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Development of glassy agglomerated rock with a focus on the circular economy

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Introduction

In Brazil, the closed recycling of post-consumer glass is still limited by collection, sorting, contamination, and logistics bottlenecks, which keep relevant fractions outside the bottle–to–bottle cycle. In this context, open recycling appears as a complementary route for recovery, especially in construction, a sector capable of transforming waste into products with a long useful life. This research proposes developing vitreous agglomerated rocks from soda-lime glass bottles, using an epoxy matrix and processing them via thermal compression under vacuum, with the aim of enhancing technical performance and supporting the circular economy.

Objectives

Develop glassy agglomerated rocks using soda-lime glass from post-consumer bottles as 100% of the mineral filler, associated with the epoxy matrix and the silane coupling agent. The study sought to optimize particle-size packaging through simplex-centroid planning, define formulations with higher vibrated density and lower void volume, and produce plates by vacuum-assisted thermal compression. The selected compositions were evaluated through chemical, mineralogical, microstructural, physical, mechanical, and thermal characterization to validate their performance relative to commercial reference materials and to demonstrate their potential as an open recycling route aligned with the circular economy.

Methodology

The soda-lime glass from bottles was washed, dried, crushed, ground, and classified into three particle size ranges. The mixtures were optimized using simplex-centroid planning, selecting compositions #4 and #8. The plates were produced with approximately 89% glass and 11% epoxy resin, using silane and vacuum-assisted thermal compression. Subsequently, they were characterized through physical, mechanical, microstructural, and thermal tests.

Results and discussion

Compositions #4 and #8 showed low apparent porosity (0.25% and 0.36%) and low water absorption (0.08% and 0.14%), indicating good densification of the plates. In terms of flexural strength, they reached 44.13 ± 1.99 MPa and 42.98 ± 1.08 MPa, surpassing White PRIME (36.78 ± 3.98 MPa) and White SIENA (13.50 ± 1.10 MPa). The high resistance is associated with particle size packaging, the use of silane, and vacuum-assisted thermal compression. Dilatometry indicated greater thermodimensional stability for composition #4, reinforcing its better balance between microstructure, the glass–epoxy interface, and technological performance.



Figure 1. Glassy agglomerated rocks were produced in the research

Conclusions

It is concluded that the proposed route is technically viable for converting post-consumer soda-lime glass into glassy agglomerated rocks with higher added value. The combination of particle-size packaging, silanization, and thermal compression under vacuum resulted in plates with performance compatible with that of the internal surfaces, thereby contributing to open recycling and the circular economy of glass.

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