

ALKALI ACTIVATION OF SYNTHETIC $\text{SiO}_2\text{-CaO-FeO}_x\text{-Al}_2\text{O}_3\text{-MgO}$ GLASS

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ABSTRACT

Municipal solid waste incinerator (MSWI) bottom ash (BA) is the most significant by-product of the municipal solid waste combustion process and currently finds only minor applications. Being a silica-rich material, BA is indeed a promising precursor for the synthesis of inorganic polymer. The glass chemistry and mineralogy produced by microwave heating the MSWI BA was replicated by melting and quenching a blend of synthetic oxides. This synthetic glass was subsequently investigated for its potential use in inorganic polymers. The influence of different $\text{SiO}_2/\text{Na}_2\text{O}$ (0.8 and 1.6) and $\text{H}_2\text{O}/\text{Na}_2\text{O}$ (16 and 25) molar ratios of activating solutions on the setting kinetics and compressive strength of the resulting IP was investigated herein. The results showed that the early compressive strength is influenced by the ratio $\text{SiO}_2/\text{Na}_2\text{O}$, while no effect is observed on the 7 days strength. Fast dissolution and polymerization took place, as appeared by the calorimetry measurements.

INTRODUCTION

Towards a low carbon circular economy, intense research has led to alternative binders, such as inorganic polymers (IPs). The current work aspires to contribute to the field of using MSWI BA as a standalone precursor for IP synthesis. The performance of the IPs in terms of compressive strength, is affected among others by the activating solution and its water content^{1,2,3}. Since MSWI BA have variable and unpredictable composition, a $\text{SiO}_2\text{-CaO-FeO}_x\text{-Al}_2\text{O}_3\text{-MgO}$ synthetic glass, replicating a certain MSWI BA chemistry was used as a precursor for the IPs synthesis.

METHODS AND MATERIALS

Melting of the starting mixture of pure oxides under air atmosphere took place in an induction furnace. Subsequent quenching of the melt in water was performed to form the synthetic glass (SG). Inorganic polymer pastes were prepared by mixing different activating solutions $\text{SiO}_2/\text{Na}_2\text{O}$ (0.8 and 1.6) and $\text{H}_2\text{O}/\text{Na}_2\text{O}$ (16 and 25) molar ratios with the powder glass, under the liquid/solid ratio of 0.4. Calorimetry measurements were performed in an Isothermal Calorimeter at 20 °C. The compressive strength was determined using a crosshead speed of 2 mm/s on samples of $2 \times 2 \times 2 \text{ cm}^3$.

RESULTS

The chemical composition of the SG, as well as the amorphous content are presented on the Table 1.

Table 1: Chemical composition of the synthetic glass by XRF data and the amorphous content by XRD.

	SiO ₂	CaO	Fe ₂ O ₃	Al ₂ O ₃	MgO	Amorphous
SG	48.9	22.3	11.6	10.5	2.1	96

The early compressive strength (Figure 1) of the 1.6-25 IP is higher (7 MPa) than the one for the 0.8-16 IP (4 MPa), while the 7 days strength increases significantly for both IPs.

