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STUDY OF THE LASER CLEANING OF WOODEN OBJECTS

E. Borrelli[1], L. Calienno[2], D. Fodaro[3], A. Lo Monaco[2], C. Pelosi[4*], A. R. Rubino[1], L. Sforzini[5]

[1] Cultural Heritage, Independent Consultant and Trainer, Roma, Italy
[2] Department of science and technology for Agriculture, Forests, Nature and Energy (DAFNE), University of Tuscia, Viterbo, Italy
[3] Istituto Superiore per la Conservazione e il Restauro, Roma, Italy
[4] *Department of Cultural Heritage Sciences (DISBEC), University of Tuscia, Viterbo, Italy. Email: pelosi@unitus.it
[5] Livia Sforzini restauro e conservazione, Genova, Italy

This paper aims to study the possibility of extending the laser technique to wooden surfaces by investigating the cleaning efficacy and the laser interactions with the material. The aim is also to show as a conservative intervention can be brought to the experts' attention by using new documentation tools to support scientific, technical, conservative, and material aspects.
The study was focused on a wooden sculpture representing *Saint Joseph* (Figure 1) attributed to the workshop of Ignaz Günther (1727-1775), an important artist operating in Bavaria during the 18th century (Christiane 2011).

Fig. 1. The *Saint Joseph* (40 cm high) by the workshop of Joseph Günther, front and back of the sculpture with the sampling points for the surface materials' analysis

The preliminary phase of the work was devoted to the collection of the information needed to prepare the "condition report" including data acquisition, documents, graphics and photographs both in traditional and digital format. The data, significant for the assessment of the results, were interactively transferred on a 3D model.
The peculiar features of the wood supports often prevent the use of traditional cleaning procedures to remove the surface dirt, soot or carbonaceous deposits and other materials coming from environment or old conservative interventions (Aligizaki et al. 2008; Wiedemann et al. 2000). Wood is a very sensitive material that can absorb the organic solvents and the water solutions usually adopted by the restores for the surface cleaning. Moreover the wood surface can be easily scratched. To overcome the difficulties in the cleaning of the wooden objects, laser technology was tested. The laser irradiation and cleaning tests were carried out with a Q-switched Nd:YAG system. The surface was analyzed before and after the laser cleaning, with the aid of a video microscope and a reflectance

spectrophotometer, in order to evaluate the influence of the irradiation on the surface morphology and to monitor the possible colour changes (Pelosi et al., 2013).
Before the cleaning, the component materials of the wooden sculpture were analyzed by micro-Raman spectroscopy in order to identify the pigments, Fourier Transform Infrared spectrometry to study the binders and the restoration materials, optical microscopy to examine the technique utilized and to identify the botanical species of wood (Macchioni et al. 2010).
The analysis highlighted the presence of lead white applied by a siccative oil and barium sulphate; traces of calcium carbonate and proteins were also found. The micro sample cross sections showed a thin surface layer based on barium sulphate applied over the thick white painting made of lead white mixed with smalt fragments. The FTIR analysis of the brown surface layer revealed the presence of shellac. The microscopic observation of wood thin sections allows to state that wood is obtained by lime tree. The shellac, superimposed during a late restoration, was considered as material to remove. For this purpose a series of laser tests were performed under different conditions in order to find the threshold values of energy useful to remove the brownish surface layer without damaging the wood support. In particular, three different tests were performed at 1064 nm wavelength and 5 Hz frequency:
1) distance 30 cm, spot diameter 8 mm, energy 4 mJ, fluence 0.01 J/cm^2;
2) distance 15 cm, spot diameter 2 mm, energy 20 mJ, fluence 0.64 J/cm^2;
3) distance 20 cm, spot diameter 4 mm, energy 20 mJ, fluence 0.16 J/cm^2.
The laser conditions used in the tests 1 and 3 were not effective enough to remove the shellac layer producing only a reduction of its thickness, while the test 2 allowed the removal of the shellac layer showing the original wood surface. To support the evaluation of the results, twelve points for colour measurements were chosen in the three tested area, before and after the laser irradiation. The positive result obtained with the test 2 was highlighted by the reflectance spectra showing only a brightening of the surface with a slight modification of the shape of the reflectance spectral curve. Thanks these results it can be stated that with the test 2 the almost completely removal of shellac is confirmed and the final surface colour is similar to that of lime wood. On the contrary the conditions employed in the tests 1 and 3 caused a shift of dominant wavelength in the yellow-red area of the visible spectrum confirming that shellac was still present.
This research demonstrated that the laser cleaning applied to wood material can be an effective method to remove the surface deposits preserving the original patinas without affecting negatively the original support.
The results gathered in this work encourage to continue the research in order to better understand the interactions between the laser beam and wood surfaces and to find the most appropriate systems to clean the wood sculptures having in mind the divulgation and the sharing of the obtained data.

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