Geopolymers: innovative green materials for cultural heritage conservation-restoration

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Geopolymers are inorganic polymeric materials obtained by mixing of solid aluminosilicate precursors with an alkaline solution (NaOH and Na_2SiO_3 mixed in various ratios) plus other constituents such as fibers or aggregates [1,2]. These materials resemble artificial rocks or ceramics and have been recently proposed as substitutes for conventional materials in interventions of conservation-restoration of built heritage [3]. The precursors used in their production are raw materials of different nature, including industrial waste (ceramic tiles, bricks), volcanic (ash, ghiara paleosoil, pumices) and sedimentary rocks (clays, calcarenites). These products represent an innovative tool in terms of recycle and sustainability, since their production is carried at low temperature, involves the re-use of waste material from human activity and produce low emission of CO_2 and energy consumption in comparison with Portland cements [3,4].

The Advanced Green Materials for Cultural Heritage (AGM for CuHe) project (PNR fund with code: ARS01_00697; CUP E66C18000380005), currently carried at University of Catania (Italy), aims to formulate geopolymers using local (Sicilian) raw materials as precursors. Volcanic rocks, together with industrial waste materials are widely available in Sicily, and show promising perspectives in terms of chemical, mineralogical, mechanical and aesthetic compatibility with the local built heritage. As an example, bricks and tiles can be used as geopolymer precursors for substitution, consolidation and repairing of brick masonries of archaeological interest, since they are compatible with the wall substrates. On the other hand volcanic stones can be used in the geopolymers production since they mimic the traditional materials used in the Etnean area.

The process of geopolymers production requires a wide characterization of the involved materials in order to evaluate their chemical, textural and mechanical features. This is achieved by a multi-analytical approach (XRD, XRF, FT-IR, Raman spectroscopy, SEM-EDS, XAS, mCT, mechanical tests) in order to optimize the formulation design and to evaluate mechanical properties and chemical stability of the final product for use in conservation-restoration intervention on historical buildings. These techniques have their best application at Synchrotron Light facilities. As few examples, mCT is fundamental for investigating the inner structure of the finite product and relate its texture to mechanical properties. Element specific techniques such as XAS and μXAS are instead employed in the close control of the fate of selected elements (among others, mainly Fe), crucial to attain controlled aesthetical properties and to monitor potential release of polluting species during the future alteration of such materials.

References

[1] J. Davidovits, J. Therm. Analys. **37**, 1633-1656 (1991).
[2] A. Palomo and F. Glasser , British Ceramic. Trans. J. **91**, 107-112 (1992).
[3] M. Clausi et al., App. Clay Sci. **132**, 589-599 (2016).
[4] G. Habert, C. Ouellet-Plamondon, RILEM Tech. Lett. **1**, 17-23 (2016).