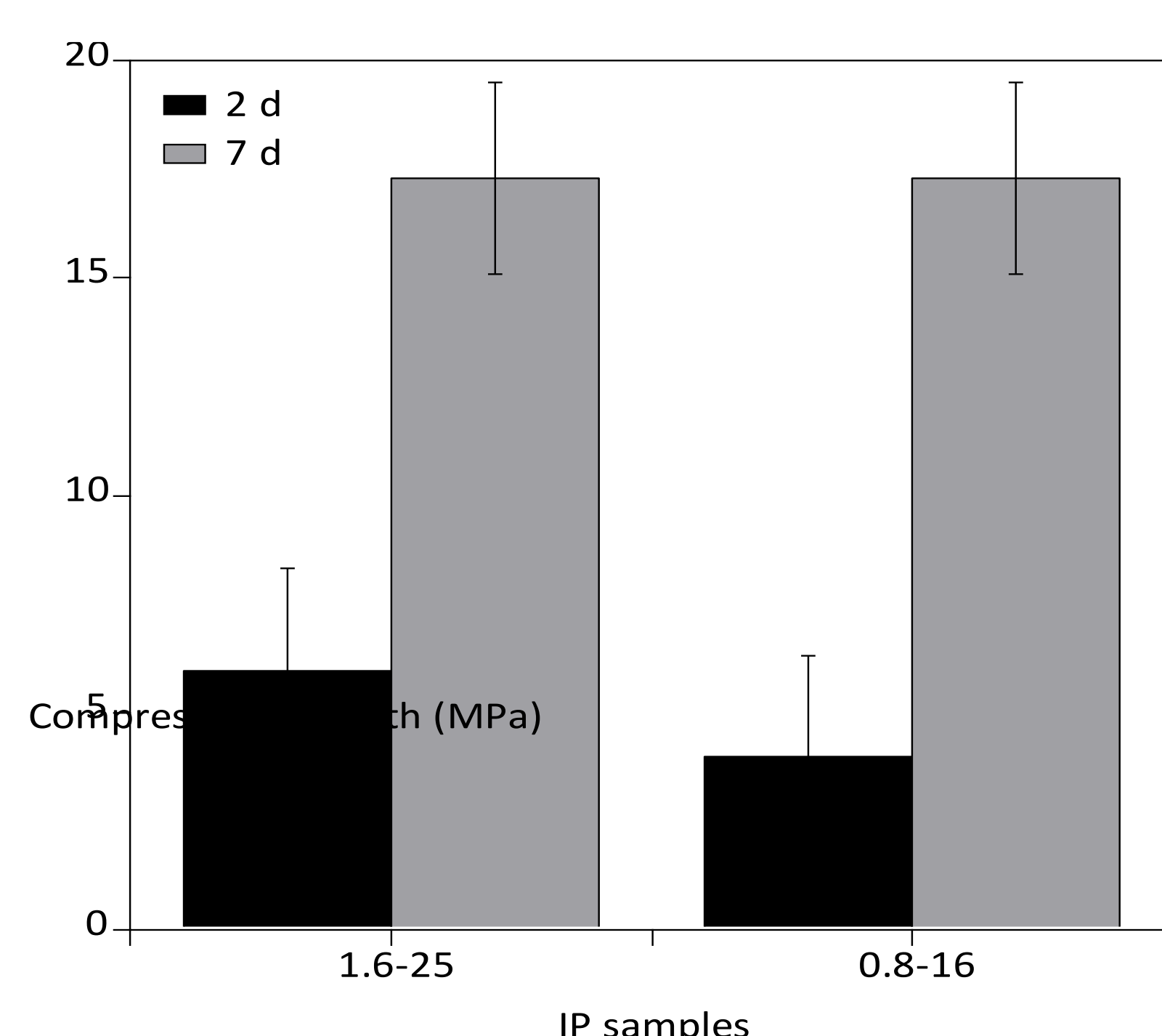


Figure 1: Compressive strength of the inorganic polymers for 2 days and 7 days.

The peaks observed in calorimetry measurements in less than one hour for both IPs, are related to the dissolution and, because the onset of setting was observed within this timeframe, the formation of the polymeric network. The heat flow abruptly decreases after the initial reaction peak. Nevertheless, it should be noted that the reaction kinetics could not be directly correlated to the mechanical properties of the produced IPs, as more heat was evolved at 48 hours from the sample with a lower 2 days strength.

