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Abstract

Evaluation of the Reactivity of Red Mud-Based Slags for Geopolymers Production †

Tânia Gameiro *, João Labrincha and Rui M. Novais

Department of Materials and Ceramic Engineering, CICECO-Aveiro Institute of Materials, University of Aveiro, 3810-193 Aveiro, Portugal; jal@ua.pt (J.L.); ruimnovais@ua.pt (R.M.N.)

* Correspondence: tania.gameiro@ua.pt

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Global waste generation is expected to reach 3.4 Bt by 2050. Some waste streams are particularly distressing due to their hazardous character (bauxite residue) and/or their very high production rate (e.g., construction and demolition wastes). To date, these waste streams are mostly disposed of in landfills or accumulated in tailing dams. An eco-friendly alternative is their incorporation into new materials for the construction sector, and this avenue creates value and avoids resource depletion in the manufacture of new construction materials. In the geopolymerization process, solid precursors react with an alkaline solution, and under suitable conditions, the materials harden, forming a cement-like material. In this work, the solid precursors were combined in different proportions (red mud, clay bricks from construction and demolition wastes, and coal fly ash) to produce a reactive slag. The present study aims to evaluate the reactivity of the red mud-based slags in an alkaline medium, thus providing insights regarding their alkali-activation ability.

The results show that the slags with high red mud and fly ash contents (coded as 1 and 4) present the highest leaching of Al, Si, Ca, and Fe, regardless of the nature of the activating solution (potassium silicate or potassium hydroxide), and this behavior can be related with the slag's chemistry. With potassium silicate solution, slag 1 showed the highest leaching of Al, Ca, and Fe when compared to the other compositions, with approximately 70% of Al and Ca present in this slag leached in the first 6 h, reaching values higher than 90 % after 24 h. Comparatively, in slag 4, the leaching of Al reached only 60% after 24 h.

Potassium hydroxide solution modified substantially the leaching behavior of the slags, reaching much lower dissolution rates when compared to the use of a potassium silicate solution. The four slags showed an Al leaching extent lower than 20%, for both 1 M and 3.5 M KOH solutions. In addition, an increase in the KOH molarity strongly enhanced Al leaching from the slags, a four-fold increase being observed for both slags 1 and 4. The Si leaching followed the same trend, increasing from 17 and 28%, with slags 1 and 4, respectively, using 1 M KOH, to roughly 50% for both slags after 24 h in 3.5 M KOH.

The results obtained in this work demonstrate the possibility of tailoring the mixture composition to favor the alkali-activation of the slags envisioning their use in the construction sector, for the obtention of new eco-products. The use of industrial wastes as resources to obtain high-value and sustainable products, as proposed here, is aligned with the circular economy concept and might mitigate the environmental impact of complex and hazardous wastes.

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