments with less emphasis on tempera. After retiring in 1934 Täuber published the article '*Kleiner Ratgeber in künstlerischen Materialfragen*' ('Concise manual of questions of artists' materials') (Täuber 1934/1935; 1935) as a condensed outcome of his teaching, which also contained a very short passage on tempera binders. Täuber provided recipes for an egg-linseed-oil and a casein-linseed-oil emulsion (Täuber 1934/35: 51) (see Table 2). He considered it acceptable to add resin solutions in small quantities and advised that the addition of wax emulsions might have some positive effect but additions such as glycerine and vinegar were rejected categorically. To avoid colour change induced by varnishing, the application of a solution of casein or zapon was recommended before applying a dammar matt varnish (*Dammar-Mattlack*). Whereas in Berlin Täuber and Wirth seemed to have cultivated a peaceful and harmonious coexistence, the situation in Munich was affected by rivalries and competition.

Munich

Ernst Berger

Ernst Berger (1857–1919) experienced this atmosphere of intrigue when his lectureship at the Academy of Fine Arts (Akademie der Bildenden Künste) came to an end in 1904 after two winter semesters. Berger's research into the history of painting techniques and his extensive teaching exerted a remarkable influence on the reception of tempera painting (Kinseher 2016). Berger supplied a series of tempera recipes (see Table 2),[9] even including some from standard works on decorative painting (Berger 1897: 258–60),

