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Carbon Sequestration through Seeded Mineral Carbonation of Scubbed CO2 in a Semi-batch Reactor

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Abstract: This study investigated seeded magnesium carbonation for mineral-based CO2 capture. In a semi-batch reactor set-up, with optimal operational parameters identified: high initial carbonate (15 mM), pH 10, a 1:1 magnesium to carbonate ratio, and 200 rpm stirring, all enhancing reaction kinetics and granule formation. Subsequently, in a fluidized bed reactor (FBR) application, increasing the seed dose improves carbonate removal but diminishes granulation due to excessive nucleation, highlighting the need to optimize seed load for balanced efficiency and granule size. With comprehensive product characterization (FTIR, SEM, TGA, XRD), confirmed hydrated magnesium carbonate synthesis, primarily well-ordered hydromagnesite. This product exhibited unique hierarchical lamellar morphology and a three-stage decomposition, affirming its stability for long-term CO2 storage. Experimental results consistently validated thermodynamic predictions from Visual MINTEQ, reinforcing speciation modeling reliability and establishing key trends in reaction efficiency, product morphology, and process behavior. This research provides essential baseline data for future optimization and scale-up of seeded magnesium carbonation in FBRs, significantly advancing mineral-based carbon capture technologies.

Key Words: carbon sequestration; magnesium carbonation; CO2 capture; fluidized bed reactor; mineral carbonation

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