

Multi-scale and 3D imaging spectroscopies of finishes coating historical musical instruments: recent developments and trends

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The varnished wooden surfaces of historical musical instruments – violins, lutes, etc.– represent promising research topics, whether in terms of conservation or history of varnishing techniques. For the past six years, research has been conducted at the *Musée de la musique* in Paris on various aspects around this topic, from the chemical composition of 16th-18th c. varnishes¹ to the optical properties and visual appearance of varnished woods².

We present several analytical and imaging methods which were developed for the characterization of the varnishes of violins, lutes and other musical instruments of the collection of the *Musée de la musique*. At the micrometer scale, μ -IR spectroscopy, μ -Raman spectroscopy and DUV-Vis-NIR luminescence μ -imaging spectroscopy were applied to non destructively characterize multi-layer cross-section samples, using synchrotron radiation on various beamlines^{3, 4}. 3D in situ μ -imaging was performed on violins using Optical Coherence Tomography (OCT)⁵ and, more recently using Multi-Photon Microscopy, a method which provided a better imaging and chemical contrast⁶.

Current research includes the development of methods for the characterization of organic coatings (resins, oils, waxes, dyestuffs, etc.) using non destructive in situ methods, which are currently lacking to the field of archaeometry and conservation science. In particular, imaging techniques based on chemical signatures could efficiently provide information on the heterogeneity, of a varnished surface, and allow a first step in the classification and identification of the coating materials.

In the framework of a PNRCC project –partially funded by the French Ministry of Culture, and in collaboration with other research institutes (LADIR and CRCC)–, UV-Vis luminescence multispectral imaging, IR spectroscopy and FORS are used in combination on a large corpus of varnished violins. The interest is the combination of spot spectroscopic analyses (high spectral resolution and strong characterization of materials) with multispectral imaging techniques (lower spectral resolution, fast examination of large surfaces) as well as methods considered for data treatments.

1. Echard, J.-P.; Bertrand, L.; von Bohlen, A.; Le Hô, A.-S.; Paris, C.; Bellot-Gurlet, L.; Soulier, B.; Lattuati-Derieux, A.; Thao, S.; Robinet, L.; Lavédrine, B.; Vaiedelich, S. *Angew. Chem. Int. Ed.* **2010**, *49*, 197-201.

2. Viénot, F.; Bak, A.; Echard, J.-P., in *Proceedings of the CIE Expert Symposium on Visual Appearance*. CIE Publication: Paris, 2007, vol. x032, pp 230-234.

3. Bertrand, L.; Robinet, L.; Cohen, S. X.; Sandt, C.; Le Hô, A.-S.; Soulier, B.; Lattuati-Derieux, A.; Echard, J.-P. *Anal. Bioanal. Chem.* **2011**, *399*, 3025-3032.

4. Thoury, M.; Echard, J.-P.; Réfrégiers, M.; Berrie, B. H.; Nevin, A.; Jamme, F.; Bertrand, L. *Anal. Chem.* **2011**, *83*, 1737-1745.

5. Latour, G.; Echard, J.-P.; Soulier, B.; Emond, I.; Vaiedelich, S.; Elias, M. *Appl. Opt.* **2009**, *48*, 6485-6491.

6. Latour, G.; Echard, J.-P.; Didier, M.; Schanne-Klein, M.-C. *Optics Express* **2012**, *20*, 24623-24635.

Biographical statement

Jean-Philippe Echard has a Master's degree (1998) and a PhD (2010) in chemistry. He has been working at the Laboratoire de recherche et de restauration of the Musée de la musique in Paris since 1999. He was a Charles E. Culpeper Fellow at the Scientific Department of the National Gallery of Art in Washington D.C. in 2004-2005. His principal interests are the methodological developments of observation and analytical techniques applied to cultural heritage artifacts and the complementarity of historical and material sources for the knowledge of history of varnishing and painting techniques.