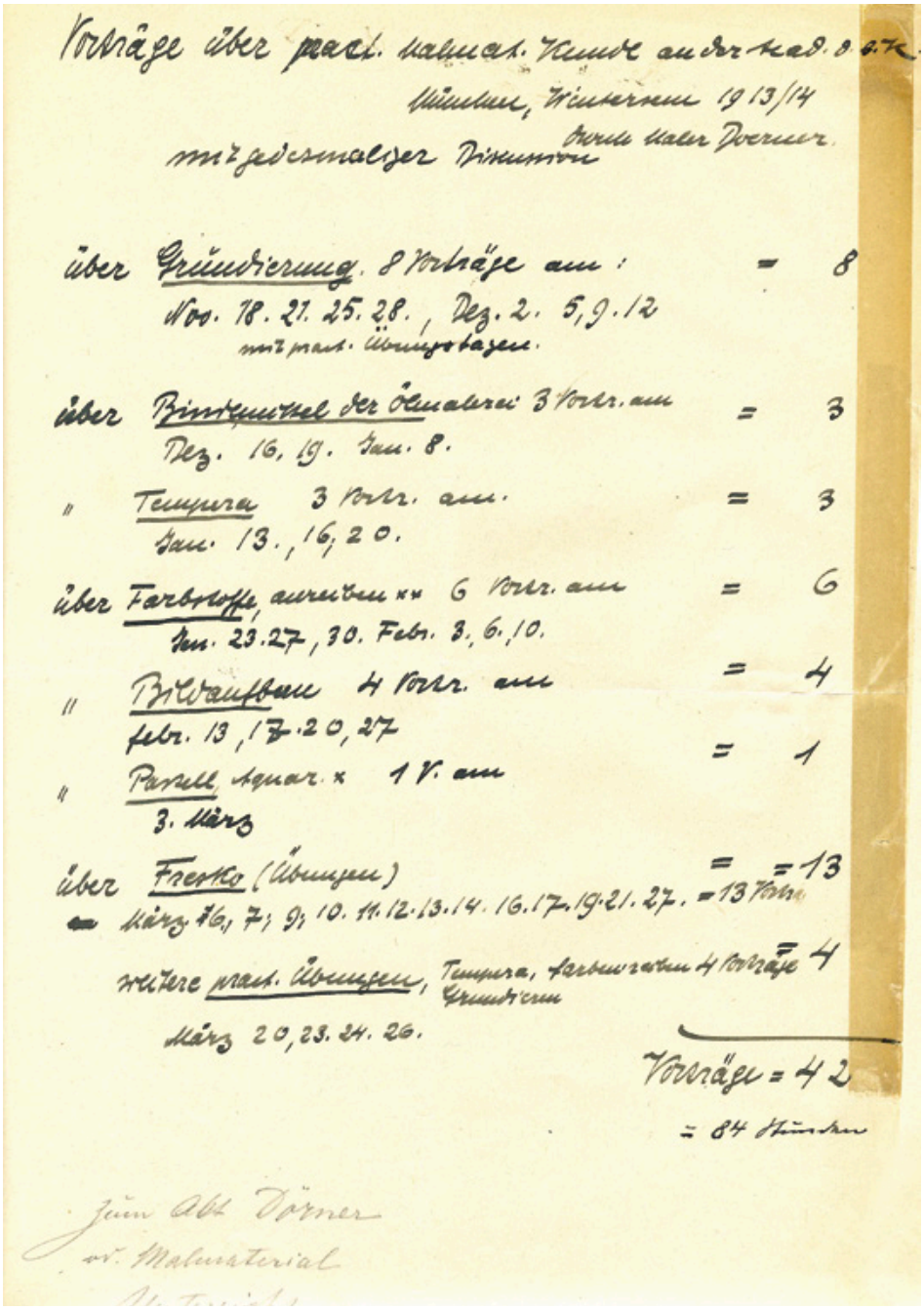

Figure 5 Max Doerner, list of lectures at the Academy of Fine Arts, Munich, during the winter semester 1913–14. (Photo: Kathrin Kinseher © Akademie der Bildenden Künste München.)

and described some of the commercially available tempera paints that already included paints mixable both with water and oil.[10] His study paintings on technique served as teaching aids as well as exhibits in the Deutsches Museum's painting room (Kinseher 2018) (Fig. 3).

Alexander Eibner

Starting from the winter semester 1905, before regular technical lessons were established at the Academy of Fine Arts, painting students were required to attend the lectures by the chemist Alexander Eibner (1862–1935) at the Technical University of Munich (Technische Hochschule München). The programme and dates of Eibner's lectures were announced in *Technische Mitteilungen für Malerei* (Anon. 1905, 1906). Different types of tempera were explained in lecture 9 (of a course of 12) among a variety of subjects that included coal tar pigments as well as inorganic and organic

