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EVALUATION OF USING THE BIO-BASED GREEN SOLVENTS FOR THE CLEANING OF OIL PAINTED WORKS APPLIED ON A SELECTED MODEL

Submitted by

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Summary

Cleaning of oil paintings is a delicate conservation procedure through which the conservators aim to enhance the readability and appearance of paintings to their original states. For this purpose, cleaning procedures as the removal of discolored varnish layers and any extraneous material deposited on the painted surface over time may be required. Organic solvents are widely used for conducting this procedure. An important start to estimate the impact of oil painting cleaning is to well understand the solubility changes of oil painting materials with aging. However, the natural chemical alternations of oil painting materials are already complex, the possible additional alternations could be induced by solvent exposure. In this context, systematic studies were carried out to evaluate the tangible and intangible solvent effects on oil paint formulations. Besides, the controversial concerns of the conventional organic solvents used for oil painting cleaning, their potential hazard emissions have a potential risk not only to the healthiness of conservators but also to the indoor environment contamination. Recently, green materials have been supported in conservation practices aiming to have a low impact on the conservators' health and environment. This is available today in some methodologies in cleaning practices as gels, aqueous cleaning systems, and bio-cleaning which mainly aim to avoid and minimize the use of toxic solvents. Bio-based green solvents are benign alternatives to conventional petroleum solvents that fulfill the twelve principles of green chemistry. In this context, bio-based green solvents' effectiveness will need to be investigated in the field of oil painting cleaning.

This thesis is divided into three chapters. **Chapter I** includes the technical conception of oil painting cleaning with a description of the cleaning methods that must be chosen according to the physical and

chemical nature of the unwanted deteriorated materials. It also involves the principles of solvent selection for cleaning with clarification of solubilization theories and solubility parameter systems and the required physical properties of solvents that could affect the cleaning procedure. The changes in solubility of oil paints, natural varnishes, and synthetic polymers are also mentioned in this chapter. The potential risks induced by solvent-based cleaning from tangible and intangible effects on the oil medium besides their toxic effects on the operators' health and the ambient environment are also discussed. Description of the bio-based green solvents, sources, and their properties are also interpreted in this chapter.

Chapter II includes the condition assessment and technical analysis of Mohamed Ali Pasha portrait which was dedicated to the National Military Museum at Saladin Citadel in Cairo. Multispectral imaging, cross-sections, stereomicroscope, scanning electron microscope coupled with dispersive energy of X-ray spectrometer, Attenuated Total Reflection-Fourier transformed infrared spectroscopy, Gas chromatography-Mass spectroscopy, and X-ray diffraction were employed for technical analysis and assessment of Mohamed Ali painting conservation state. The technical analysis includes the stratigraphic structure of the original painting and the previous additions of conservation interventions. The ground layer is mainly composed of high proportions of barite, calcium carbonate, and low proportions of zinc oxide and basic lead carbonate. The binding medium was confirmed to be linseed oil. Carbon black, burnt sienna, green earth, yellow ochre, ultramarine, and a mixture of red lead and hematite were detected in the painted layer of the painting. Dammar varnish was also identified as a final varnish. The painting was previously conserved more than once; the different varieties of verse patches applied

to the original canvas confirmed the multiplicity of conservation interventions. This chapter also includes the experimental study through which two groups of mockups with the same stratigraphy of Mohamed Ali painting and thermally aged. The two groups mainly aimed to study how the different types of oil paint contents either having a catalytic effect on the drying process or not could affect their sensitivity toward the solvent during the cleaning of painting. Five bio-based green solvents were studied with one more inappropriate non-polar solvent. The experimental study included the investigations of the laboratory-prepared samples by the means of atomic force microscopy (AFM), and scanning electron microscopy (SEM). The soluble organic components of the oil binder that may be extracted from the paint films will be characterized by gas chromatography-mass spectrometry (GC/MS). Attenuated Total Reflection Fourier transform infrared spectroscopy (ATR- FTIR) was employed to evaluate the efficacy of the cleaning procedure and to study the possibility of carboxylate fatty acids migration within the paint layer. The likelihood of the bio-solvents retention was identified with thermogravimetric analysis (TGA), and the possible total color difference of the painted layer surface was measured by a colorimeter. From the experimental study, dimethyl carbonate proved its efficacy for cleaning because it did not show high swelling by comparing with the other bio-solvents used in the experimental study along with no showing changes in palmitic and stearic acids proportions by comparing with the proportions of the varnished references. In addition to that, it has low retentive time inside the painted layer.

Chapter III includes the scientific conservation procedures that were taken to Mohamed Ali's portrait. The painting was cleaned with dimethyl carbonate which confirmed its effectiveness in cleaning the experimental

mockups. The practical study did not stop at the cleaning of the painting. The removal of the back patches from the previous conservation interventions, lining, stretcher cleaning and coating, frame conservation, ground layer filling, retouching, frame conservation, and final varnishing was carried out to retrieve the historic and aesthetic values of the painting.