Rediscovering *tempera grassa*: rheological properties of emulsion-based paints

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Painting technique in Europe went through a major shift in the 15th century, thanks to newly-developed control of the drying of oil. The use of egg as a binder in *tempera* paintings was gradually replaced by oil paint. However, this switch required adjustments and trials by Renaissance artists. For instance, analytical evidence highlights the occasional use of both types of binders, egg and oil, mixed together in a single paint layer, a technique called *tempera grassa*[1].

These emulsion-based paints remain barely studied from a physico-chemical point of view. The description of their macroscopic properties (flow, aspect, drying), strongly connected to their colloidal organization, is essential to precise and understand artistic practices. Rheological studies are particularly relevant in this field as these properties strongly impact the workability of fresh paint and its final visual aspect[2].

Without pigment, stable direct emulsions can be formed with egg yolk and oil over a wide range of oil fractions, allowing straightforward tuning of the flow of the binder (see Figure). When pigments are added, numerous colloidal systems may be formed depending on the relative fractions, characteristic sizes and affinities of each phase[3]. Formulations based on pigments such as Sienna or lead white were characterized. Study of their rheological properties reveals a strong influence of the formulation on the flow properties of the paint, depending on its structure on a colloidal scale. For instance, adding a small amount of egg yolk to an oil paint prepared with Sienna leads to a pronounced increase of its yield stress, indicative of the formation of a capillary suspension.

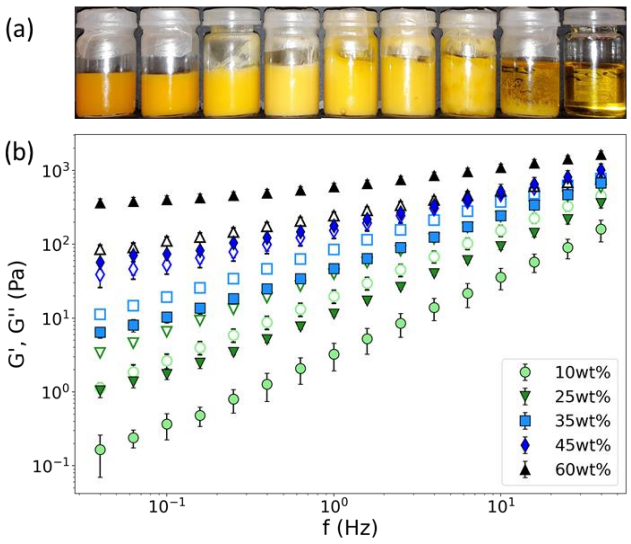

Figure: (a) Egg yolk and linseed oil direct emulsions with various oil fractions ϕ. From left to right: $\phi =$ 0, 10, 30, 45, 60, 70, 80, 90 and 100wt%. (b) Dynamic rheological properties of these emulsions: frequency sweep: G' (closed symbols) and G'' (open symbols) versus frequency for oil weight fractions ranging from 10 to 60wt%

[1] C. Bouvier, *Etude du vieillissement de peintures anciennes par imagerie par spectrométrie de masse 3D*, PhD manuscript, Sorbonne-Université (2022)
[2] J. Salvant Plisson et al., *Colloids and Surfaces A: Physicochem. Eng. Aspects*, **458**, 134 (2014)
[3] E. Koos, *Current opinion in Colloid & Interface Science*, **19**, **6**, 575 (2014)