OPEN-CELL POROUS INORGANIC POLYMERS FOR SOUND ABSORPTION

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ABSTRACT: This work describes the production of porous inorganic polymers (IPs) by alkaline activation of an iron-rich slag and chemical foaming. These materials are of interest due to their potential use for several applications and most of the literature focus on its thermal insulation properties. In this paper, the produced porous IPs are assessed as noise absorbers. The porous IPs were synthesized from a five component blend: an iron-rich slag, ground granulated blast furnace slag (GGBFS), an alkaline activator, a surfactant and aluminum powder (Al). The amount of Al was varied from 0.05 wt% to 0.25 wt%, producing different porous morphologies: when the Al was increased the total porosity changed from 45% to 85% and the pore size distribution became broader. Regarding the compressive strength and density of the samples, both decreased at increased Al concentrations. Sound absorption measurements, in the range of 200 to 4000 Hz, were carried out by means of a Kundt Tube. Different noise reduction coefficients were obtained, especially at higher frequencies, when the morphological characteristics of the samples changed. This work aspires to be the first steps in developing a sound absorption barrier using porous IPs, but further research needs to be carried out in order to improve and optimize their noise absorption capacity.

INTRODUCTION

One of the main environmental concerns in metal extraction is the co-production of metallurgical residues, such as sludges and slags.[1] In the case of Cu extraction, around 2.2 tons of Fe-rich slags are co-produced per ton of Cu[2], which are transformed into more than 20 Mt/y. So far, these residues have been used in low added value applications as aggregates for roads and constructions.[3] One of the promising valorisation options is their use in the synthesis of a novel binder, i.e. inorganic polymers (IPs). Such binder could be used for multiple purposes, including the production of porous materials. Nonetheless, the sound absorption properties of Fe-rich porous IPs have not been yet investigated. This study deals with porous inorganic polymers (IPs) synthesised by alkali activating a Fe-rich slag with concurrent foaming. Their sound absorption capacity is assessed and interpreted taking into account their porosity and thickness.

METHODS AND MATERIALS

An Fe-rich slag and the GGBFS were mechanically blended to a final Si/Al = 2.4 and (Si+Al)/(Fe+Ca) = 1.2 molar ratios. The alkaline activator had a Si_2O/Na_2O molar ratio of 1.7 and an H_2O/Na_2O ratio of 21.2. The surfactant was sodium oleate (purity 82%, Sigma-Aldrich) and the gas releasing agent was aluminium powder (purity 99.9%, AEE) with a particle size between 1 and 5 µm. The porosity of the samples was calculated using a SkyScan 1172 µ-CT from Bruker. The compressive strength was measured on samples of 3x3x3 cm3 by using an Instron 5985. The sound absorption measurements were carried out by means of a Kundt Tube, in the frequency range of 100 to 4000 Hz.

