WASTE BASED DIRECT INK WRITING FOR DESIGN, JEWELRY, ACCESSORIES AND CERAMIC HERITAGE CONSERVATION

Chiara Molinari, CNR-ISSMC, Institute of Science, Technology and Sustainability for Ceramics, Faenza, Via Granarolo 64, 48018, IT.

Additive manufacturing is opening new opportunities for the fashion, design and cultural heritage sectors by enabling unprecedented levels of creative freedom while promoting more sustainable production practices. Among these technologies, Direct Ink Writing (DIW) has emerged as a promising approach for the fabrication of customized ceramic components, owing to its capability to produce complex geometries with high dimensional accuracy. Beyond design and decorative applications, this technology could also offer interesting perspectives for the restoration and conservation of ceramic artefacts and works of art, particularly for the digital fabrication of copies or portions of missing elements in conservative restoration interventions.

At the same time, the incorporation of industrial and food residues into new manufacturing processes has become a key strategy for advancing circular economy principles and reducing dependence on virgin raw materials. The ceramic sector, traditionally characterized by high material consumption, offers significant potential for waste valorization through the development of products with both functional and aesthetic value.

Within this framework, the present work explores the feasibility of producing ceramic objects for additive manufacturing through the incorporation of waste-derived materials into printable formulations. Two mining by-products and a food-industry waste were selected as secondary raw materials. A commercial porcelain body was employed as the reference composition and partially substituted with granite waste in amounts ranging from 5 to 30 wt.%. Water, glycerol and pectin recovered from food-sector residues were incorporated as processing additives to tailor the rheological behaviour of the inks for DIW.

The resulting formulations were systematically characterized from a rheological perspective and subsequently printed using nozzle diameters between 0.41 and 0.84 mm and layer heights ranging from 0.82 to 0.90 mm. After shaping, the specimens were dried at 105°C and sintered at 1220°C. The effects of waste incorporation on the processing behaviour and final material performance were evaluated through hot-stage microscopy, scanning electron microscopy (SEM), X-ray diffraction (XRD), color measurements and flexural strength testing.

The results demonstrate that waste-derived resources can be successfully integrated into DIW ceramic formulations, enabling the production of printed components with satisfactory technological properties and limited impact on printability. These findings highlight the potential of combining additive manufacturing and waste valorization strategies for sustainable ceramic products, while suggesting possible future applications in the restoration and conservation of ceramic artefacts.