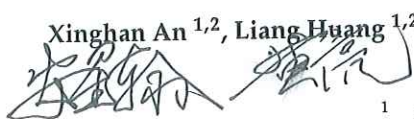


Article

CaAl-LDH-Derived High-Temperature CO₂ Capture Materials with Stable Cyclic Performance

Xinghan An ^{1,2}, Liang Huang ^{1,2,*} and Li Yang ^{3,*}

¹ Engineering Research Center for Water Pollution Source Control & Eco-Remediation, College of Environmental Science and Engineering, Beijing Forestry University, Beijing 100083, China; an18502285171@163.com

² State Key Laboratory of Efficient Production of Forest Resources, Beijing Forestry University, Beijing 100083, China

³ State Key Laboratory of Environmental Criteria and Risk Assessment, Chinese Research Academy of Environmental Science, Beijing 100012, China

* Correspondence: l_huang@bjfu.edu.cn (L.H.); yang.li@craes.org.cn (L.Y.)

Abstract

The urgent need to mitigate rising global CO₂ emissions demands the development of efficient carbon capture technologies. This study addresses the persistent challenge of sintering-induced performance degradation in CaO-based sorbents during high-temperature CO₂ capture. A novel solvent/nonsolvent synthetic strategy to fabricate CaO/CaAl-layered double oxide (LDO) composites was developed, where CaAl-LDO serves as a nanostructural stabilizer. The CaAl-LDO precursor enables atomic-level dispersion of components, which upon calcination forms a Ca₁₂Al₁₄O₃₃ "rigid scaffold" that spatially confines CaO nanoparticles and effectively mitigates sintering. Thermogravimetric analysis results demonstrate exceptional cyclic stability; the composite achieves an initial CO₂ uptake of 14.5 mmol/g (81.5% of theoretical capacity) and retains 87% of its capacity after 30 cycles. This performance significantly outperforms pure CaO and CaO/MgAl-LDO composites. Physicochemical characterization confirms that structural confinement preserves mesoporous channels, ensuring efficient CO₂ diffusion. This work establishes a scalable, instrumentally simple route to high-performance sorbents, offering an efficient solution for carbon capture in energy-intensive industries such as power generation and steel manufacturing.



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Keywords: CO₂ capture; calcium looping; CaO-based sorbents; layered double oxides; cyclic stability

1. Introduction

The global challenge of CO₂ emissions has reached critical severity. According to the Intergovernmental Panel on Climate Change (IPCC), atmospheric CO₂ concentrations in 2024 surged at an unprecedented rate, nearly doubling the threshold set by international climate agreements. The continuously rising concentration has led to global warming, frequent extreme weather events, and intensified ocean acidification. The resulting El Niño phenomenon has further weakened the carbon sink capacity. Despite progress in energy transition and carbon mitigation efforts, fossil fuels remain the dominant contributors to global emissions, with energy-intensive sectors like steel and cement production being under mounting decarbonization pressure. While renewable energy deployment has expanded, persistent technological limitations in energy storage and carbon cycle efficiency

证 明

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