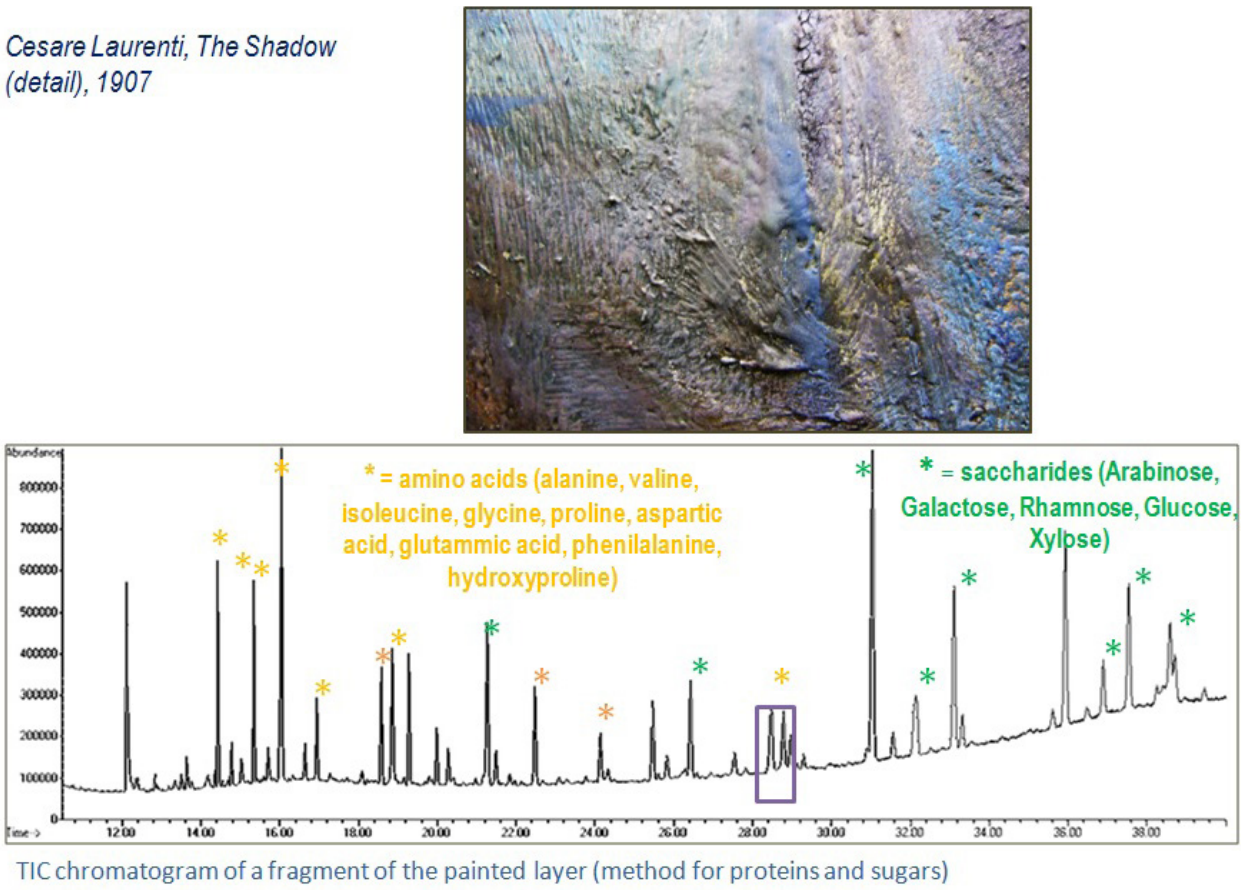

Figure 5 GC-MS analysis of Laurenti's tempera.

Figure 6 Cesare Laurenti, *The Shadow* (detail), tempera on wood, 1907, Museo Ca' Pesaro, Venice.

