

Figure 16. Impression resulting from the non-homogeneity induced by the stretcher on the painted surface.

UV fluorescence can be useful for the examina-

tion of inscriptions or stamps that are faded or

otherwise degraded and consequently have be-

come barely legible. In this case, if the materials are fluorescent in the ultraviolet, UV examina-

Generally speaking, any element drawn on the

back of the support (canvas, wood or others)

can be revealed by IR reflectography, according

to its medium. Carbon chalk or usually carbon-

black based mediums typically provide the best

Figure 19. Angelo Maccagnino (Ferrarese School, XV

century), Erato, Pinacoteca Nazionale, Ferrara. Back of the

tion may be able to make them legible.

3.5.2 Ultraviolet fluorescence

3.5.3 Infrared reflectography

results (Figures 19 and 20).



weakening of the canvas.



Figure 18. Accidental damage with

shredding of the fibers.

State of conservation

3.6 How to detect the mechanical deformations of the support?

NON-DESTRUCTIVE TECHNIQUES

3.6.1 Raking light observation

Canvas is a fragile material and easily weakens under the effect of chemical, biological and physical deteriorations. Ageing and environmental conditions (light, relative humidity, temperature, pollution, etc.) lead to its weakening, and eventually to its breaking. The nature of the fabric, the way it was manufactured, and the conservation conditions are therefore key factors in the occurrence of deterioration. Raking light highlights deformations or changes in the flatness of the support due to constraints connected to both the manufacture and the use of the canvas support itself, as well as to external effects like climatic variations. Moreover the deformations may also be caused by earlier restoration treatments or by accidents (blows, tears, etc.). Any canvas support gradually loses its tension and becomes limp. Natural ageing of textile fibres, accentuated by variations in temperature and relative humidity, reduces the can-

vas elasticity. On the other hand the modification of canvas's internal tensions is caused by different phenomena. They may be related to an original lack of tension or to a local over-tension (caused for example by an excessive opening of the frame's corners). Breaking of the canvas anchorings (tacks) to the frame also produces deformations.

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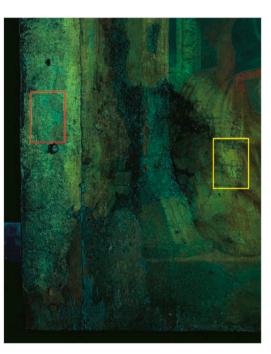


Figure 11. Imagine of oleo-resinous materials with different locations on the painting surface: a recent resinous material(red square) and a more ancient one (yellow square).

nishes and synthetic varnishes¹. Old paintings have often been cleaned several times over the centuries. Currently the varnishes used on old paintings are in most cases constituted of one or more layers of natural resin-based (generally Mastic or Dammar resins) or synthetic varnishes. All varnishes tend to yellowing over time, with the exception of certain synthetic resins developed in recent decades2, which offer interesting perspectives but for which we lack sufficient distance in time to assess their real stability and reversibility, despite detailed research, including artificial ageing tests. It goes without saying that the uniformity of a layer of varnish can be observed more easily on a deteriorated varnish by the yellow colour which is more marked and darker in stains or runs alterations. 3. The technique of application of a varnish equally influences its thickness and final appearance. Varnishes can be dabbed on or applied with a brush or spray gun. By observing the uniformity of a varnish in reflected light one can determine how it has been applied. A dabbed-on varnish is generally absorbed by the

paint layer; it characterized by surface irregularities, opacity or glossy due to the differences in varnish's absorption by certain colours which are more or less rich in binder or where the grain size of the pigment varies. A varnish applied with a brush has generally a more uniformly shiny and smooth appearance. If the painting has been varnished in a vertical position, little droplets or runs can be occasionally observed (Figure 10). A varnish applied with a spray gun generally has a silky appearance. However, if the varnish has been sprayed too thickly, formation of a so-called 'orange peel' effect is sometimes observed: the surface, though smooth, is dotted with tiny holes. The varnish's thickness varies depending on the number of layers present. Several coats of varnish of different types may have been applied in successive periods. Moreover, an artificial patina or a pigmented medium, uniform or partial and, finally, foreign elements like dust, dirt or nicotine may also be present.

7.3.2 UV fluorescence imaging

UV fluorescence can be used to determine the homogeneity of the application of a varnish layer, as differences in the thickness will fluoresce differently. However, fluorescence cannot be used to quantify layer thickness or difference in layer thickness.

