

Synthesis and characterization of calcium oxide based particles for CO₂ adsorption applications

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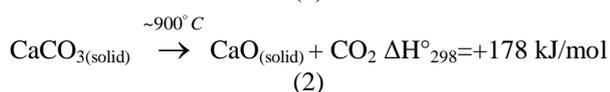
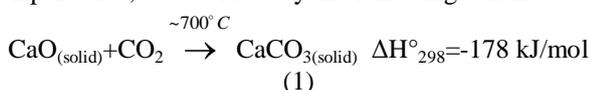
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It is generally accepted that the significant increase in atmospheric carbon dioxide (CO₂) concentration is strongly linked to the greenhouse effect. Therefore, CO₂ capture and storage or utilization have emerged as critical research areas that require the development of inexpensive materials with large and stable CO₂ adsorption capacity.

Calcium-based sorbents constitute a group of materials that are promising for CO₂ storage applications (Choi et al, 2009). Calcium Oxide (CaO), also known as quicklime, is a widely used and inexpensive chemical compound. It is manufactured by thermal decomposition of abundant materials (e.g. limestone or chalk), which mainly consist of CaCO₃. CaO, among other uses, is also a promising candidate for CO₂ capture from fossil-fuel based power plants (Schaube et al, 2011).

CO₂ capture and release, with the aid of CaO, is based on a carbonation-calcination reaction cycle at high temperatures, as described by the following scheme:



The aim of the current study was to prepare CaO-based materials with higher surface area than commercial materials and also to exhibit structural and morphological stability at high temperatures and in particular during the aforementioned two-step process (Eq. (1)-(2)).

To this respect, CaO-based, as well as composite calcium oxide particles were synthesized by Aerosol Spray Pyrolysis (ASP) (Karadimitra et al, 2001) and by Liquid Phase Self-propagating High temperature Synthesis (LPSHS) methods. In ASP, a precursor solution is atomized into fine droplets, which act as micro-reactors undergoing evaporation of the solvent and precipitation of the reacting material. In LPSHS the total precursor amount is processed in a single reactor and involves gradual solvent evaporation which, in the presence of a fuel, results to a combustion reaction.

The effect of the synthesis method and of the precursor materials utilized in each case was studied in order to comparatively identify the obtained particles morphologies and their preliminary performance in the aforementioned CO₂ capture and release scheme.

The materials morphology was examined by Transmission and Scanning Electron Microscopy (TEM & SEM), showing a nearly spherical morphology for the ASP-synthesized particles (Fig. 1) and irregularly shaped, open-structure particles for the LPSHS-synthesized materials.

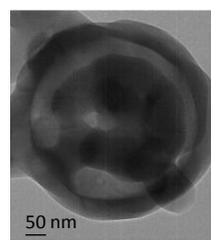


Figure 1. TEM image of CaO/Ca₁₂Al₁₄O₃₃ particle by ASP.

CaO-based materials were also structurally characterized by X-Ray Diffraction (XRD). It was indicated that Ca₁₂Al₁₄O₃₃ was the predominant phase in the ASP-particles, while the Ca₃Al₂O₆ phase was identified as the main compound in the LPSHS samples.

Surface area and pore size measurements were conducted by BET analysis. The materials had a surface area in the range of 3-10 m²/g, depending on the process synthesis conditions with the ASP-prepared powders exhibiting higher surface area than the LPSHS-synthesized particles (Table 1).

Table 1. Comparison of the surface area of the ASP and LPSHS-obtained particles.

Method	BET (m ² /g)
ASP	10.57
LPSHS	3.02

The CO₂ adsorption capacity was evaluated by Thermogravimetric Analysis (TGA), as well as with the aid of fixed bed reactor experiments.

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