TAILORING THE PROPERTIES OF POROUS INORGANIC POLYMERS: EFFECT OF THE PRECURSOR

Arnaud BOONEN, Roberto MURILLO ALARCÓN, Lubica KRISKOVA, Tobias HERTEL, Yiannis PONTIKES

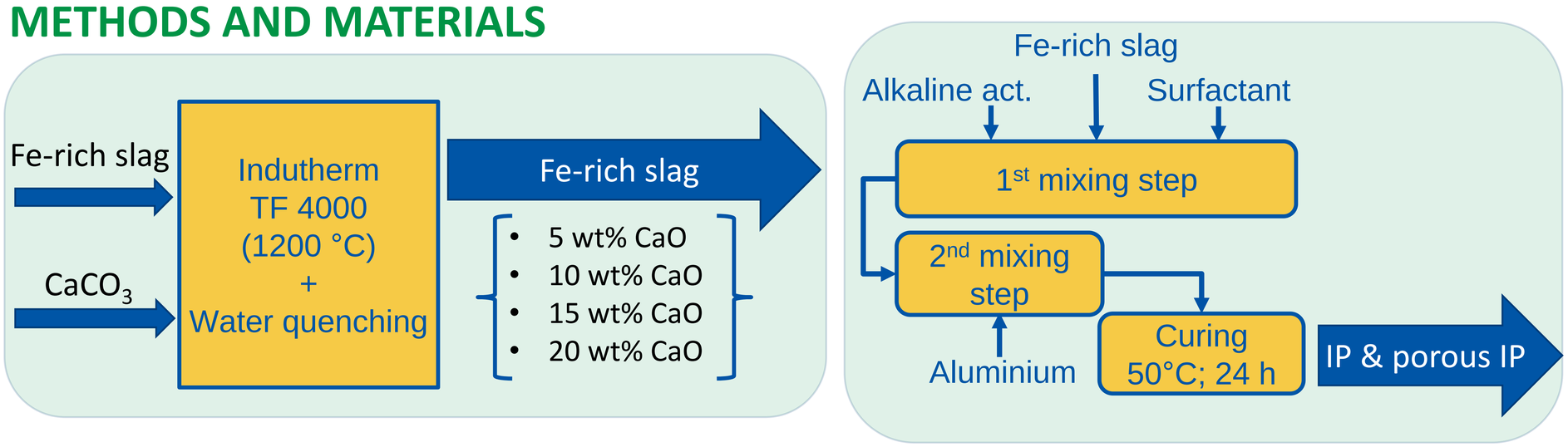
KU Leuven, Department of Materials Engineering, 3001 Leuven, Belgium

ABSTRACT: Inorganic polymers (IPs) are potential alternative binders to conventional cements. They are often produced in the scope of sustainable construction materials, as they offer a possibility to contribute to waste valorisation and low production emissions. The aim of this work was to investigate the effect of the CaO concentration of a Fe-Si based slag from a secondary Cu production on the properties of porous inorganic polymers, such as setting time, expansion kinetics, strength and microstructure. For this purpose, the CaO concentration of the Cu slag was altered to 5, 10 and 15 wt% CaO. Porous IP were synthetized by means of an alkaline activator (SiO_2/Na_2O = 1.6; H_2O = 75 wt%), an aluminium powder (gas releasing agent) and sodium oleate (surfactant). Results showed that a higher CaO content in the slag promotes faster reaction and setting of the synthetized IP. Furthermore, at higher CaO concentrations, the rate of expansion was slower and the pore structure showed less irregular shapes and narrower pore size distribution. It was also observed that the magnitude of the expansion, the porosity and the thermal conductivity did not differ significantly at a given concentration of aluminium.

INTRODUCTION

Slag valorisation is a topic of increasing importance for circular economy and increased sustainability within the metallurgical industry. The copper industry, for example, produces annually about 24 million tonnes of Fe-rich slag worldwide.[1] One of the potential valorisation options for this slag is the production of porous IPs[2], which are lightweight materials that can be synthetized by mechanical or chemical foaming.[3] This works uses the latter, and it is done by means of a gas releasing agent (i.e. Al, H_2O_2, Si), that is added to the IP paste.[4] Various process parameters are known to affect the foaming reaction as well as the final foam properties.[5] This study investigates the effect of the precursor on the expansion kinetics and final properties, in particular, the amount of CaO in the used Fe-rich copper slag.