As a varnish ages, its fluorescence will increase, and this variation can be used to compare the relative age of different varnish applications in the same painting (Figure 11). This analysis is merely qualitative: the absolute age of a varnish layer cannot be determined using the intensity of fluorescence.

DESTRUCTIVE OR MICRO-DESTRUCTIVE

7.3.3 Optical microscopy (OM) and UV

Microscope observations of paint cross-sections under both visible and UV light illumination allow the thickness and uniformity of varnish layers to be documented. The case shown in Figure 12 documents the presence of a discontinuous (5 to 12µm thickness) thin organic var-

DESTRUCTIVE OR MICRO-DESTRUCTIVE

7.7.3 Fourier Transform Infrared (FTIR)

Among the many types of cleaning interven-

tions carried out in the past on paintings, the

use of strong alkaline solutions was the most

One of the side effects of such type of cleaning

can be traced by FTIR, as micro samples col-

lected from the paint surface are generally char-

acterised by the presence of calcium carbonate,

metal carboxylates generated by saponification

or hydrolysis of fatty esters and oxalates (Figure

37). The same results can be achieved non-de-

structively with the use of portable FTIR equip-

Furthermore, the higher solubility of metal car-

boxylates, if compared with the original fatty es-

Figure 37. Micro FTIR spectrum of a micro fragment

Tabernacle' (Museum of S.Marco, Firenze Italy,). The

soaps and oxalates is evident.

collected from the Virgin cloak of Beato Angelico's 'Lanaiuoli

presence of calcium carbonate, as well as fatty esters, metal

TECHNIQUES

spectroscopy

widespread one.

VARNISH LAYERS



Figure 35. Anonymous 14th century panel with scenes from the life of the Virgin (Alken predella or Kortessem Panel) (Royal Museums of Fine Arts, Brussels). Old overpainting covering the entire surface. Photograph under raking light.

handwriting, enabling eventually to clearly discern the deteriorations and retouchings. This phenomenon can be compared to the time the eye needs to adapt when entering into a dark room: at first the eye sees only dark, but after a certain time it is able to make out the details.

7.7.2 UV fluorescence imaging

UV fluorescence is often the primary non-destructive techniques used to reveal areas of restoration and in-painting. This technique can distinguish between different materials or applications made at different times, when making a direct comparison on the same artwork (Figure 36). Nevertheless, the ability to interpret these results depends on the experience of the operator, particularly when there is mutual interference between layers of the painting.

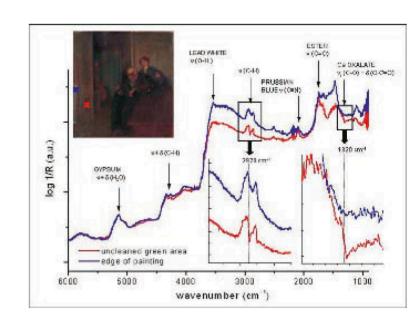
Figure 36. In-paintings carried out in two different under a resinous varnish with a green fluorescence (red line in the picture on the left), the recent one (yellow line) is located over the varnish laver and is not fluorescent. In the pictures on the left (visible light) both the in-paintings have been removed.





Figure 31. Spectral comparison between an unvarnished edge and an area within V. Zolla's 'The open door'.

panel in diffused light.



7.6.2 UV fluorescence imaging

This technique can detect the presence of deposited materials, provided they are fluorescent, because it shows an increase of intensity.

7.6.3 Fourier Transform Iinfrared (FTIR) spectroscopy by fiber optics

The fiber optics mid-FTIR method is very sensitive to inorganic surface materials and deposits, such as sulphates, phosphates, oxalates. As an example, spectra recorded on V. Zolla's painting 'The Open Door' (1917, Quirinale Palace, Roma) are here reported. The scene was greatly obscured by the presence of an altered superficial varnish layer. In order to gain a better understanding of the altered varnish material in question, an initial range of mid-FTIR reflectance spectra was taken from differently coloured areas of the painting, as well as from the unvarnished edge of the painting. Figure 31 compares two spectra acquired from an area within the painting and from the unvarnished edge, with corresponding band assignments. All areas, varnished or not, show the presence of gypsum [characteristic $v+\delta$ (H₂O) combination band at 5145 cm⁻¹], lead white [characteristic v (O-H) at 3537 cm⁻¹], Prussian blue [characteristic and strongly absorbing v (C \equiv N) at 2095 cm⁻¹] and of an organic component [v

(C=O) at 1745 cm⁻¹, ν (C-H) at approximately 2920 cm⁻¹, ν + δ (C-H) combination band centred around 4300 cm⁻¹] that could account for the painting binding medium. The varnished areas, hence areas far from the frame, in addition show a significant derivative shaped band assigned to calcium oxalate [v_s (C=O) and δ (O-C=O) at 1320 cm⁻¹] probably related to the altered superficial layer.

