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Control of Free-CaO in Steel slag via heat treatment

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In Korea, approximately 20 million tons of slag are generated annually from ironmaking and steelmaking processes, underscoring the need for effective recycling strategies. Since CaO, a major component of slag, reacts with CO2 to form CaCO3, the utilization of slag as a CO2 sorbent has paid great attention.
Specifically, free-CaO (f-CaO) within the slag also participates in carbonation reactions, contributing to CO2 capture capacity. However, research on the direct application of iron and steel slags for CO2 capture and utilization remains limited. Furthermore, the presence of f-CaO poses significant issues, such as strength degradation due to volume expansion, when slag is utilized as a construction material. Therefore, the removal of f-CaO is crucial not only from a CO2 capture perspective but also for enhancing the applicability of slag in the construction industry.
In this study, a leaching–precipitation process was employed to steel slag to evaluate and optimize its CO2 capture performance. The effects of leaching temperature, particle size, and agitation method on the amount of captured CO2 were systematically investigated. In addition, heat treatment was employed to induce phase transformations in the slag by varying the temperature and duration, and the resulting changes in f-CaO content and crystalline phases were subsequently analyzed. Furthermore, to investigate the correlation between the structural changes in the molten slag and the quantitative analysis results of f-CaO, molecular dynamics (MD) simulations were employed to examine the relationship between Ca-O and other metal ions at various heat treatment temperatures.
Based on the quantified CO2 capture efficiency under various operating and thermal conditions, this study assesses the potential of steel slag as a high value-added resource for CO2 sequestration and utilization.

Keywords: Free CaO, CO2, CCUS, Steel slag

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