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Volume 1

- Topic A: Applied Mechanics, Civil and Energy Engineering
- Topic B: Earth and Environmental Sciences
- Topic C: Arts & Humanities

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investing in knowledge society
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DESIGNED BY EFI PANAGIOTIDI

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Topic A

Applied Mechanics, Civil and Energy Engineering

Oil paintings on paper support: Determination of condition criteria via non destructive testing and microanalysis

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Keywords: paper support, analytical techniques, multispectral imaging, artificial ageing

Abstract
This paper presents the physicochemical methodology especially nondestructive testing and microanalysis applied for the documentation of the condition of oil paintings and oil sketches on paper support. The research is focused on the effect of the oil binder on the paper and the changes caused during the progress of deterioration in order to provide criteria for the better evaluation of the condition. Six original artworks representative samples of the Greek artists of the 18th-20th century, belonging to the National Gallery - Museum and Alexandros Soutzos Museum were investigated. The research was supported by experimental laboratory study of artificially aged mock ups made of linseed oil and different paper supports. The research methodology involved non-destructive imaging (UVF, multispectral), FORS, colourimetry, microscopic techniques (optical VLM/FLM, SEM) and micro analytical techniques (HS-SPME-GC-MS, SEM–EDX, and FTIR) for the examination and the identification of the materials and the degradation products of the original artworks and the mock-ups before and after ageing. The present article discusses the evaluation of the obtained results and the assessment of the techniques employed as far as the applicability and the efficacy in the study of the particular subject. The appraisal of the methodology is expected to contribute to the development of an experimental tool for the evaluation of the condition of this particular type of works.

Introduction

Oil binders have been widely used in various works on paper supports, such as oil sketches, oil studies, drawings and paintings, as well as, images and texts in books printed with traditional oil based inks. Certain problems recorded in these works appear to be related to the presence of the oil binder; discoloration of the paper varying in intensity, reduction of the mechanical strength and embrittlement of the support on areas where oil diffusion or absorption has occurred. Even though the subject raises conservation and preservation issues, there are only sporadic references in literature and limited publication upon research on this matter. The majority of the publications refer to the painting materials, the types of support and the preparation required/applied, the various techniques used, the terminology and their distinction respectively (Gritsay et al, 2004, Bower, 1992,). There is a limited number of articles referring to the condi-

tion and the problems presented in this type of works, the conservation treatments and the risks involved. They are mostly focused on oil stain removal, colour change reversion, repair and lining techniques, methodology to support the fragile paper in rigid secondary supports for display and storage (McAusland,1989, Banou et al, 2015).

Methodology

Six original works of art, representative samples of the Greek artists of the 18th-20th century, belonging to the National Gallery and Alexandros Soutzos Museum were investigated. The research was supported by experimental laboratory study of artificially aged mock ups made of linseed oil and different paper supports (pure cellulose Munktel, typical watercolour Montval and a Kraft type paper). The mock ups were submitted to close environment artificially ageing according to ASTM D 6819-02 2002 standard (90 °C, 78%RH 1,4,7,14,21 and 28 ageing days). The methodology of research involved technical examination using non-destructive imaging techniques (Fisher and Kakouli, 2006) like UVR, UVF and Vis/IR multispectral imaging (Fig.1), FORS and colourimetry, as well as microscopic techniques (optical VLM/FLM, USB Microscopy in combination with SEM–EDX) and the advanced VOC/MS analysis (HS-SPME-GC-MS) applied for the first time to the study of the effect of drying oils in paper except in our own preliminary studies, for the examination and the identification of the materials and the degradation products of the original artworks and the in depth study of extensive multi – parameter series of mock -ups before and after ageing.

Fig.1 N.Gysis, “Sewing studio” Oil painting, detail (NGASM). The comparative study of the same area in Visible, UV Reflection, UV Fluorescence, False Colour Infrared (FCIR) and Hyperspectral imaging (MuSIS HS) at 600 and 1000nm reveal information (the sketch, the pigments, the morphology) from different depth.

Results

Optical microscopy and SEM offered valuable information about the oil – paper system Observations on morphology of the three different types of paper show that papers without an oil application present qualitative changes that are far less in extent than those of the oiled papers indicating a rather more stable behaviour upon ageing (Fig.2). Generally, the morphological changes and damage of the fibres recorded are limited. Oiled mock-ups of the three types of paper, before ageing, present a similar condition: a layer of oil that almost completely covers the paper surface. The oil layer presents a surface profil which responds to the relief of the fibre net or might be attributed to the different adsorption degree of the oil locally, which is connected to the porosity of each paper and relevant surface tension properties.

Upon ageing the phenomena evolve in the same way for all three types of paper. There is a progressive but uniform sinking of the oil film, parts of the surface fibres are progressively more distinguished, holes and recesses appear, revealing the fibres and the fibre net. By the final stage of ageing the bulk of the oil film is still present at a lower level and the presence of holes and recesses is so extended that the oil layer seems to be fragmented.

