Novel 'inorganic' gel casting process for the manufacturing of glass foams

A new technique, based on gel casting, has been developed for the production of highly porous soda-lime glass foams (porosity >85 vol%). The new process is less expensive and more environmentally friendly than the current procedures, based on the sintering of glass powders mixed with foaming agents, which decompose and release gases at temperature well exceeding the glass softening point (850-950 °C).

The alkali activation of soda-lime waste glass allows the obtainment of well-dispersed concentrated suspensions, undergoing progressive gelification by treatment at low temperature (80 °C), owing to the formation of calcium-rich silicate hydrates. An extensive direct foaming is achieved by mechanical stirring of partially gelified suspensions, exhibiting a marked pseudoplastic rheological behavior (see Fig. 1), comprising also a surfactant.

The final microstructure (total amount of porosity, cell size) can be directly correlated with the degree of gelification (Fig. 2). A sintering treatment, at only 700 °C, is finally applied to stabilize the structures, particularly for limiting the leaching of alkaline ions (Fig. 3a).

The specific strength ($\sigma f/\rho$) of the newly developed foams approaches 10 MPa cm³/g, in good agreement with the data for commercial foams.

The process can be easily extended to many types of glasses, Ca-rich (e.g. bioglasses, Fig. 3b) or not (e.g. nearly Ca-free alumino-boro-silicate glass from the recycling of pharmaceutical vials., Fig. 3c)

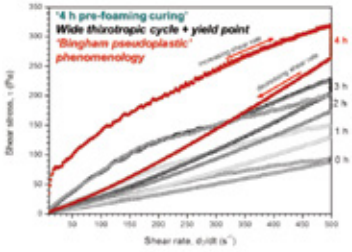


Fig.1 (left) – Flow curves of soda-lime glass suspended (65 wt% solid content) in alkali activated aqueous solution (2.5 M KOH) after different gelation times, before mechanical stirring

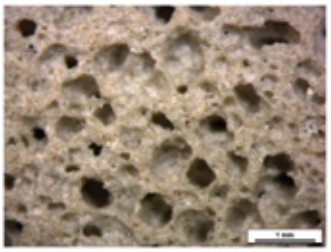
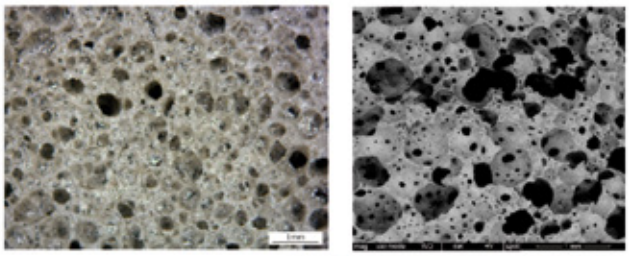


Fig.2 (right) – 'Green' soda-lime glass foam, after mechanical stirring and drying (24 h at 75 °C)



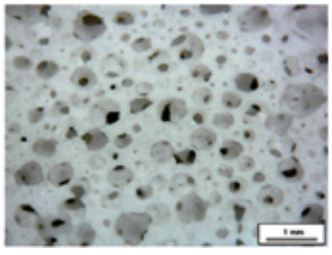


Fig.3 – Examples of glass and glass-ceramic foams from gel casting (followed by sintering)
a) soda-lime glass foam after firing at 700 °C
b) bioactive wollastonite-diopside glass-ceramic foam, after sinter-crystallization at 900 °C
c) Glass foam from pharmaceutical glass, sintered at 700 °C

Materiali avanzati
Advanced Materials

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More information on glass and glass-ceramic foams available at http://www.sciencedirect.com/science/article/pii/S0955221917300262 (open access) and http://www.mdpi.com/1996-1944/10/2/171 (open access)

Main research topics:

- Novel construction materials from inorganic waste and/or recycled glasses
- Monolithic and cellular glasses and glass-ceramics
- Nanostructured ceramic composites from preceramic polymers and fillers
- Advanced porous ceramic components
- 3D printing of ceramics
- Bioceramics from novel formulations and novel processing
- Porous geopolymers