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NOVEL 'INORGANIC GEL CASTING' PROCESS FOR THE MANUFACTURING OF GLASS-CERAMIC FOAMS

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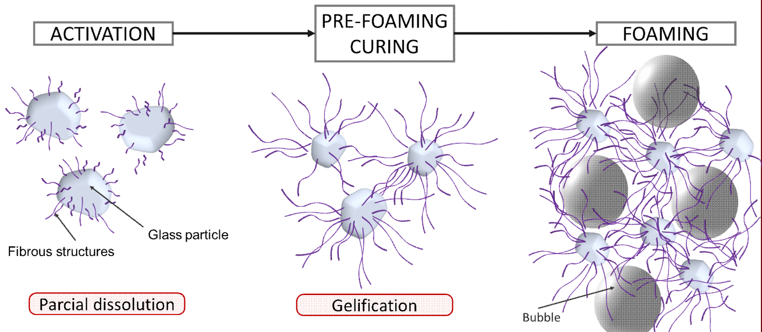
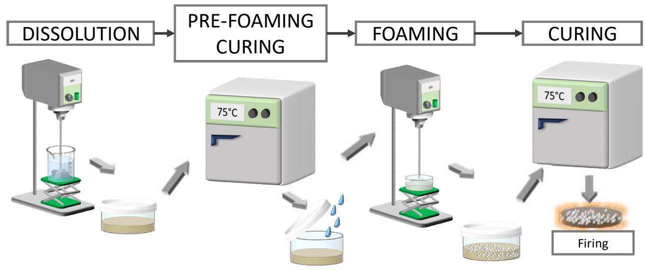
INTRODUCTION

- Conventional glass foams are manufacturing by gas evolution, in a pyroplastic mass of softened glass, provided by substances undergoing thermal decomposition or oxidation.
- A new technique for the production of glass foams was developed, based on alkali activation and gel casting. This technique also allows the incorporation of metallurgical slag.
- A 'weak alkali activation' of the glass/slag mixtures is not intended for complete dissolution of components, but it is aimed at developing gels in turn allowing for low temperature hardening.
- A sintering treatment, at 800-1000 °C, may be later applied to convert highly porous 'glass-based mortars' into glass-ceramic foams sowing to glass-slag interactions, limiting the leaching of alkaline ions.



METHODS AND MATERIALS



- The powders were suspended in aqueous solutions containing 2.5M KOH for solid loading of 65 wt%, subjected to alkaline attack for 3h.
- Partially dissolved powders were cast in closed moulds and cured at 75 °C for 2h.
- Suspensions were later added (4 wt%) with a non-ionic surfactant Triton X-100 and subjected to vigorous mechanical mixing.
- Foamed gels were kept at 40°C for 24 h, before being demoulded.
- Finally, hardened foamed gels were fired at temperatures between 800-1000 °C, for 1h, with a heating rate of 10 °C/min.

Chemical compositions of starting materials

(wt%)	SiO_2	Na_2O	CaO	Al_2O_3	MgO	K_2O	Fe_2O_3	BaO	ZnO	B_2O_3
SL	70.8	13	9.4	2.4	2.1	1.1	0.3	0.2	0.12	0.12
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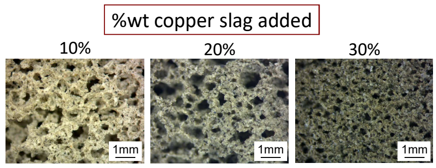
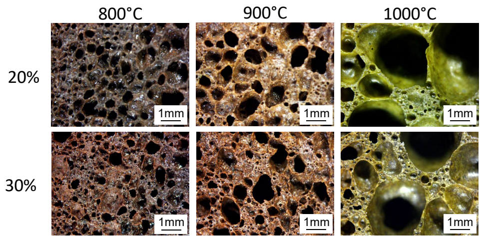
RESULTS AND DISCUSSION

Microstructural details of the hardened foams



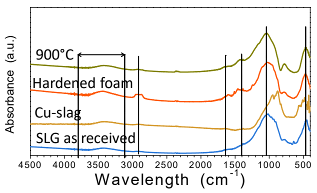
- After gel hardening high uniformity of pores.
- Pore structure influenced by the amount of copper slag added.

Microstructural details of the fired foams



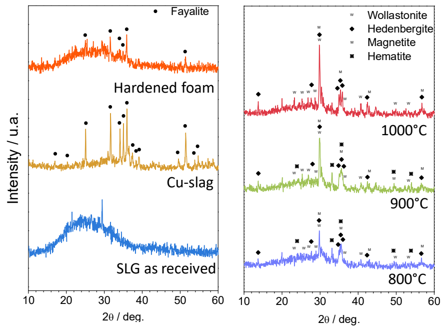
- At 800 °C some reshaping of the pores during the heat treatment.
- At 900 °C some cell coalescence, but an overall homogeneous cellular structure is maintained.
- A significant coalescence is observed for foams obtained at 1000 °C.

FTIR spectra of selected materials



- High –OH absorption for the green foams, thanks to the formation of hydrated compounds after the alkali activation.
- Bands from 1290 to 900 cm^{-1} and at 800 and 450 cm^{-1}, are identified with Si-O-Si groups.

X-ray diffraction patterns

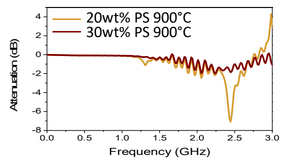


- Fayalite (Fe_2SiO_4), as main crystal phase in the copper slag, it is not dissolved upon alkaline activation.
- shifting of the 'amorphous halo' after the alkaline activation.
- After heat treatment main crystal phases wollastonite ($CaSiO_3$) and hedenbergite ($CaFeSi_2O_6$).
- Reduction of iron oxides formation of magnetite (Fe_3O_4) and hematite (FeO).

Mechanical properties of the developed glass-ceramic foams

Firing T (°C)	% total P	% open P	ρ (g/cm³)	σ_c (MPa)
800	76 ± 3	59 ± 9	0.23 ± 0.03	4.3 ± 0.9
900	78 ± 3	70 ± 4	0.22 ± 0.03	2.3 ± 0.4
1000	75 ± 7	45 ± 9	0.24 ± 0.07	3.3 ± 1.1

Magnetic shielding



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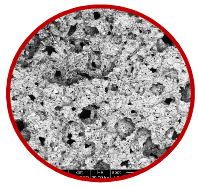

CONCLUSIONS

- Glass ceramic foams can be obtained by alkali activation of suspensions of glass particles and copper slag though a gel-casting technique.
- Surfactants affect the morphology of 'green' foams, but do not determine 'secondary foaming'.
- The secondary foaming depends on decomposition of hydrated ferrous and compounds during the heat treatment process.
- Glass ceramic foams with similar characteristic to commercial ones, with additional functionalities (magnetism).

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