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Alkali activated slag based on steelmaking slag: application and properties

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Alkali activated slag (AAS) is an environmentally friendly material which were extensively investigated in a pass two decade. Currently, these materials are considering as an effective alternative for cement binder. Process of slag alkali activation involves a chemical reaction between solid calcium aluminosilicate materials and a highly alkaline activator. The alkali activation mechanism of slag consists of the slag dissolution in a highly alkaline which is followed by the condensation and hardening processes yielding formation of calcium (alumina) silicate hydrate C–(A)–S–H gel as a reaction product of slag alkali activation [1]. Properties of these materials primarily depends on the choice of solid row materials. Primarily, granulated blast furnace slag, by product of iron production) is considering as a precursor for AAS synthesis. However, an important shift towards the use of steelmaking slag is also observed [2].

Although electric arc furnace slag has already found its application mainly in civil engineering, this investigation has aimed to investigate properties of AAS prepared using the electric arc furnace slag (EAFS) with an emphasize with different possibilities of its application. Characterization of AAS involved XRDP, SEM/EDS and pore size analysis with the aim to build up a detailed illustration of AAS from the stand point of different application.

AAS prepared using EAFS and Na_2SiO_3 solution at solid to liquid ratio of 4 and cured at 65 ^oC for a period of 48 h, reached the compressive strength of 38.8 MPa which enables its application in civil engineering. Sintering of such prepared AAS at temperature up to 1000 ^OC additionally increased the strength of AAS up to 51 MPa. Strengthening of AAS structure upon sintering is attributed to the mineralogical transformation of wüstite into magnetite and pore size reduction (Fig 1). Strengthening of AAS upon heating enables its application in a high temperature conditions.

Powdered AAS can be used as an effective adsorbent for Cu^{2+} removal from sulphate aquatic solution. The ions of copper are adsorbed on the surface of AAS slag in the form of postnjakite (Fig. 2. The achieved removal efficiency of Cu^{2+} ions at 20 ^oC was 63.93%. The adsorption of Cu^{2+} onto AAS proceeds via pseudo second adsorption mechanism and Langmuir isotherm model fits well the experimental data. Adsorption process is fast, spontaneous and endothermic in nature.

AAS can also be used as an effective agent for stabilization/solidification of toxic electric arc furnace dust (EAFD) which is also the byproduct of steel production in electric arc furnaces. Slag replacement with dust in the order of 5% enables potential use of product in construction applications while the product with higher amounts of dust met the criteria for landfill purposes. Fixation of dust into the AAS matrix occurred by chemical (A area in Fig 3) and physical immobilization (B area in Fig. 3)

References:

[1] W Chen and HJH Brouwers, Journal of Material Science **42** (2007) p.428.
[2] I Nikolić, et. al , Materials Letters **133** (2014) p.251.
[3] The authors acknowledge the support of the Centre for Nanoanalysis and Electron Microscopy (CENEM), Friedrich-Alexander University Erlangen-Nürnberg, Erlangen, Germany and the National Center for Electron Microscopy the Molecular Foundry, Lawrence Berkeley National Laboratory, which is supported by the U.S. Department of Energy under Contract # DE-AC02-05CH11231.

