

Construction and demolition waste as a precursor to sustainable CO₂ adsorbent materials

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Introduction

Worldwide, 10,000 Mt/year of construction and demolition waste are generated, composed of concrete, ceramics, bricks, tiles and metals.¹ Due to their composition, abundance, and disponibility, these wastes can be valued in different sectors. On the other hand, CO₂ emissions continue to increase due to various anthropogenic activities, with the construction sector being one of the most significant contributors due to the extraction of raw materials and the production of Portland cement. Hence, the use of industrial wastes as raw materials for preparing CO₂ sorbent is an attractive topic due to its advantages, such as availability, abundance, low cost, high reactivity, and a complex matrix where different elements can favor capture or regeneration processes. Lithium-based materials have been studied deeply because of their excellent performance as high-temperature CO₂ sorbents.²⁻⁷ Therefore, the aim of the present work is the valorization of construction and demolition wastes in the preparation of a sustainable CO₂ adsorbent evaluating the effect of the lithium reagent used, the temperature and de CO₂ partial pressure over the CO₂ capture capacity and the regeneration process.

Material and methods

Construction and demolition waste was characterized by X-ray fluorescence (XRF), X-ray diffraction (XRD), N₂ adsorption-desorption, and scanning electron microscopy (SEM). The alkaline silicates evaluated as adsorbent materials were prepared using three different lithium reagents (Li₂O, Li₂CO₃ and LiAc) and construction and demolition waste by the solid-state reaction method. The CO₂ adsorbent capacities of the alkaline silicates were evaluated by thermogravimetric analysis using partial pressures of CO₂ (P_{CO_2}) between 0.2 and 0.05 and high temperatures. Finally, the regeneration capacity was evaluated through consecutive adsorption-desorption cycles.

Results and discussion

According to the XRF results, the main component of the construction and demolition waste is silicon (49 wt% as SiO₂). According to XRD analysis, Li₄SiO₄ was the principal crystalline phase with 78, 69 and 55 % abundance in lithium silicates prepared from Li₂CO₃, Li₂O, and LiAc, respectively. In addition to Li₄SiO₄, different secondary phases were identified in each material, such as LiAlO₂, Li₂CO₃ and Fe₃O₄. The CO₂ capture tests were performed at temperatures between 400 and 700 °C and P_{CO_2} =0.05-0.2. The CO₂ capture over time shows an exponential behavior at all temperatures

and P_{CO_2} . The secondary phases formed in each material affected the maximum CO_2 capture capacity and the corresponding temperature (Figure 1A). Li_2O -silicate reached the maximum CO_2 capture of $210 \text{ mg}_{CO_2}/\text{g}_{\text{material}}$ at 650°C while $LiAc$ - and Li_2CO_3 - silicates achieved their maximum at 550 - 580°C ; above this temperature, the desorption started. Lithium silicates prepared from $LiAc$ and Li_2CO_3 present good stability over 30 cycles of adsorption-desorption (Figure 1B); however, the regeneration of Li_2O -silicate was not complete. The presence of $LiAlO_2$ in $LiAc$ - and Li_2CO_3 - silicates favored the regeneration process; instead, the iron phases presented in the Li_2O -silicate hindered the desorption process.

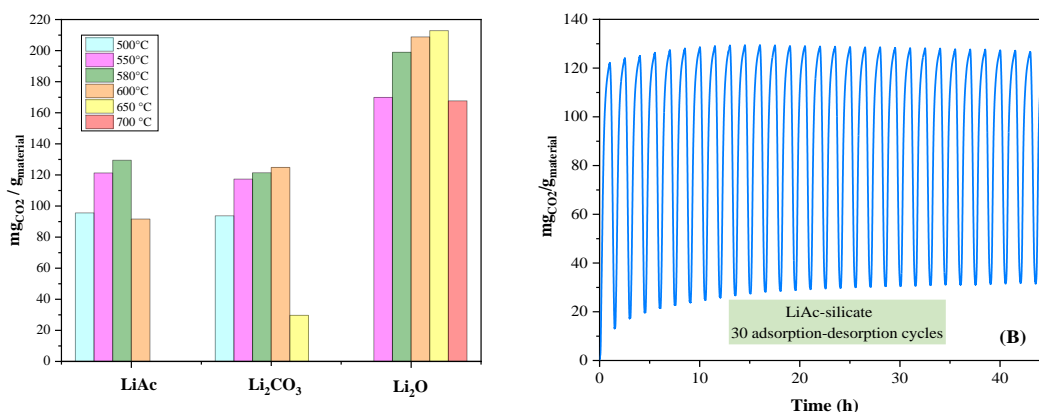


Figure 1. CO_2 capture capacity of lithium silicates prepared from construction and demolition waste with $P_{CO_2} = 0.20$ (A) and stability over 30 adsorption-desorption cycles of $LiAc$ -silicate (B).

Conclusions

Construction and demolition waste was successfully used as a precursor of CO_2 adsorbent material. The secondary phases formed during the synthesis and carbonation process affect the regeneration process in each material. According to the results, Li_2O -silicate achieves the best CO_2 capture capacity but cannot be regenerated. Thus, the $LiAc$ -silicate with a CO_2 capture capacity of $120 \text{ mg}_{CO_2}/\text{g}_{\text{material}}$ presented good stability over 30 cycles of sorption-desorption.

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