ACTIVATION OF FAYALITE SLAG TOWARDS INORGANIC POLYMERS

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Main focus points of research

- Development of phosphate cementitious matrix
- Minimal environmental impact & acceptable cost
- Development of Textile Reinforced Cementitious materials with glass fibres
- Development of cement for 3D printing

Secondary goal

- Rethinking of the traditional wall structure (High-Insulating sandwich panels)

All components = Inorganic

Phosphate Cements

- Made by mixing a hardening liquid and a solid phase
- They solidify in acid rather than in alkaline environments

Known to be fast reacting systems!

Strong advantage: They become pH neutral after hardening

→ Compatibility with glass fibers

ACIDIC ACTIVATION

Fayalite slag received from a Belgian industry was used as the powder precursor. Two different grain sizes were used, to investigate the influence of the particle size on the reactivity and workability of the produced cementitious materials. The powder was milled for 1 and 16 hours respectively.
Fayalite slag, pure phosphoric acid (85%), and distilled water were mixed at an l/s mass ratio of 1.38, with a high shear mixer for about 2 min to obtain a homogeneous slurry. The final molarity of the activating solution was 8.5 M. The ratio of fayalite slag to quartz sand by mass that was chosen for the preparation of mortars was 1:1.

Unfortunately, it was not possible to synthesise specimens with fayalite slag after 16 hours of milling in large-scale, due to the extremely short pot life. More specifically, the reaction between the activating solution (H_3PO_4 with KH_2PO_4) and the milled FS powder occurred almost instantly, while mixing the components.