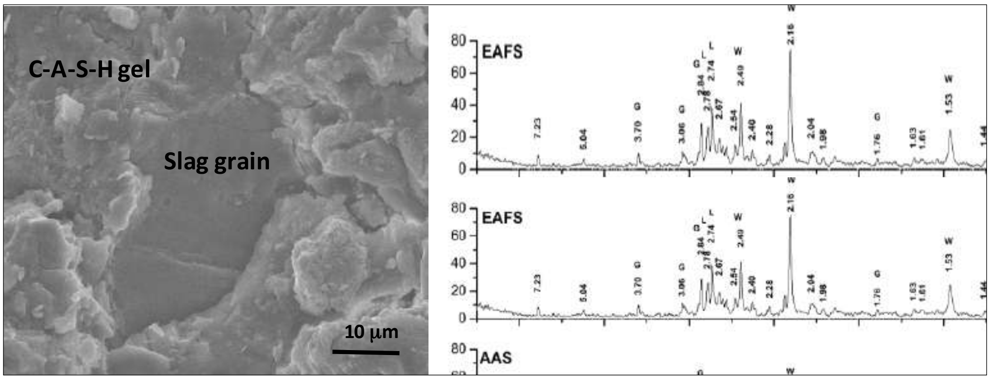

Figure 1. SEM and XRD of alkali activated slag before and after sintering

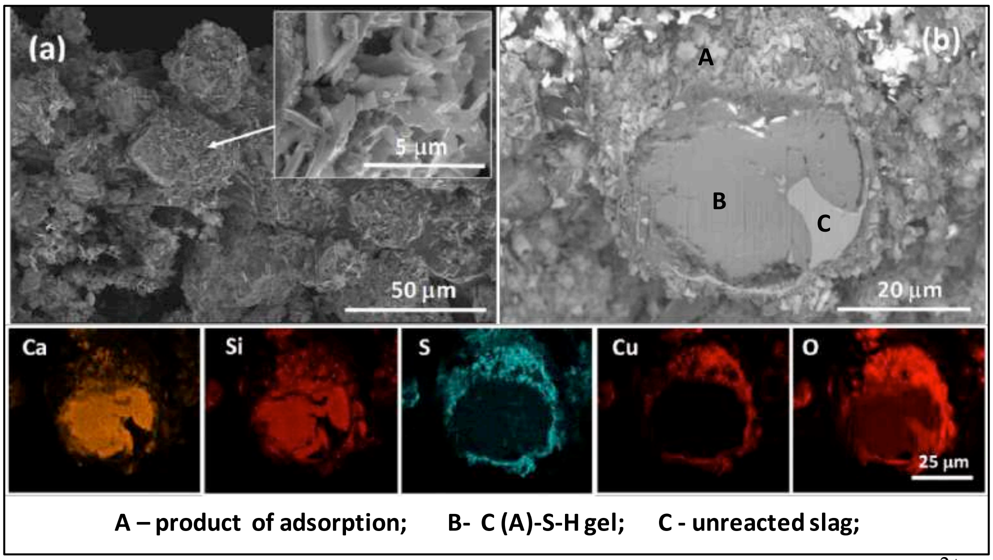

Figure 2. SEM micrographs of the cross-section of AAS after adsorption of Cu^{2+} ions and appropriate EDS composite maps of elemental distribution.

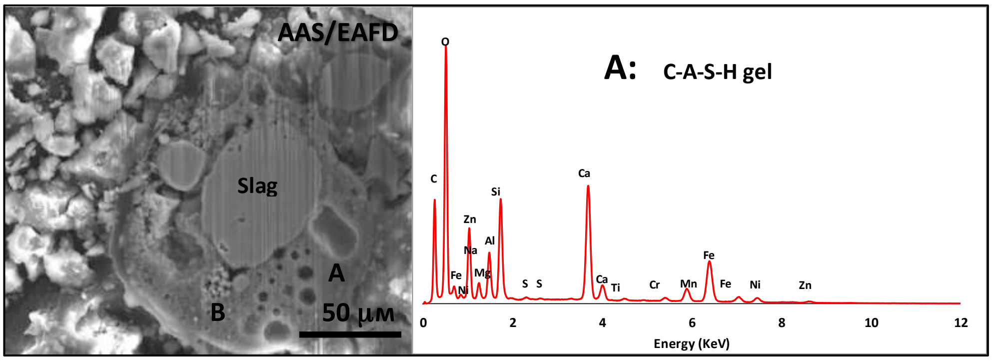

Figure 3. SEM/EDS of AAS sample doped with 5% EAFD.

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