

Color fastness of green pigments in egg tempera technique under accelerated aging and weathering tests

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Egg tempera is a painting technique that was used by great artists through the centuries as it gives great plasticity and color brilliance to whichever artwork is used. Pigments can be natural or synthetic, inorganic and organic, grounded into fine powders. The green pigments, to which this study is focused, are used since ancient times but are very problematic and unstable colors [1]. Determining the degradation mechanisms of these materials helps a conservator to plan the methods of preventive and interventive conservation of works of art, which has aesthetic aims and also leads to prolonging life expectancy as well as better exhibition and storage conditions in the future [2].

The present analysis is a part of a comprehensive study of the artificial aging of art materials in different painting techniques and focuses on different green pigments (malachite, verdigris, viridian, green earths etc.) mixed with egg yolk as a medium. The samples were aged artificially in different conditions in order to isolate the factors that influence them. Firstly, the samples were kept for 45 days at 60°C in a drying oven and then, for 24 hours, at 120°C lacking humidity in another oven. In a second experiment, thin layers of the samples were exposed to UV light for 700 hours in a controlled environment chamber at 40 % relative humidity and 50°C temperature [3]. Another color palette with green pigments and egg yolk including 20% TiO₂ was prepared and exposed to the latest conditions. Titanium dioxide white is the leading white color since the beginning of the 20th century and used by many artists to produce the desired color tone and make the final color last more in time [4]. Measurements were taken periodically using Fourier Transform Infrared Spectroscopy (FTIR) and X-ray diffraction (XRD) in order to identify the possible changes in the chemical composition of the samples. Changes in the physical properties were observed even without the use of optical augmentation. The samples were also measured by a reflective spectrophotometer so as the color coordinates L, a, b, E, H to be determined [5].

The surface mechanical and chemical properties of the pigments were also observed after four experimental circles according to ISO B06 - concerning color fastness to artificial daylight including humidity adjustments - inside a weathering chamber, where the samples were exposed to alternating cycles of UV light and moisture at controlled and elevated temperature. The photodegradation that occurred was a reproduction of the damage that would have occurred naturally over months or years outdoors [6].

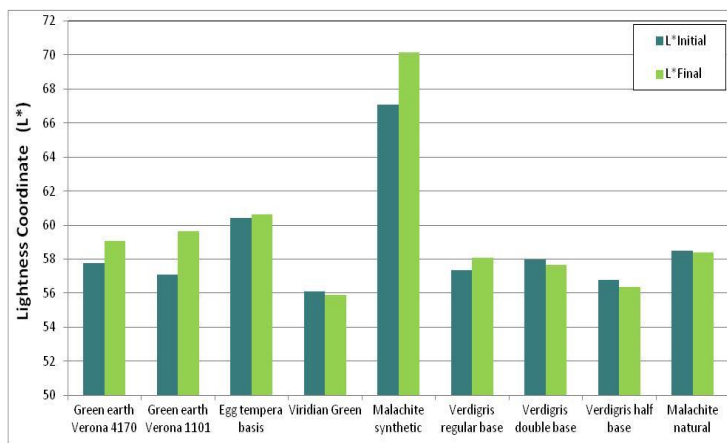


Figure 1. Lightness coordinate diagram of samples before and after the accelerated aging

The experimental results showed that heat alone does not chemically affect the samples and does not contribute to their aging process. As far as the physical properties are concerned, a change in the color of the samples was observed and the surface of some of them was cracked. However, regarding the influence of UV radiation combined with

temperature, changes were observed in the FTIR spectra mainly to the sample of the pure binder, as well as cracking, yellowing and discoloration [6]. Color change, gloss loss, cracking and embrittlement was also observed due to aging in the weathering chamber. The modifications in the chemical composition under the conditions of weathering experiment, as well as the results concerning the interaction of organic binders with inorganic pigments in general and the overall observation on the light fastness of the colors, were very interesting and will be investigated extensively in future work.

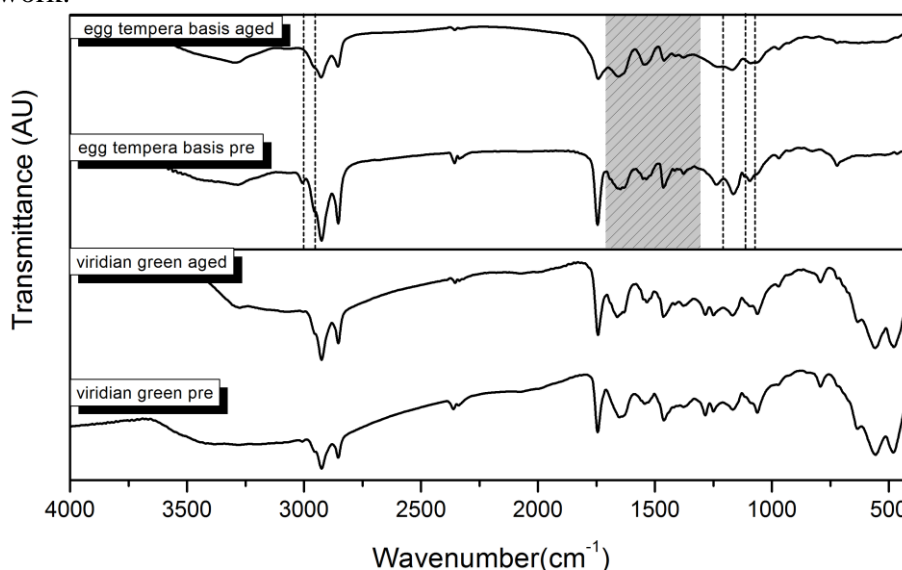


Figure 2. FTIR spectra of indicative samples before and after the accelerated aging

References

- [1] N. Eastaugh, V. Walsh, T. Chaplin, R. Siddall, Pigment Compendium, Butterworth-Heinemann (2004) 248 and 385
- [2] P. Dellaportas, E. Papageorgiou, G. Panagiaris, Heritage Science 2 (2014) 2
- [3] D. Saunders, J. Kirby, National Gallery Technical Bulletin 15 (1994) 79 - 97
- [4] Z. E. Papliaka, N. Wendland, E. A. Varella, e-PS 7 (2010) 48-54
- [5] L. Samain, G. Silversmit, J. Sanyova, B. Vekemans, H. Salomon, B. Gilbert, F. Grandjean, G. J. Long, R.P. Hermann, L. Vincze, D. Strivay, J. Anal. At. Spectrom. 26 (2011) 930 - 994
- [6] M. San Andres, J.M de la Roja, V.G. Baonza and N. Sancho, J.Raman Spectrosc. 41 (2010) 1468 - 1476
- [7] J.M. Powers, P.L. Fan, C.N. Raptis, J. Dent Res 59 (1980), 2071-4