METHODS AND MATERIALS



RESULTS

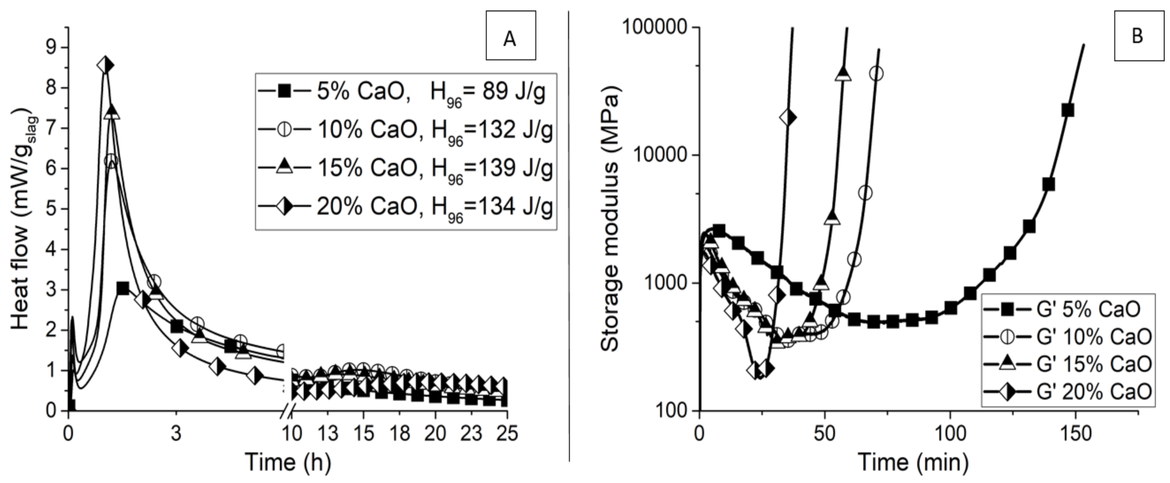


Figure 1: A) Calorimetry measurements, B) rheology measurements of the pastes

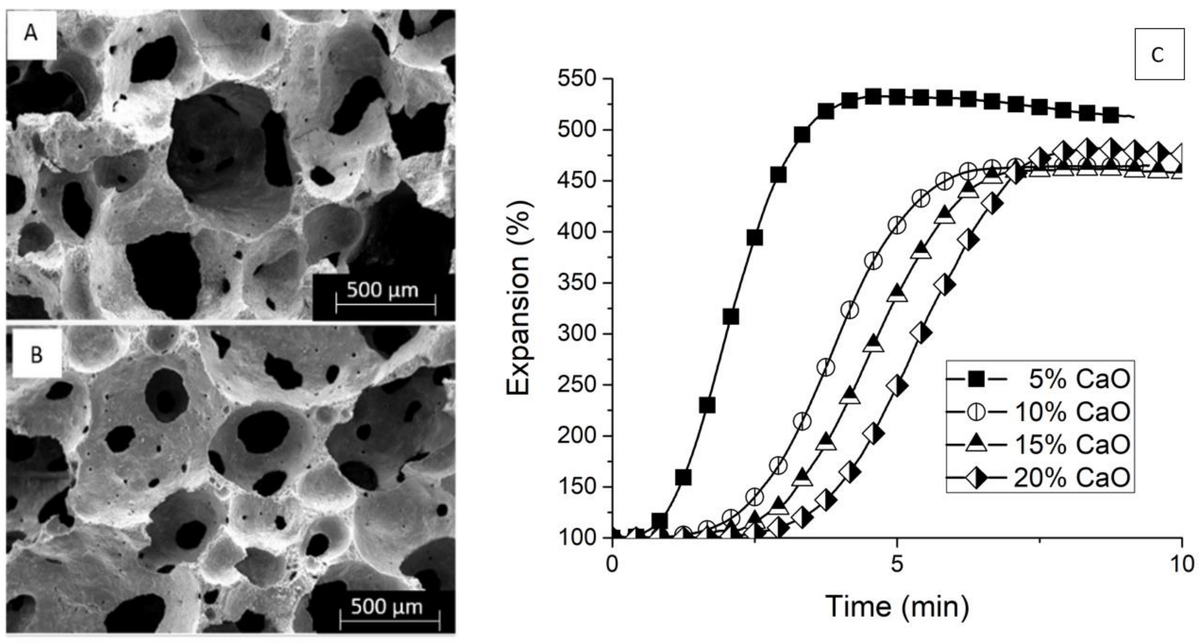


Figure 2: A) SEM image of a 5% and B) a 20% CaO IP. C) Expansion of the IPs after mixing.

Table 1: Compressive strength and thermal conductivity of the porous IPs

Porous IP	Compressive strength (MPa)	Thermal conductivity (W/m K)
5 wt% CaO	0.5 ± 0.1	0.058
10 wt% CaO	0.8 ± 0.1	0.059
15 wt% CaO	0.5 ± 0.1	0.064
20 wt% CaO	0.5 ± 0.1	0.057

CONCLUSIONS

✓This work demonstrated that morphological characteristics of porous IPs could be tailored by altering the CaO concentration of the precursor.

✓Altering the CaO content in order to tailor the composition of the resulting slag could be a cost-effective method to modify Cu slags during the production step, without compromising the quality of the Cu.

✓The optimisation can be done for the setting time and reactivity of the paste, as well as for the expansion time of the inorganic polymer.

✓The pore size distribution and pore characteristics can be altered without changing the porosity of the polymer.

REFERENCES

1. B. Gorai et al, Resour. Conserv. Recycl., 39 (4) 299-313 (2003).
2. Y. Pontikes et al, Appl. Clay Sci., 73 (0) 93-102 (2013).
3. M. Strozi Cilla et al, Ceram. Int., 40 (4) 5723-5730 (2014).
4. Z. Liu et al, Int. J. Miner. Metall. Mater., 21 (1) 89-94 (2014).
5. J. Denissen et al, Proceedings of the 5th SVS, 441-444 (2017).

6th International Slag Valorisation Symposium

Science, Innovation & Entrepreneurship in Pursuit of a Sustainable World

1-5 April 2019 Mechelen, Belgium