FTIR

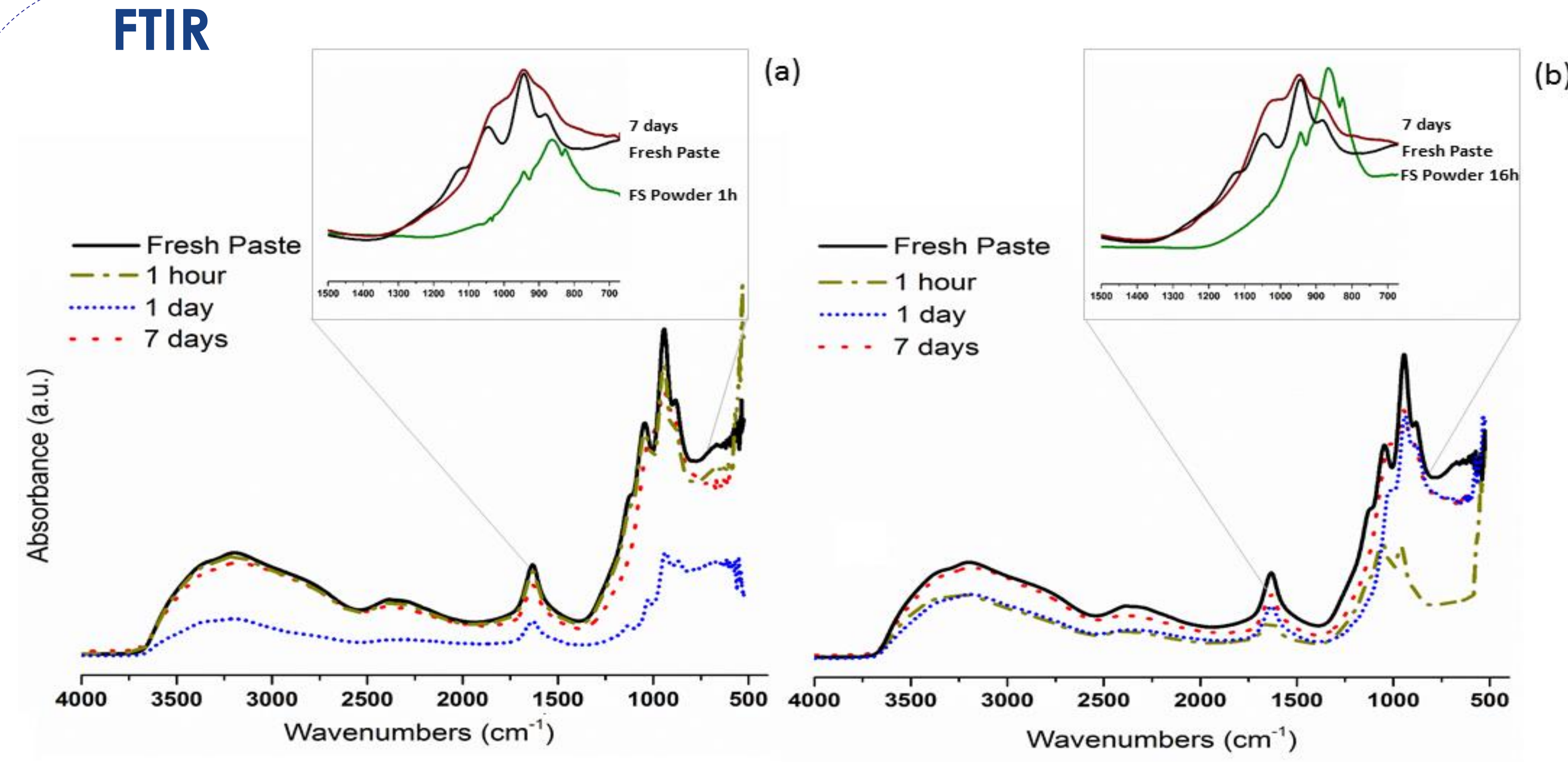

Fig. 1: Comparison of the FTIR spectra of pastes activated by phosphoric acid solution with (a) fayalite slag after milling for 1 hour and (b) after milling for 16 hours. The l/s mass ratio which was used is 1.38.

- Broad band in the 3700-2500 cm^{-1} region: related to stretching vibrations of adsorbed water and bending vibrations at 1650 cm^{-1}.
- Band situated in the 1255-800 cm^{-1} region: refers to Si-O vibrations from fayalite or newly formed products.
- Band at ± 1045 cm^{-1} and shoulder at ± 1200 cm^{-1}: attributed to P-O vibrations.
- Shoulder at ± 1200 cm^{-1} disappears with increasing aging, while, the characteristic bands around 1045 and 945 cm^{-1} end up to a single broad band at 945 cm^{-1} after seven days of curing. This merge to a single band could be ascribed to the low mobility which molecules have after hardening.
- The band at ± 1045 cm^{-1} became sharper and shifted towards lower wavenumbers.

TGA

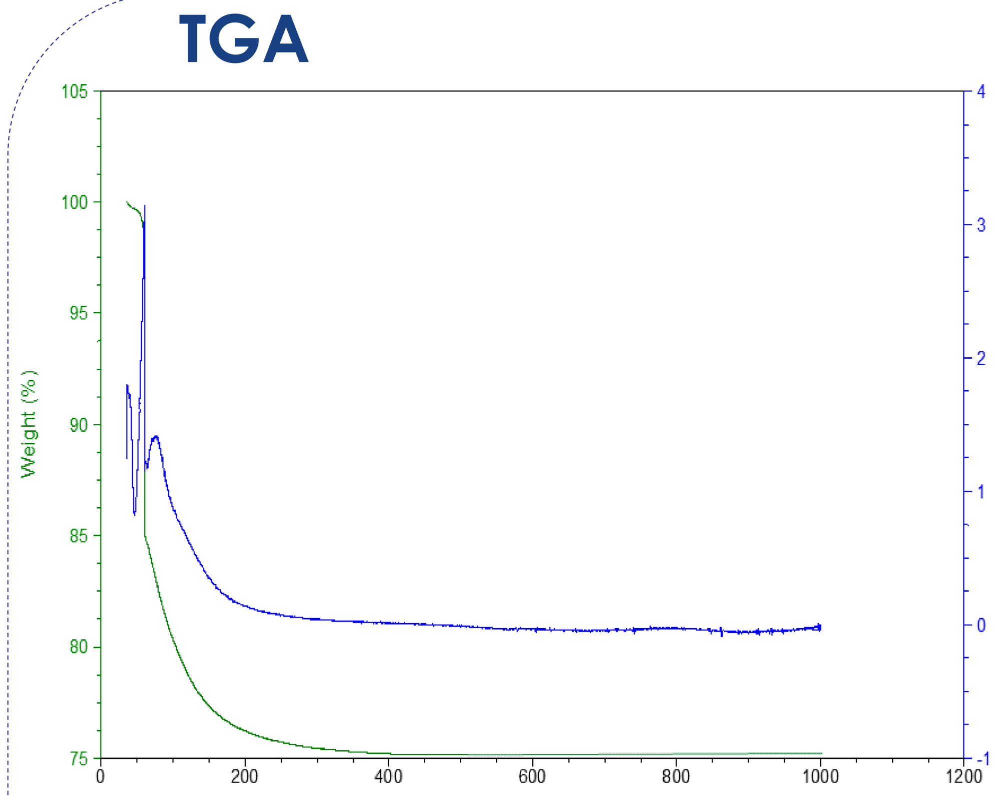

Fig. 2: TGA of the hardened cement paste with l/s mass ratio of 1.38.

