MICRO-RAMAN SPECTROSCOPY FOR THE STUDY OF CERAMICS

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Pots and dishes made of ceramics or stone (*e.g.*, soapstone) are one of the most important classes of archaeological findings. They are very complex objects, consisting in a ceramic or stone body and an external decorated layer which could contain, in turn, a paint layer and an ingobe or a glaze. Crystalline and amorphous, inorganic and, sometimes, organic phases have to be identified.

A complete characterization requires the use of many different experimental techniques. Raman spectroscopy can play a very important role in the analysis of this kind of materials thanks to some specific capabilities. Raman spectroscopy is non-invasive; it is possible to analyze the archaeological objects without any sampling. Unmovable artistic objects preserved in museums could be studied by portable Raman equipment. It is possible to analyze both crystalline and amorphous phases. In the analysis of ceramic or stone bodies, the high space resolution of Raman spectroscopy allows the identification of minor phases, useful for provenance study. Raman is a "point" technique, and so the coupling with a diffraction technique (X-ray or neutrons) is very effective to obtain a quantitative determination of the different phases.

Raman spectroscopy is an invaluable tool for the analysis of the inorganic or organic pigments, in-glaze or under-glaze. The only exception is when the colors are obtained by metal ions dispersed in the glaze. In that case, the best combination is with an elemental technique.

Some particular aspects of the Raman analysis of ceramics and stone artefatcs are discussed: *i*) the use of titanium oxides for thermometry; *ii*) the hematite to magnetite ratio for the characterization of the heating atmosphere; *iii*) the mistakes induced by the high difference in Raman cross-sections of the various phases.

In the particular case of soapstone pots, it is possible to have detailed information on the composition of the crystalline phases: the case of garnets and olivines is shown. The use of Raman mapping to obtain the microscopic distribution of the different phases and their orientation is reported.