Masterpieces as chemical systems: unlocking the reactivity of art

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Paintings are dynamic chemical systems that, from the moment of their creation, undergo a wide range of chemical and physical changes that can ultimately alter their appearance and stability. Phenomena such as discolorations, the formation of disfiguring surface crusts, dramatically increased transparency, water sensitivity, paint embrittlement or the formation of protruding lead soaps aggregates are frequently encountered in historical oil paintings. Understanding the mechanisms and driving forces behind the ageing and degradation processes in oil paintings is highly challenging due to the complexity and heterogeneity of these systems.

To gain deeper insights, masterpieces undergo comprehensive chemical analyses spanning the macro- to nanoscale in one, two, and three dimensions. Techniques range from macro-X-ray fluorescence scanning (MA-XRF) and Reflectance Imaging Spectroscopy (RIS) to correlated X-ray fluorescence and ptychographic nano-tomography. Analyses begin with non-invasive methods and, where feasible, extend to invasive investigations. The results are interpreted in the context of the conservation history of the painting and historical documentation of painting materials.

Insights obtained from the examination of real paintings guide the design of chemically well-designed model systems, which are subsequently studied to target specific reactions or mechanisms. Understanding these processes is essential for predicting how aging and degradation phenomena may progress over time, as well as for assessing the impact of conservation treatments, display conditions, and storage environments. In addition, this research provides a more detailed understanding of the artists' creative processes. In this plenary lecture, examples will be presented from paintings by, among others, Rembrandt, Vermeer and Van Gogh.

Figure 1: 'The Night Watch' (1642) by Rembrandt van Rijn, Rijksmuseum, Amsterdam, The Netherlands. Daylight photo (leftside) and elemental map of lead (M-shell) taken with the MA-XRF. (credits image: Operation Night Watch team, Rijksmuseum, Amsterdam)