Carbon speciation in ancient and historical systems using X-ray Raman spectroscopy and imaging

L. Bertrand[1,2], R. Georgiou[1,2], P. Gueriau[1,3], C.J. Sahle[4], A. Mirone[4], N. Daly[5], R. Garrouste[6], J. Giaccai[7], R. Popelka-Filcoff[8], K. Trentelman[5], S. Bernard[9], J.-P. Rueff[2,10], U. Bergmann[11]

[1]IPANEMA, CNRS, Ministère de la Culture, UVSQ, Université Paris-Saclay, BP 48 Saint-Aubin, 91192 Gif-sur-Yvette, France; [2]Synchrotron SOLEIL, BP 48 Saint-Aubin, 91192 Gif-sur-Yvette, France; [3]Anom Lab, Institute of Earth Sciences, University of Lausanne, CH-1015 Lausanne, Switzerland; [4]ESRF-The European Synchrotron, 71 Avenue des Martyrs, 38000 Grenoble, France; [5]Getty Conservation Institute, 1200 Getty Center Drive, Los Angeles, CA 90049, United States; [6]Institut de Systématique, Évolution, Biodiversité, ISYEB, UMR 7205, CNRS, MNHN, UPMC, EPHE, Muséum national d'Histoire naturelle, Sorbonne Universités, 57 rue Cuvier, CP 50, Entomologie, F-75005, Paris, France; [7]Department of Chemistry, The George Washington University, Washington, DC 20052, USA; [8]College of Science and Engineering, Flinders University, Adelaide, South Australia 5001, Australia; [9]Muséum National d'Histoire Naturelle, Sorbonne Université, UMR CNRS 7590, IRD, Institut de Minéralogie, de Physique des Matériaux et de Cosmochimie, IMPMC, 75005 Paris, France; [10]Sorbonne Universités, UPMC Université Paris 06, CNRS, UMR 7614, Laboratoire de Chimie Physique-Matière et Rayonnement, F-75005 Paris, France; [11]Stanford PULSE Institute, SLAC National Accelerator Laboratory, Menlo Park, California 94025, United States;
loic.bertrand@synchrotron-soleil.fr

We investigate and discuss the potentials and limits of X-ray Raman scattering (XRS) to probe carbon speciation in complex heterogeneous solid ancient samples. The hard X-ray inelastic scattering technique was used to collect carbon K-edge XANES data in a non-destructive manner, in air, with bulk sensitivity, to provide information not compromised by surface contamination, thus overcoming important constraints in the characterization of ancient materials. The potential of XRS is demonstrated through the analysis of carbon-based artists' pigments, which are until today poorly understood due to their complex chemistry, based on experiments at SOLEIL and the ESRF in collaboration with SSRL at Stanford [1]. XRS was used to determine the speciation in a consistent set of modern and historical samples used in the arts. Furthermore, we collected XRS-based carbon K-edge XANES on fossil samples. XRS spectra provided information on the degree of aromaticity, the signatures of oxidized COO groups, the presence of carbon bound with heteroatoms and turbostraticity. Additionally, we further tested and developed non-invasive 3D chemical imaging of ancient organic materials by X-ray Raman hyperspectral imaging at the K-edge of carbon [2]. These results show the potential of XRS as a powerful and convenient probe to discriminate carbon-based compounds in complex, heterogeneous samples which can be further applied to a wide range of ancient and historic materials.

References

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