Innovative construction materials from pharmaceutical glass waste

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Abstract

Boro-alumino-silicate glass (BASG) used in pharmaceutical packaging is a considerable growing market ((i)) partly because of the COVID-19 emergency. Differently from other type of glass, i.e. sodalime glass, BASG is not closed-cycle recyclable and nowadays its end-life destination is the disposal in landfill(ii). As a matter of fact, the debate of glass recycling concern the quality of glass articles which can be significantly degraded ((iii)). One of the possibility investigated is the up-cycling process of glass waste that allows to obtain higher-value products, with limited energy and materials inputs. Construction materials, such as bricks, can be achieved starting from dismantled BASG thanks to alkali activation and gel casting. Fine glass powder (below 75 μm) with different degrees of impurity is typically suspended in relatively weak alkaline solution (2.5-5M NaOH/KOH or NaOH), for a liquid /solid ratio of 0.67. Slurries, made by mixing for 3 hours at 500 rpm, undergo gelification by treatment at low temperature (40∘C) for 7-14 days, to save energy, accomplishing a 'cold consolidation'. Slurries can be used as a matrix to encapsulate other inorganic waste materials such as glass powder deriving from plasma processing of municipal waste ("Plasmastone"), volcanic ashes from Mt. Etna or foundry sands with different composition. According to a partnership with a brick manufacturing factory , new building materials have been developed minimizing the use of 'virgin' feedstock. Instead of distilled water, alkali hydroxides are dissolved in 'mud' (pH=9.5) deriving from the cutting and polishing of clay bricks; moreover, solid inert waste from brick manufacturing are embedded in glass-derived cementitious matrix. All developed materials are based on stable gels, verified by water boiling tests. Alkali activation of glass is confirmed as a tool for the manufacturing of inorganic foams, for thermal and acoustic insulation ((iv)). Foamed materials are obtained either by adding cenospheres or expanded glass ("Poraver"), at the end of mixing, or by adding sodium perborate monohydrate (as foaming agent, accompanied by sodium dodecyl sulphate (SDS) as stabilizing agent), already in the starting mix.

((i)) R.K. Chinnam, S. Molinato, E. Bernardo and A.R. Boccaccini, Borosilicate glass foams from glass packaging residues, J. Ceramics for Environmental and Energy Application II (2014) 203-210, https://doi.org/ 10.1002/9781118771327.ch20

((ii)) A. Winterstetter, D. Laner, H. Rechberger and J. Fellner, Framework for the evaluation of anthropogenic resources: A landfill mining case study – Resource or reserve? Res. Cons. Recycl. 96 (2015) 19-30, https://doi.org/10.1016/j.resconrec.2015.01.004

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((iii)) A.R. Romero, S. Tamburini, G. Taveri, J. Toušek, I. Dlouhy and E. Bernardo, Extension of the 'Inorganic gel casting' process to the manufacturing of boro-alumino-silicate glass foams, Materials 11 (2018) 2454, https://doi.org/10.3390/ma11122545

((iv)) A.R. Romero, G. Giacomello, M. Pasetto, E.Bernardo, Novel 'inorganic gel casting' process for the manufacturing of glass foams, J. Eur. Ceram. Soc. 37 (2017) 2227-2234, https://doi.org/10.1016/j.jeurceramsoc.2017.01.012

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