- Between RT and 100 ºC, water evaporates resulting in mass loss of 15% and sharp increases of the first derivative.
- During the reaction a certain percentage of water becomes chemically bonded and the rest remains as free water.
- The sharp peak of the first derivative corresponds to chemically bonded water.

SEM

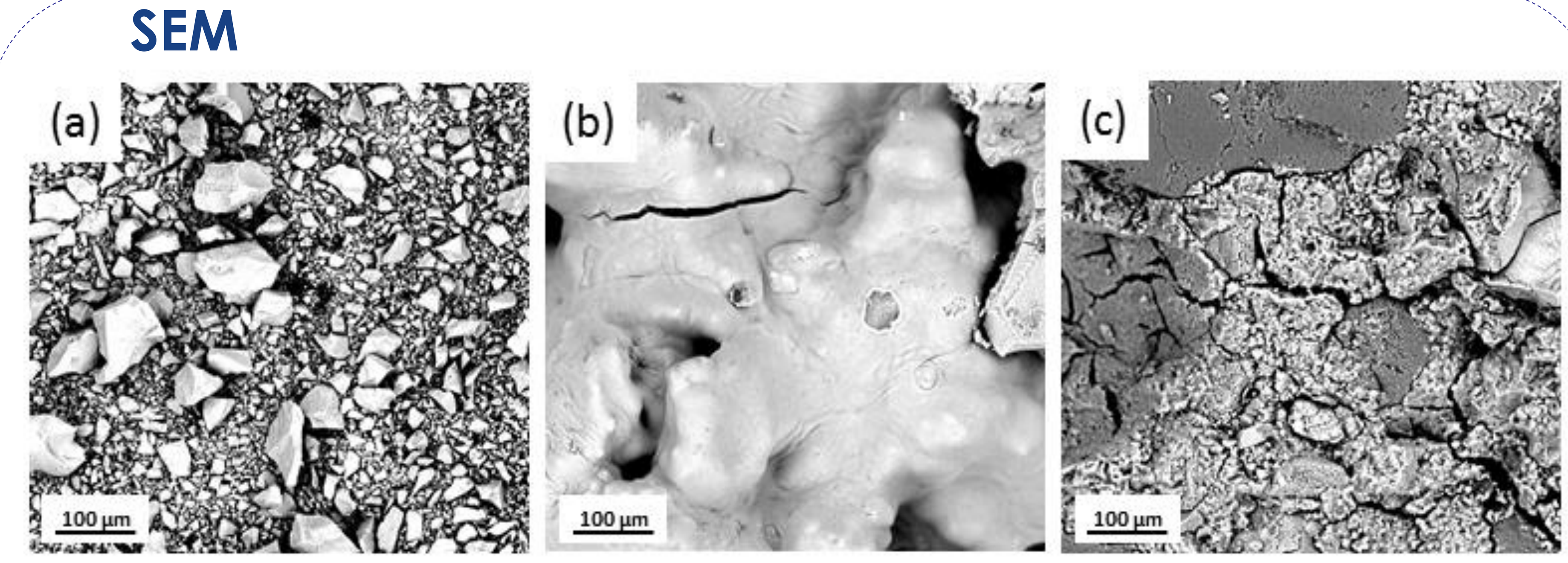

Fig. 3: SEM cross-section of the: (a) FS powder after 1 hour of milling, (b) paste of phosphate cement with r=1.38, after 1 hour milling, (c) mortar of phosphate cement with r=1.38, after 1 hour milling

CONCLUSIONS

Inorganic polymers based on fayalite slag were fabricated, under acidic activation, at a first stage research, and presented good mechanical properties at room temperature. The compressive strength of the newly developed cement was > 15 MPa, reaching up to a maximum of 19 MPa.

The work demonstrated the importance of the particle size of the raw precursor, as well as its influence on the workability of the mixture. It has been proven that by starting from a rather coarse powder, it is possible to produce specimens, with an acceptable pot life. Further development of the material will require a more in-depth analysis of the rheology, thermal behavior, and microstructure.

References

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