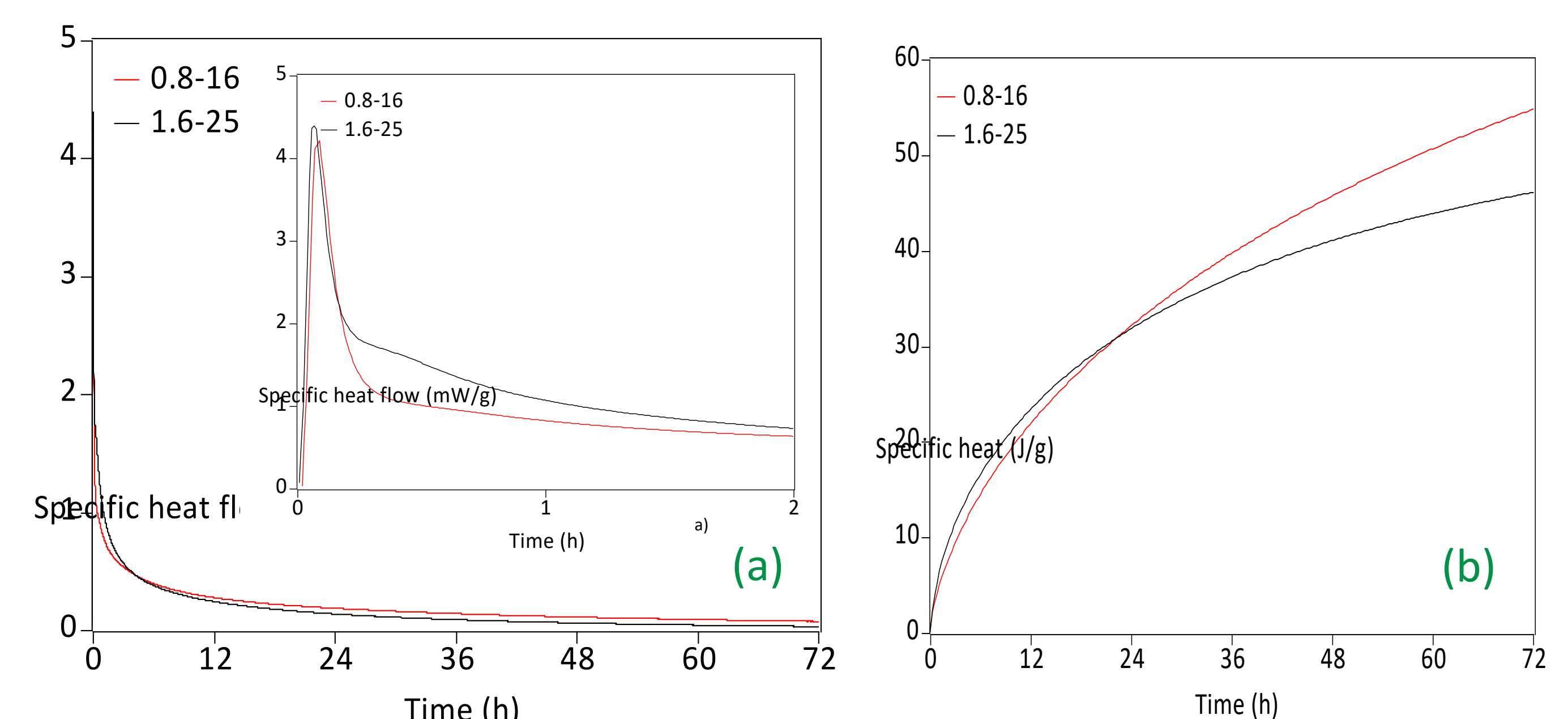


Figure 2: Specific heat flow (a) and (b) specific heat in isothermal calorimetry at 20 °C during the first 70 h after mixing

CONCLUSIONS

- ✓ Early age strength appears to be influenced by the ratio $\text{SiO}_2/\text{Na}_2\text{O}$.
- ✓ No effect of the solutions is observed on the 7 days strength.
- ✓ Calorimetry measurement shows fast dissolution and polymerization.

REFERENCES

1. K. Komnitsas *et al.*, J.Hazard. Mater., 161 (2-3) 760-768 (2009).
2. I. Maragkos *et al.*, Miner. Eng., 22 (2) 196-203 (2009).
3. L. Kriskova *et al.*, J.Sustain. Metall. 1(3) 240-251 (2015).

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