



Influence of morphology, porosity and crystal structure of CaCO_3 precursors on the CO_2 capture performance of CaO-derived sorbents



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HIGHLIGHTS

- Several CaCO_3 samples different in nature are used as CaO-based sorbent precursors.
- The nature of the CaCO_3 precursor influences the impurities content in the CaO-derived sorbent.
- Low impurities contents in the CaO-based sorbents favor the CO_2 -capture performance.

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ABSTRACT

In this study, several different CaCO_3 samples both natural and synthetic, showing diverse physico-chemical characteristics (particle morphology, crystal structure and porosity) were used as precursors of CaO-based sorbents for the capture of CO_2 . In order to identify the most favorable CaCO_3 properties for a high stability and optimal CO_2 uptake by CaO-derived sorbents, both series of materials were characterized using the following analytical techniques: X-ray diffraction, N_2 adsorption and scanning electron microscopy. Moreover, the main differences in chemical composition, particle morphology and sorbent porosity of the CaO-based materials were correlated to the maximum CO_2 uptake and loss-in-capacity after several carbonation/calcination cycles. The results indicate that the crystal structure of CaCO_3 parent samples strongly affects the physical properties of the calcium oxide formed during the calcination step, significantly influencing the maximum CO_2 uptake. The agglomeration of CaO particles after the calcination of the CaCO_3 precursors controlled to a certain extent the carbonation rate. However, this factor could not be correlated with the loss of activity of the CaO-derived sorbents in tests carried out over consecutive carbonation/calcination cycles.

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1. Introduction

Calcium carbonate (CaCO_3) is commonly found in rock formations throughout the World. It also constitutes one of the main components of marine organism shells, snail shells, pearls and eggshells. In addition, CaCO_3 can be synthesized through different laboratory procedures such as precipitation reaction [1–4], bubble templating [5–7], interfacial reaction [7,8], ionic liquid-assisted hydrothermal [9] and solvothermal processes [9,10]. The precipitation reaction method has attracted a great deal of research interest since it is a simple and low-cost way to produce CaCO_3 [3,11]. Moreover, it allows the use of solvents, surfactants or organic additives which can control the nucleation, growth, and alignment of inorganic crystals [4,7,9,11–13]. As a result, it is possible to obtain

CaCO_3 samples with different degrees of purity, morphologies, and porous structures. Owing to its varied properties, CaCO_3 is employed in a large number of applications which are usually heavily dependent on its crystal structure or morphology. Among others, CaCO_3 has been used in catalysis [14], as encapsulation for proteins [8], as an anticancer drug carrier [15], as a filler in polymers [16] or as a source of CaO-based CO_2 sorbents [17,18].

Based on the reversible chemical reaction: $\text{CaO(s)} + \text{CO}_2(\text{g}) \leftrightarrow \text{CaCO}_3(\text{s})$, CaO-based materials from minerals (limestone) [19–21] and other natural sources such as eggshells [22] or synthetically produced CaO [18,23] have been proposed in recent years as potential CO_2 sorbents because they have a large adsorption capacity at high operating temperatures. As an example, around 90% molar conversion has been achieved with CaO-based sorbents derived from natural minerals at 700 °C [24]. However, there are still critical and unsolved challenges that require further development of natural lime-based CO_2 sorbent technologies (e.g.

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