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A new nano CaO-based CO_2 adsorbent prepared using an adsorption phase technique

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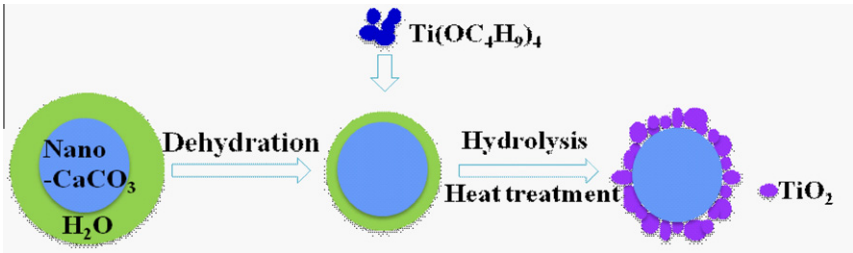
HIGHLIGHTS

- Using "adsorption phase technique", a coating layer of 4.5 nm–11.6 nm was formed with the TiO_2 content increasing.
- TiO_2 content played an important role of CO_2 adsorption durability.
- Compact factor between 0.8 and 1.3 was tested to relate the adsorption stability.

GRAPHICAL ABSTRACT



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ABSTRACT

This study describes for the first time micro-scale hydrolysis has been used in the adsorption phase to prepare a nano CaO-based CO_2 adsorbent with a highly durable sorption capacity. The hydrolysis of $Ti(OC_4H_9)_4$ to form TiO_2 was used to prepare TiO_2-coated nano $CaCO_3$, which was then calcinated to prepare a nano CaO-based CO_2 adsorbent with a controlled coating layer. The coating compactness was defined for the first time in this study to describe the mole ratio of Ti to Ca on the surface of the nano $CaCO_3$. The coating compactness and the durability of the sorption capacity of samples with varying TiO_2 content, hydrolysis temperature, and ester concentration were studied in detail. The properties of the reactive adsorption of the prepared nano CaO-based CO_2 adsorbents were tested using a thermogravimetric analyzer. The results showed that, of the conditions tested, the TiO_2 content exerts the most influence on the durability of the sorption capacity. The nano $CaCO_3$ that was coated with 10 wt.% TiO_2 and prepared under 20 °C, which has a corresponding coating compactness of 1.0, exhibited a much more durable CO_2 sorption capacity than the other prepared samples.

1. Introduction

The capture of CO_2 through the use of a CaO-based adsorbent plays an important role in the efficient separation of CO_2 from combustion/gasification gases [1–3] and sorption-enhanced hydrogen production processes [4–6]. This capture is based on the reversible carbonation reaction of CaO [7]. CaO is a potential adsorbent because of its high reactive sorption capacity and the abundance of its natural precursors, such as limestone ($CaCO_3$) [8] and dolomites (Ca, $Mg(CO_3)_2$) [9,10]. However, the CaO-based adsorbents exhibit a rapid decay in their absorption capacity during multiple carbonation–calcination reaction cycles [11]. It is widely believed that the capacity decay is mainly due to the sintering of CaO and $CaCO_3$ in the regeneration process [12], the physical aggregation of the crystals, which leads to an increased particle size, or the loss of porosity that is caused by the volume reduction of the small pores [13].

Compared with natural adsorbents, nano $CaCO_3$ has drawn increasing attention [14–17] because of its higher reactive sorption capacity, fast reaction rate and its significant improvement in the durability of the adsorbent. However, because nano $CaCO_3$ has a high ratio surface area and a high surface energy, it aggregates

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