PIXE-alpha non destructive and in situ compositional investigation of black gloss on ancient pottery

L. Pappalardo¹,², S. Barresi³, G. Biondi¹, C. Caliri², F. Caruso¹, R. Catalano²,4, G. Lamagna⁵, A. Manenti⁵, A. Orlando²,6, F. Rizzo², F. P. Romano¹,², H.C. Santos²,7

1) IBAM-CNR, Via Biblioteca 4, 95124, Catania, Italy
2) LNS-INFN, Via Santa Sofia 62, 95123, Catania, Italy
3) Miur
4) INFN, Sezione di Catania, Via S. Sofia 64, 95123, Catania, Italy
5) Museo Archeologico Regionale “Paolo Orsi”, Via Teocrito 66, Siracusa
6) INAF-OACT, Via S. Sofia 78, 95123, Catania, Italy
7) Instituto de Fisica – Universidade de Sao Paulo – SP - Brasil

Abstract - At the LANDIS laboratory of IBAM/CNR-INFN/LNS of Catania, a systematic study on the chemical composition of ancient black gloss present on the surfaces of attic vases and of the ones exhibiting typologies belonging to different archaeological periods has been carried out by means of the PIXE-alpha (Particle-Induced X-ray Emission) portable system. The use of the PIXE-alpha spectrometer is particularly suited for the black gloss characterization because the analysis is confined into the first 10-20 microns of the surface due to the sharp range of the alpha particles in a silicate matrix. The low and medium atomic number elements are well evidenced (from Na to Zn) and detected. The composition of the analyzed surfaces has been investigated and a chemical-based discrimination between attic and other typologies of black gloss has been proposed.

INTRODUCTION

Different studies [1-4] have been, in the last years, carried out on attic black gloss characterization, by the use of various techniques both non destructive (PIXE, XRF and by the use of Synchrotron Radiation) and destructive (ICPP, SEM, etc.) with the aim of studying the production technologies and of finding new tools, whenever the observation is not sufficient, for the discrimination between attic black gloss (whose chemical composition is well known) and other typologies of black gloss related to archaeological periods who overlap or are very close to the attic one and so, stylistically, do not present sometimes a well appreciable difference. Quantitative, non destructive and in situ determination of the constituents is mandatory [4] if a large number of precious artifacts, generally preserved at the museums, are to be examined.

The non-destructive analyses have been carried out in our laboratory on same few sherds of local ceramics [5] and in-situ at the “Paolo Orsi” Archaeological Museum in Syracuse (Sicily) and at the Archaeological Museum of Catania [6]. Results are presented and discussed.

THE MEASUREMENTS

The portable PIXE-alpha spectrometer developed at LNS-INFN-CNR/IBAM has been used [7]. As it is known, it make use, as charged particle emitter, of an annular ²¹⁰Po radioactive alpha (of about 5 MeV energy) source, realized in the LNS Alpha-laboratory. The energy resolution of the PIXE-alpha spectrometer is 122eV and an He flux between the source and the sample is assured in order to reduce the absorption of the alpha particles and of the low energy X-rays so allowing the analysis of light atoms like Na.

Figure 1 shows the spectrometer during a measurement at the Archaeological Museum of Catania. Figure 2 shows an X-ray energy spectrum taken on a black gloss of an attic Greek vase. The X-lines corresponding to the characteristic chemical elements (from Na to Fe) are well visible. The quantitative analysis has been carried out by the use of the GUPIX software [8] in the matrix iteration option.

Figure 1: The PIXE-alpha spectrometer during a measurement on the black gloss of an ancient vase.
In figure 3 the ratio K₂O/CaO vs. CaO concentration values is plotted for the black gloss measured in various vases surfaces. Attic glazes are all characterized by a high-from 2 to 4 value of the above ratio due to the use of an important quantity of fusing agent mixed to illitic well refined clay and associated with low value of CaO, whereas local and siceliote potters data show larger concentration of CaO and lower K₂O/CaO ratio probably corresponding to less refined clay.

**Figure 2:** X-ray energy spectrum taken on a black gloss of an attic vase. Note the high intensity of the Si, K, Fe X-lines characteristic of attic black gloss.

**Figure 3:** K₂O/CaO ratio vs. CaO. All the analyzed attic black gloss results (red) lies on the left part of the dashed line. Siceliote (blue) and local data on the right part. However, some of the late (VI-V B.C.) siceliote data are non distinguishable from the attic ones. Destructive results on Attic vases from ref.2 are also presented (black). Errors on the K₂O/CaO and CaO are 20% and 10% respectively.

**CONCLUSIONS**

The use of PIXE-alpha non destructive and portable spectrometer has allowed the quantitative analysis, in situ, of the black glaze of several ancient pottery surfaces. The data on attic ceramics agree, within the errors, with the destructive results of ref. [2] so, giving a sufficient confidence to our method. As general result it could be noted that the present chemical data confirm the use of an elaborated technology in producing the attic glaze surface; very similar chemical data are found in the analysis of late (VI-V B.C.) siceliote artefacts. This could suggest that they were produced in Greece and explicitly destined to exportation or produced in Sicily by using the imported material and technology as suggested by ref. [1]. The most recent (V-IV B.C.) siceliote and local ceramics show, on the contrary, a more variable recipe suggesting a less controlled process of production.

**REFERENCES**


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