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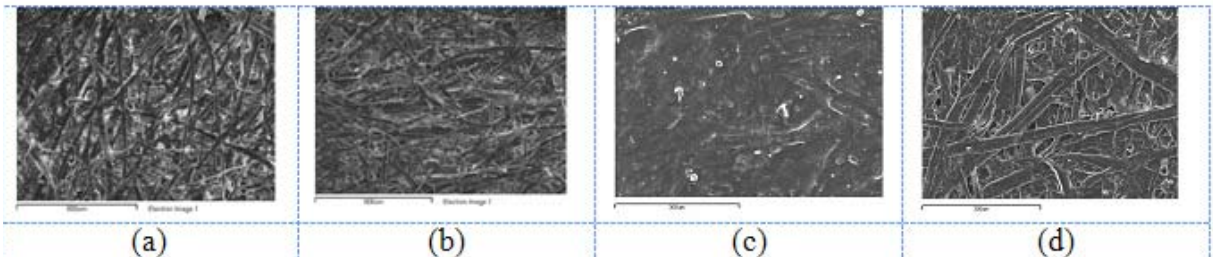

Fig.2. Electronmicrographs of kraft paper without oil (a), (b) and with oil (c), (d). no ageing (a), (c) and after 28 days ageing (b),(d). Magnification x200

In all three paper types, oil application results in the significant reduction of brightness which reaches comparable values of the L* coordinate at the 28th day (Fig. 3). Analogous decrease of yellow colour upon ageing is also observed. For the white colour papers the increase of the red colour, and the fluctuation pattern within that, could be indicative of the chemical changes. Also differences in colour through each mock up are strongly associated with the oil concentration on the paper locally. The creamy oiled montval paper mock ups get an orange-brown hue from the first day of ageing and turn gradually darker to a warm brown colour upon the progress of ageing. The colour of the mock ups turn to an intense dark brown colour at the final stages of ageing. It is likely that linseed oil application is principally responsible for the colour changes during ageing, though oxidation of the cellulose in the paper may also contribute to the colour change, especially if , as we suspect, the oil is enhancing the rate of oxidation of the paper, as indicated in our VOC emission studies.

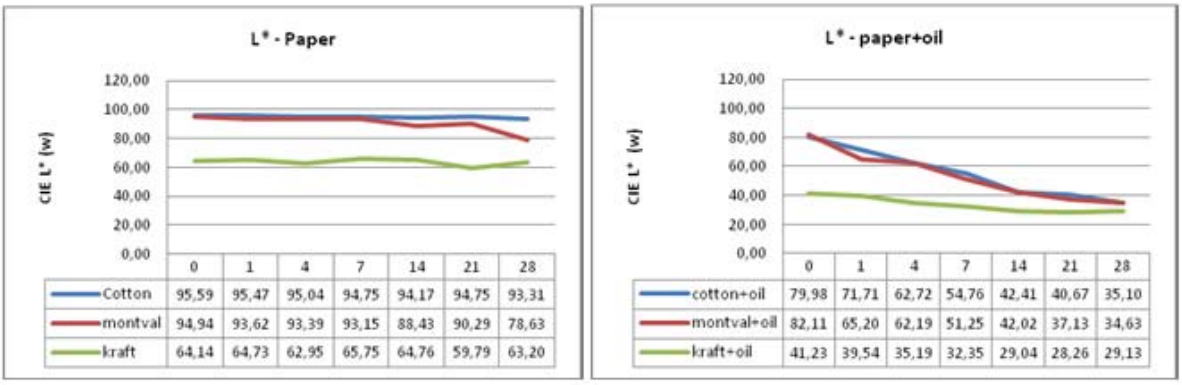

Fig.3 The L coordinate values for the three types of paper mock ups at all ageing periods. Left: paper mock ups without oil application, right: paper mock ups with oil application*

In transmitted light (Fig.4), the three types of paper (cotton, montval and kraft) allow a limited amount of light to pass through, differing in quantity among the paper types, with kraft paper being significantly less transparent than the others. The oiled mock ups of the three paper types appear to allow gradually less light pass upon ageing, without getting absolutely opaque even at the 28th day of ageing.

The presence of drying oil in paper greatly accelerates the emission of volatile cellulose degradation products both for cotton based and wood based papers. In the cotton paper it has greatly accelerated the emission of furfural, 2-ethyl furan, 5- methyl, 5- ethyl furfural and 5-pentylfuranone during ageing, while in the wood based papers has greatly accelerated the emission of furfural, 5-methy furfural, 5-ethyl furfural and 5-pentylfuranone.

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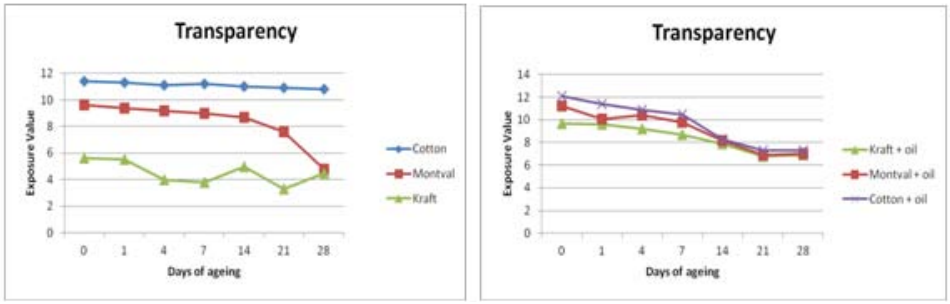

Fig.4 Transparency of non oiled (left) and oiled mock-ups (right)

Conclusions

Deep understanding of the paper – oil system optical alterations due to the deterioration were established through extensive studying of mock-ups. The catalytic effect that oil medium has on the acceleration of the entire degradation was examined and recorded in various ways. The research has shown that the presence of dried oil films accelerates the oxidative degradation of artists' paper including both cotton, and therefore rag paper and also wood based artists' papers. We can conclude that since drying oil clearly accelerates the destructive oxidation of the paper in the mock ups that it is having the same effect in the works of art in the collection studied. The associated loss of mechanical strength and deterioration of optical properties such as colour will also be accelerated in these works. A methodology based on non-destructive analysis was also established that enables the conservation scientists to have a better insight in the deterioration of the originals. These findings will provide sound data on which informed decisions can be made regarding the conservation treatments for these works and that therefore this research will have an impact on the lifetime of these works making them available for public viewing for an extended period.

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