

Incorporation of CaO into inert supports for enhanced CO₂ capture: A reviewYingchao Hu^a, Hongyuan Lu^a, Wenqiang Liu^b, Yuandong Yang^b, Hailong Li^{a,*}^a School of Energy Science and Engineering, Central South University, Changsha 410083, China^b State Key Laboratory of Coal Combustion, Huazhong University of Science and Technology, Wuhan 430074, China

HIGHLIGHTS

- Incorporation of CaO into inert supports is effective in preventing sintering of CaO sorbents.
- The state-of-the-art researches on synthetic CaO sorbents were comprehensively reviewed.
- Various synthesis methods for fine dispersion of calcium and support particles were discussed.
- The sintering-resistant effectiveness of different supports was quantitatively compared.
- Potential future development trends were recommended in this work.

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ABSTRACT

While CaO has exhibited promising prospects and been identified as one of the best candidates for high-temperature CO₂ capture, it suffers a well-known problem of loss-in-capacity; that is, its sorption capacity decays quickly with the increase of cycle numbers. In the last decade, extensive work has been conducted on the incorporation of CaO into inert solid support particles to preventing sintering and, thus, to enhance its cyclic CO₂ sorption performance. With the rapid progress in this aspect, a timely review is highly required. This work summarized the state-of-the-art researches in the literature, mainly including the synthesis methods to finely disperse inert supports among CaO particles and various inert supports to prevent sintering. In addition, the effectiveness of various supports via different incorporating methods and test conditions are discussed and quantitatively compared in the current work. The highly required future development trends of synthetic CaO sorbents are also recommended in the last part of this work. We expect that this work will inspire and guide researchers from both academic and industrial communities and help pave the way for major breakthroughs in both fundamental research and industrial applications in this field.

1. Introduction

Carbon dioxide (CO₂) is a major component of the greenhouse gases that contribute to the global warming issues. As of September 2019, the atmospheric concentration of CO₂ has reached the record high level of over 408 ppm, which is increased by nearly 95 ppm in the past sixty years [1]. Therefore, CO₂ emission reduction has gradually become the worldwide consensus. The technology of carbon capture and sequestration (CCS) has exhibited promising prospects in reducing the emission of CO₂ into the atmosphere and drawn tremendous attentions of the global researchers. Dozens of solid sorbents have been investigated for CO₂ removal at low (< 200 °C), intermediate (200–400 °C) and high temperatures (> 400 °C) [2–7]. As one of the high-temperature CO₂ sorbents, CaO has exhibited great potential for realistic application due to its abundant and cheap calcium sources, fast sorption kinetics and

high sorption capacity [8–11].

Calcium looping process (CLP) is based on the reversible reactions between the carbonation of CaO and decomposition of CaCO₃, which are typically operated between 650 °C and 900 °C. Carbonation is characterized with an initial fast chemical reaction-controlled stage, followed by a transition to a relatively slow diffusion-controlled process [12]. Then, the carbonated sorbents are regenerated at a higher temperature and transported back ready for another cycle. Currently, one of the main obstacles for the practical application of CLP lies in the well-known loss-in-capacity problem that the sorption capacity of CaO-based sorbents decays dramatically with the increase of the cycle number. As a result, the CO₂ sorption capacity of the sorbents usually quickly decrease to < 10% of its initial value after only a few sorption/desorption cycles [13].

Loss-in-capacity problem remains the greatest challenging problem

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