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Environmental-friendly materials by alkali activation

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Alkali activation is the chemical process through which an aluminosilicate powder (referred to as the *precursor*) interact with a strongly alkaline medium (the *activator*) to yield ceramic-like materials with good binding properties. The process occurs at room temperature starting from waste or industrial by-products, allowing for a significant reduction of emissions of greenhouse gases. Nowadays, Alkali Activated Materials (AAMs) have emerged as novel engineering materials with potential use in many application fields, in particular as environmental-friendly alternative to traditional construction materials. AAMs exhibit properties, which include formability comparable to epoxies, high temperature stability, chemical resistance comparable to ceramic oxides and compressive strength superior to concrete. Moreover, they show adsorptive properties towards metal cations, wastewater pollutants and CO_2. Tailoring the properties of AAMs for specific applications requires full control on synthesis conditions and understanding of the structural and microstructural features of the final product.

In a recent work from our group, the feasibility of using sulphate-bearing kaolin for alkali activation has been assessed [1]. Alunite, $KAl_3(SO_4)_2(OH)_6$, which is present in the kaolin, hinders the use of these clays in the ceramic industry due to the release of SO_x at HT. Nonetheless, it is a potential source of potassium and aluminium. AAMs obtained at temperature below desulphation show high thermal stability and compressive strength as high as ca. 80 MPa. Thenardite, Na_2SO_4, deriving from the dissolution of alunite, was observed in the final products. Nonetheless, sulphate is still present in the samples after leaching. In order to identify the possible non-soluble sulphate-bearing phases and evaluate the possibility of sulphate uptake by the gel itself, zeolitisation of kaolin was carried out under molten conditions [2] in the absence or presence of sulphate.

Kaolin-alunite mixtures were melted with NaOH at 550°C, incubated in vessels with distilled water, and resulting powders characterized by Rietveld refinements of XRPD patterns, FT-IR and SEM-EDS. Zeolites Y and A crystallize in sulphate-free mixtures, as expected, while sulphate-bearing CAN is the main reaction product of all alunite-containing batches. Therefore, sulphate ion could drive the nucleation and precipitation of CAN-type zeolites at room pressure, analogously to CO_3^-, NO_3^-, and SO_3^{2-} [3]. These findings suggest that sulphate may have the same effect also in alkali activation process. This hypothesis is supported by preliminary ^{29}Si and ^{27}Al NMR data, indicating cancrinite as one of the candidate phases for trapping sulphur in AAMs.

References:

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