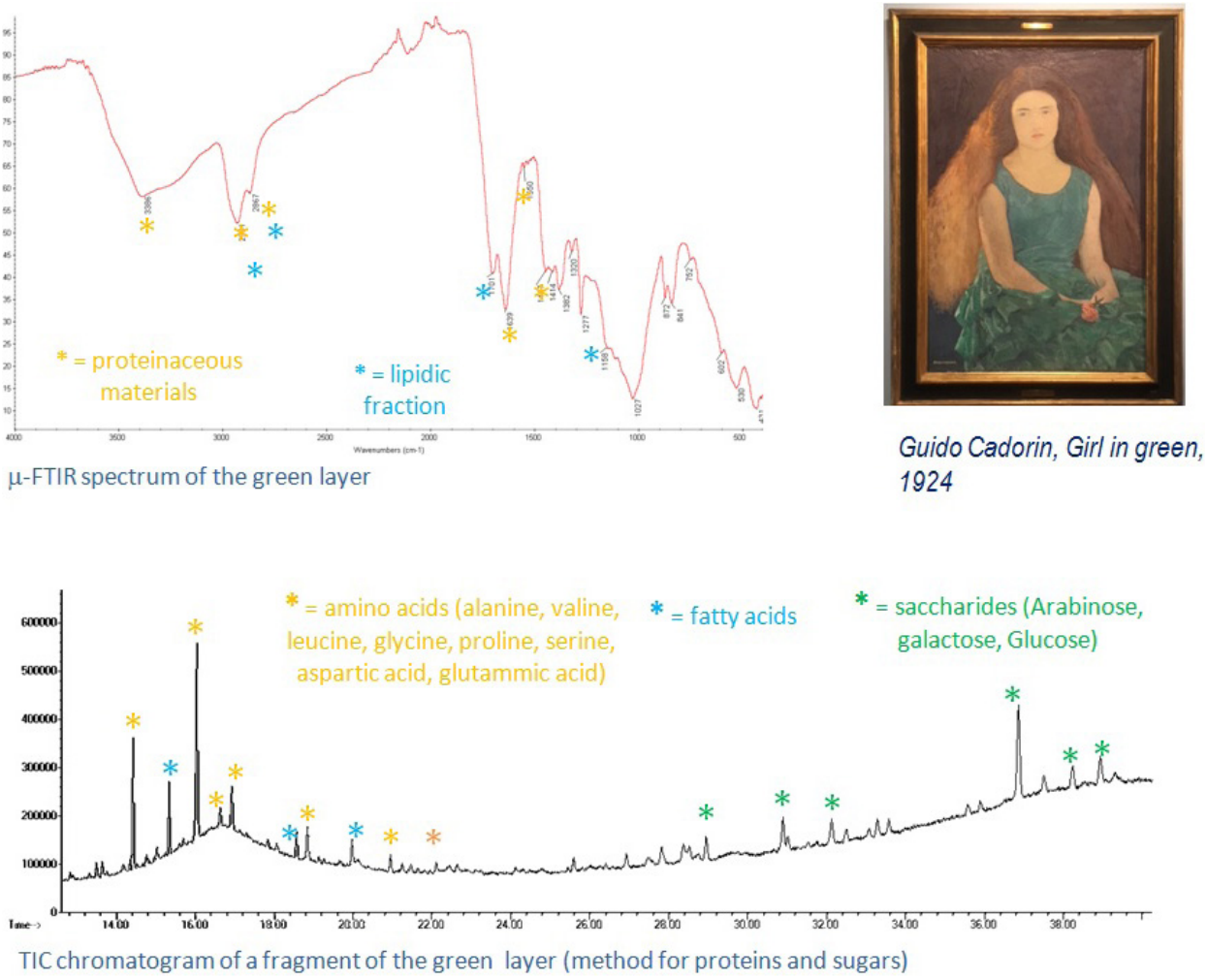

Figure 7 Micro-FTIR and GC-MS analysis of Cadorin's tempera.

years from the age of 15, Cadorin attended the school run by Laurenti from whom he learned the love of tempera (Dal Canton 2007: 32–9). In his technical notes, Laurenti suggested the use of skin glue-based tempera as a medium for clear colour and a mixture of gum arabic and flax seed mucilage for dark colours (Laurenti 1990: 81; Rinaldi *et al*. 2017) but until now his tempera medium has not been analysed. In this study, for the first time, we have scientific evidence of the recipes used by Laurenti for two important paintings in the International Gallery of Modern Art Ca'Pesaro in Venice, *New Flowering* (1897) and *The Shadow* (1907), both dating to the period in which the artist carried out most of his experiments with tempera recipes. Analyses using μ-FTIR and GC-MS performed on microsamples taken from the selected paintings confirmed Laurenti's descriptions of his recipes: in particular, animal glue was found as the binding medium for white and clear brushstrokes, while the typical polysaccharidic compounds present in the gum arabic and flaxseed mucilage were detected for dark and brown colours (Fig. 5). Furthermore, Soccol's reconstruction tests showed that the latter recipe is perfect for dark pigments especially in thin layers as can be observed in *The Shadow* (Fig. 6).

With reference to Cadorin's tempera paints, it is known that he mainly used an emulsion tempera containing egg, glue and linseed oil (Fig. 7) for easel paintings and a casein-based tempera on walls. Unlike Maimeri or Ferrario, neither Cadorin nor Favai turned from self-made paints to industrial tempera even in the 1940s and 50s when inexpensive Italian commercial tempera paints were easily available. From the 1960s Cadorin added Vinavil (a vinyl polymer produced by Montedison, Italy) to his egg

Figure 5 *Fall of the Titans*, *c.*1904, casein paint on canvas (reproduced from Galland 1916, fig. 42].

