Characterization of Oil Paints Through An In-Situ Experimental Micro-Mechanics Approach : Linking Deformation Behavior to Chemistry

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Abstract

Historical oil paintings represent an invaluable cultural heritage. At the same time, however, from an engineering perspective, oil paintings are also complex, multi-phase systems, in which the mechanical properties of oil paint are influenced by several factors, including composition, pigment-to-binder ratio, environmental conditions (temperature and humidity), and the age of the paint. These factors crucially affect the paint stiffness, ductility, and fracture response.
This study aims to investigate the mechanical behavior of oil paint through a novel integration of real-time microscopic inspection and micro-mechanical testing. Using advanced micro-mechanics techniques, based on micro-tensile testing (1), we conduct a detailed experimental analysis of stress-deformation responses in oil paint samples. Departing from profilometry images taken with a profilometer, Digital Image Correlation (DIC) is employed to obtain local strain maps of the paint samples during testing (2). The thickness of the samples can also be accurately measured before mechanical testing by correlating the top and back surface height profiles of the paint samples from the profilometry images. After the micro-tensile experiments, based on the obtained strain maps and force values for each step of loading and knowing the thickness of samples, stress-strain curves can be constructed, providing information about the mechanical properties of oil paints such as ductility and stiffness at the micro-scale.

To validate the experimental methodology, model system titanium white samples are prepared on polyester substrates. The samples are then exposed to accelerated thermal aging for different periods under controlled temperature and humidity levels.

This in-situ experimental methodology additionally incorporates spectroscopic analyses to characterize the chemical properties of the paint. By combining mechanical and chemical

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analyses, we gain a deeper understanding of the correlation between the chemistry and mechanical behavior of oil paints over time. This approach offers a versatile framework for studying a range of oil paint samples, linking their micro-structure to micro-mechanical properties, and shedding new light on the long-term behavior of oil paints.

References

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