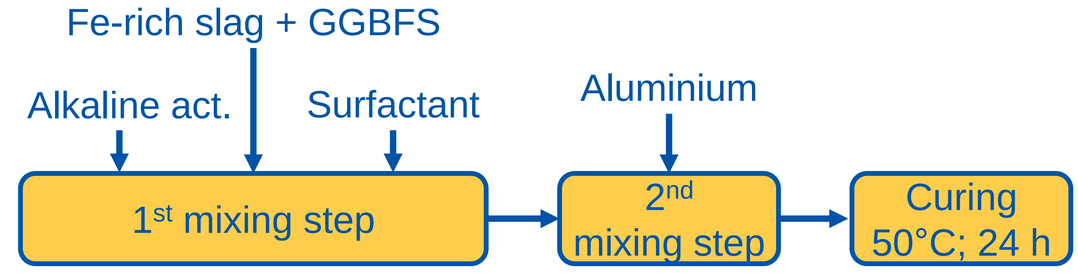

Figure 1: Porous IP synthesis procedure

RESULTS

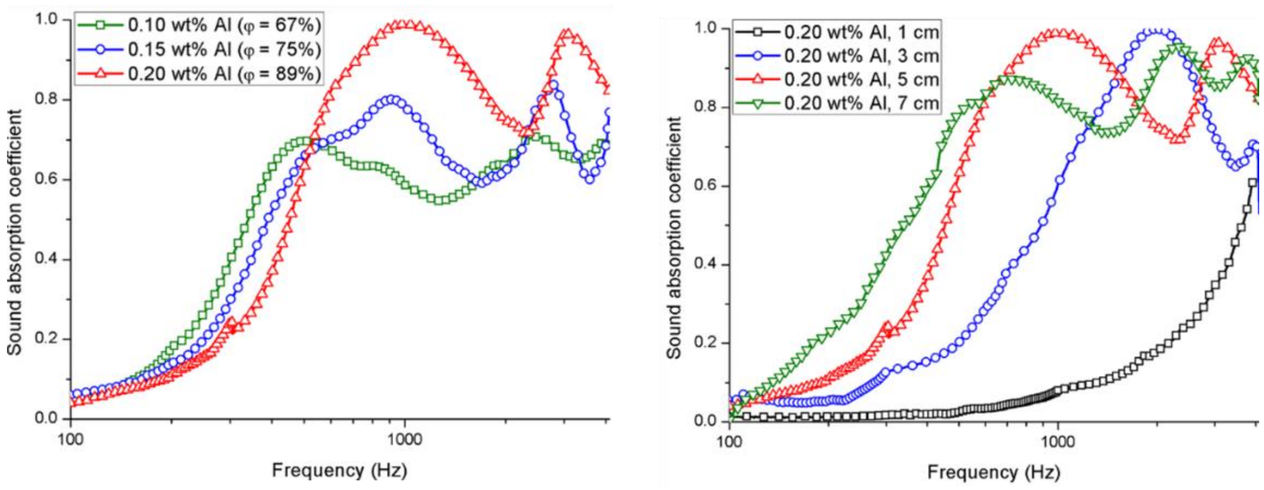

Figure 2: : Sound absorption coefficient between 100 and 4000 Hz: a) Porosity effect with constant thickness (5 cm) and b) sample thickness effect.

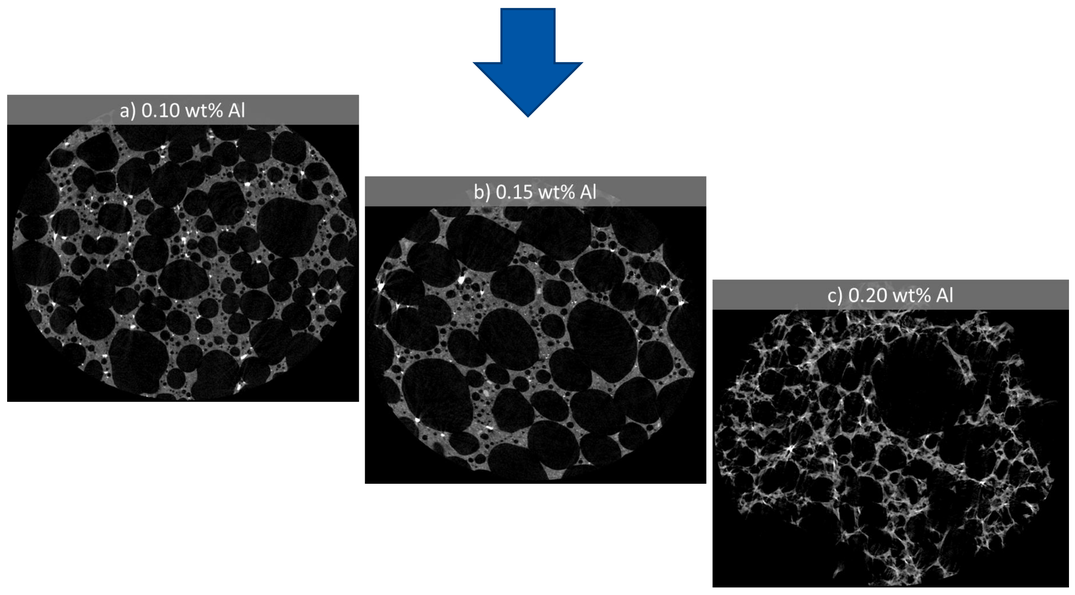

Figure 3: Reconstructed cross-sections from µ-CT analysis

Table 1: Summary of the compressive strength, density and porosity results

Sample	Compressive strength Mpa	Density (ρ) kg/m³	Porosity (φ) %
0.10 wt% Al	3.4 ± 0.1	850	67
0.15 wt% Al	1.8 ± 0.1	600	75
0.20 wt% Al	1.0 ± 0.1	440	89

CONCLUSIONS

✓ The sound absorption capacity of the porous IPs could be engineered, by modifications of their porosity as well as by a sufficiently large sample thickness, to reach high absorption coefficients in a broad range of frequencies.

✓ Increasing the porosity increases the absorption at high frequencies, at the expense of a decrease of absorption at low frequencies.

✓ Samples with higher porosity, however, have a lower compressive strength.

ACKNOWLEDGEMENTS

This work forms part of the GHRANTE project: "Geopolymers and Hybrid Cements for Roads and Tunnels" (HBC.2017.0608), financially supported by SIM.

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