Figure 6 *Head of Apollo*, 1901, tempera on canvas on cardboard, 88.5 × 64.5 cm, Städtische Galerie Dresden – Kunstsammlung Museen der Stadt Dresden. (Photo: Franz Zadnicek.)

away in small flakes when it is painted; very bad!' (Prell 1916: 76).[22] The drenching of the surface in casein or a mixture of wax and petrol was unsuccessful. Recognizing that Gerhardt's impregnation lacquer made the painting appear darker he only used it elsewhere (Prell 1916: 76). The tempera from Neisch & Co. was used for the top paint layer (Prell 1916: 76).[23] Finally he was satisfied at least with the aesthetic aspects of the execution, noting that 'it looks just like fresco, but it is not so firm as all the rest, and care will be needed when it comes to be cleaned' (Prell *c.*1921, XVI: 55).[24]

Fall of the Titans: casein paint on canvas

The staircase ceiling had originally been divided into three areas by stucco ornaments. Prell however intended to create just one picture, and had a wire-mesh plaster ceiling installed below the existing ceiling (Prell *c.*1921, XVI: 1). The painting (80 m^2) was executed in tempera paints on canvas and later adhered to the ceiling (Wünsch 1994: 24) (Fig. 5).

Before carrying out the work, Prell tested a number of technical variants: 'Experiment with Neisch tempera, on the Neisch Helferling ground, and egg, zinc white, chalk slurry and boiled linseed oil. The ground is firm; when moistened from behind it softens, however; it is easy to moisten from in front. The paint is easy to treat; it remains almost entirely unchanged' (Prell 1916: 71).[25] The tempera study *Head of Apollo* (Fig. 6) for this painting, dating from 1901, has survived, with an inscription recording a similar recipe: 'Ground does not take easily/ and runs/ Helferling/ chalk-egg/ boiled linseed oil.'[26]

Two further studies are inscribed with technical details that show how the artist approached the materials. *Titan and Horse* (Fig. 7) was painted in casein paints from Neisch on a Helferling ground

Figure 7 *Titan and Horse*, *c.*1901, tempera on canvas, 71 × 100 cm, Städtische Galerie Dresden – Kunstsammlung Museen der Stadt Dresden. (Photo: Franz Zadnicek.)

with casein zinc white and judged by Prell to be very good: 'Ground: casein-zinc-white [Helferling] Neisch/ casein paints Neisch/ very good, even on dry [canvas]/ only slight brightening/ very firm.'[27] He painted *Titan's Head* (Fig. 8) in tempera paints made by Neisch on a moist Helferling ground: 'Neisch tempera/ Helferling ground/ wets from behind.'[28]

The execution on 'casein canvas' (Prell 1916: 71) seems to have corresponded with his 'casein technique on canvas' for the Danzig paintings described above: 'The large cartoon for the ceiling picture transferred to the canvas by two pupils, [Richard] Schlösser and [Paul] Harnisch and the underdrawing executed' (Prell *c.*1921, XVI: 28).[29] In the process, he carried out the 'underpainting on the dry [canvas] with umbra, terra di siena, ultramarine – as needed. Finally underpainting in local colours without looking at the effect until no bare canvas was anywhere to be seen and the picture was there in its entirety' (Prell XIV, 310).[30]And then Prell began to paint:

> I had it moistened from behind piece by piece with a spray and a large sponge, until it was totally wet. The wet area looks considerably darker. I mixed the main hues, as with fresco, in glass jars until they were stiff, in order to constantly keep the

Figure 8 *Titan's Head*, 1903, tempera on canvas, 43.6 × 30.8 cm, Städtische Galerie Dresden – Kunstsammlung Museen der Stadt Dresden. (Photo: Franz Zadnicek.)