DESTRUCTIVE OR MICRO-DESTRUCTIVE **TECHNIQUES**

7.6.4 Fourier Transform Iinfrared (FTIR) spectroscopy

The analysis of efflorescences and surface depo-

sition materials requires a careful and selective

Figure 32. Material collected from the surface of a XVI century painting by Agnolo Bronzino. The FTIR spectrum (red) shows that the main component is wax (green spectrum) but other bands indicate the presence of a cellulosic material

as well, most likely a residue material of a restoration work. VARNISH LAYERS 135

tested on the Renaissance frescoes by Spinello Aretino in the Guasconi Chapel of the San Francesco Cathedral (Arezzo, Italy). Through non-destructive mid-FTIR measurements performed *in situ*, the effectiveness of the treatment as well as its long-term stability have been

The painting had been coated with a thick layer of an acrylic resin 40 years before, during a restoration. Consequently the infrared reflectance spectrum of the surface pointed out a strong specular feature in the region of carbonyl absorption, as shown in spectrum a (Figure 41). Microemulsion was applied following the wood poultice technique (two hours of application, temperature between 20 and 23 °C) and washing the cleaned surface twice with isopropanol and several times with deionized water until the residual surfactant foam disappeared. The reflectance spectrum of the cleaned surface showed clearly that the acrylic layer had been successfully removed, since the carbonyl signal at 1730 cm⁻¹ disappeared completely (spectrum b of Figure 41). The results obtained corresponded with those gathered from the analysis of microsamples taken from the fresco surface. Additionally, through the reflectance surface analysis, a new signal at about 1230 cm-1 was observed, next to the carbonyl band disappearing. This band, strongly affected by specular distortion, was assigned to the SO₄— stretching of residual surfactant. After an additional treatment with saturated solution of ammonium carbonate, the surface resulted perfectly clean as shown by the features of spectrum c.

termine any variation in the colour's appearance. Differently, in point 33, the effect due to the old varnish began to be very important for a perception of the colour: the conservation treatment has determined a consistent increase in the reflectance values. Moreover, it was possible to note that the removal of the varnish revealed the original colour of the painted layer. In fact, the spectra acquired after restoration (blue line) had the typical absorption bands of a zinc white mixed with an ochre, neither of which could be identified prior to the intervention.

7.8.2 Fourier Transform Infrared (FTIR) spectroscopy by fiber optics

The general applicability of a new cleaning method has been proven by mid-FTIR spectroscopy for the cleaning of a 40 years aged coating on a Renaissance fresco. Determining the cleanliness this way, it was pointed out that special attention must be paid in the removal of the surfactant used in the cleaning processes. Additionally, this work fostered the importance of a non-invasive validation of conservative treatments. In fact, using the mid-IR spectral range and chalcogenide fiber optics, a spectroscopic instrument capable of surface fresco analysis was set up. Reflectance midFT-IR spectroscopy boasts several appealing aspects, such as: the ability to discriminate a wide variety of organic and inorganic components from carbonate substrate, rapid analysis time, and capability for in situ application. Microemulsion was

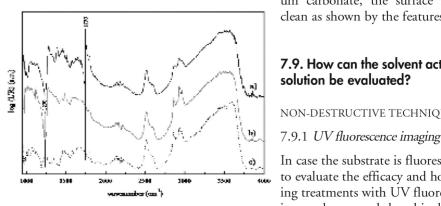


Figure 41. Reflectance midFT-IR spectra of fresco surface: a) before the cleaning, b) after the cleaning, and c) after the ammonium carbonate treatment.

7.9. How can the solvent action of a cleaning solution be evaluated?

NON-DESTRUCTIVE TECHNIQUES

In case the substrate is fluorescent, it is possible to evaluate the efficacy and homogeny of cleaning treatments with UV fluorescence. However, it must be stressed that this should be used just as an initial test, and not as a constant illumination during cleaning.