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Microwave-Assisted Zeolite Production from Spodumene Mining Residue

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Abstract

The residue generated during the lithium extraction process, resulting from the mining of spodumene, represents a significant source of industrial discard. For every tonne of lithium extracted, approximately 10 tonnes of residue are produced, primarily composed of quartz (SiO_2), aluminates, and small amounts of alkali and alkaline earth metals. The management of this residue poses an environmental challenge. In this context, the use of this material as an alternative source of silicon, aluminium, and sodium for zeolite synthesis, specifically LTA zeolite (Linde Type A), emerges as a sustainable solution. Zeolites are crystalline aluminium silicates widely used in applications such as water treatment, catalysis, and detergents. This work aims to explore the availability of Si and Al present in the residue resulting from the mineral processing of beta-spodumene for zeolite synthesis, using microwave-assisted alkaline digestion. The waste was subjected to microwave digestion at power levels of 500 and 750 W for 30 minutes. Subsequently, the extracted Si source was used in the crystallisation process with static greenhouse thermal treatments for 4, 6, and 8 hours. These materials were characterized, X-ray diffractometry (XRD), and scanning electron microscopy (SEM), coupled to Electron Scattering Spectroscopy (EDS), to determine their structural properties, morphological and chemical composition. The data shows that the residue has a Si/Al ratio ranging from 2.9 to 3.2, as well as a morphology consisting of elongated prismatic crystals, characteristic of silicoaluminous materials belonging to the pyroxene family. After heat treatment for crystallization in static greenhouse, the XRD data confirmed the formation of LTA and SOD zeolites, with the optimal conditions for LTA zeolite synthesis—featuring high crystallinity and a cubic morphology with rounded edges—achieved with digestion at 750 W and 4 hours of thermal treatment, leading to the attenuation of the sodalite phase. Thus, this study demonstrates that lithium processing waste can be effectively utilised as a source of Si and Al for zeolite production, representing an environmentally beneficial approach to waste management.

Keywords: Lithium; alkaline digestion; LTA zeolite.

References

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