Recycling Man-Made Vitreous Fibres hazardous waste for the manufacture of traditional ceramics

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Environmental sustainability is a key priority on the global agenda, with increasing focus on sustainable waste management practices. In the search for innovative solutions aligned with the principles of the circular economy, this study introduces an innovative and patented process for the thermal treatment (melting) of hazardous exhaust mineral wool and the recycling of secondary raw materials for the manufacture of traditional ceramics (Arletti et al., 2023).

The proposed process, named Re.Wo (Arletti et al., 2023), aims to: (i) Facilitate the recovery and recycling of materials not currently managed by existing supply chains, which are otherwise destined for hazardous waste landfills; (ii) Encourage the use of alternative raw materials to promote resource efficiency from both ecological and economic perspectives; (iii) Recycling the secondary raw material offers several advantages: a) It replaces primary natural mineral resources in production, reducing reliance on virgin materials; b) It decreases the need for importing raw materials over long distances, thereby minimizing environmental impacts and lowering energy costs; c) It mitigates supply chain risks, such as disruptions due to export bans.

The secondary raw material is produced through a patented process (European Patent EP 22153845.7, 2022) that thermally inertizes exhaust mineral wool. Waste packages, typically destined for controlled landfills, are melted in a specialized plant using a melting furnace operating in an oxy-combustion regime. This technology is inspired by principles widely applied in the production of ceramic frits and glass-ceramics.

The melting process destroys the fibrous structure of the mineral wool, resulting in an inert, non-hazardous, obsidian-like glass (**Fig. 1**). This material can then be used as a secondary raw material in the production of building materials, such as ceramic tiles (Arletti et al., 2023; Sisti et al., 2024).

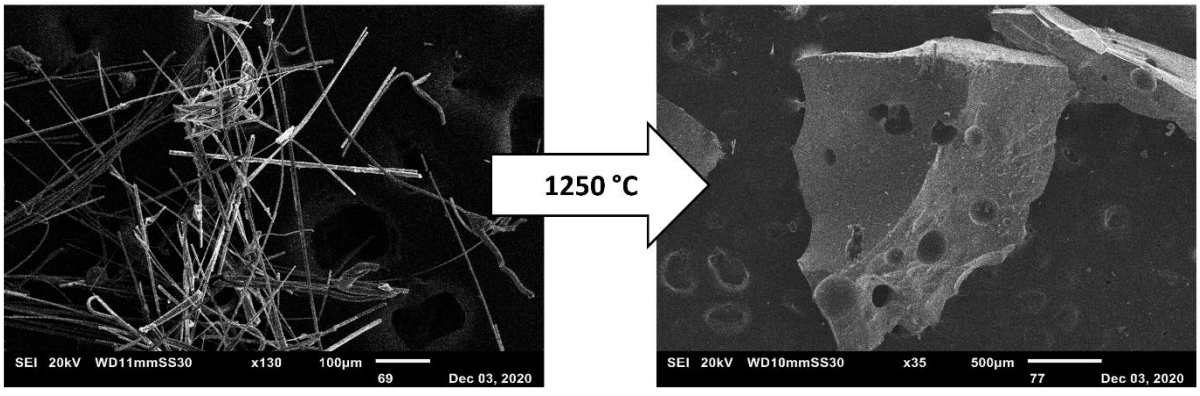

Fig. 1. SEM pictures showing the change in the shape of the raw hazardous mineral wool from fibrous (left) to compact obsidian-like (right) after the melting at 1250 °C in the Re.Wo *end-of-waste* process.

Additions of the secondary raw material Re.Wo up to 9wt% in the formulation of porcelain stoneware mixes was tested. The properties of the final products resulted satisfactory as the values of all the technological parameters recorded for the bodies realized with waste perfectly match the standard requirements for porcelain stoneware (ISO13600). Moreover, the introduction of inertized waste allowed to lower the firing temperature up to 40 °C with respect to the benchmark (called V0). The only drawback observed is related to the colour of the ceramic bodies: the amount of Fe intrinsically present in the inertized glass lead to a darker final colour (**Fig. 2**) (Arletti et al., 2023).

Re.Wo was also successfully tested for the formulation of ceramic glazes, incorporating between 40 and 50 wt% of this glass material. The most promising formulation involves 44 wt% of Re.Wo, resulting in a shiny,

dark ceramic glaze. This outcome demonstrates the suitability of this waste material as a valuable secondary raw material also for the manufacture of traditional ceramic glazes. (Sisti et al., 2024)

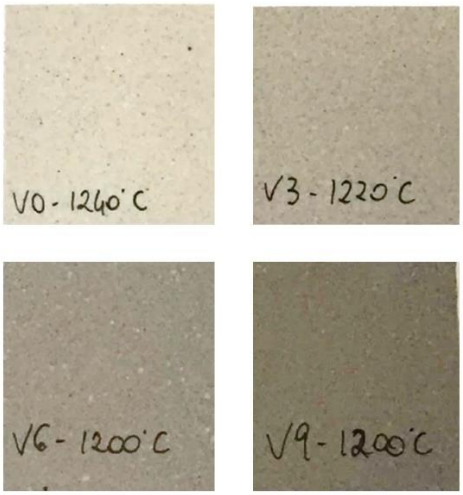

Fig. 2. Appearence of specimen of Re.Wo-rich stoneware tiles. Legend: V0 = benchmark industrial formulation for porcelain stoneware; V3 = V0 + 3wt% of Re.Wo; V6 = V0 + 6wt% of Re.Wo; V9 = V0 + 9wt% of Re.Wo.

The industrial validation of the recycling of glass from hazardous waste in ceramic production could pave the way to a significant potential development of the thermal inertization technology. This can also be applied to other hazardous wastes currently not exploitable in the manufacture of traditional ceramics due to various constraints not only related to safety but also to unsuitable technological behaviour. Vitrification can remove such limitations, stabilizing the waste. The possibility of recycling of vitrified component in ceramic field depends on the know-how acquired in the formulation preparation and in the definition of the behaviour as a function of the glass features (Arletti et al., 2023).

References

Arletti, R., Conte, S., Zanelli, C., De Iuliis, M., Di Giuseppe, D., Scognamiglio, V., Malferrari, D., Dondi, M., Gualtieri, A.F. (2023). Recycling the Product of Thermal Inertization of Man-Made Vitreous Fibres for the Manufacture of Stoneware Tiles. Waste and Biomass Valorization, 14(5), 1721-1736.

European Patent EP 22153845.7 ”Apparatus for treating waste containing mineral wool“. Filing date March 18, 2022.

Sisti, M., Guidetti, D., Altimari, F., Andreola, F., Barbieri, L., Lancellotti, I., Casini, L., Colombo, F., Arletti, R., Fantini, R., Gualtieri, A. F. (2024). Sustainable glazes for ceramic tiles: exploiting inertized man-made vitreous fibres waste as a resource. Ceramics International.

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