Nano-dispersed calcium oxide as a reversible and efficient CO$_2$ sorbent for temperatures between 300-500 °C

Philipp Gruene$^1$, Marco J. Castaldi$^1$, Robert J. Farrauto$^2$

$^1$Department of Earth and Environmental Engineering (HKSM)
Columbia University, New York, NY 10027

*$pg2346@columbia.edu$

$^2$BASF Catalysis LLC
Iselin, NJ 08830-0770

Calcium oxide produced from bulk calcium carbonates, like limestone or dolomite, is a very abundant, cheap, and in principle stoichiometric CO$_2$-sorbents. Unfortunately, it suffers from three major drawbacks. (i) The kinetics of the adsorption decrease quickly because of diffusion limitations. (ii) Regeneration of the sorbent is energy-intensive and (iii) leads to loss of adsorption capacity after few carbonation/regeneration cycles.

We show that nano-dispersed calcium oxide on high-surface area supports can overcome all of these three drawbacks. On a sufficiently thin film of CaO, all sorbent atoms are located on the surface and diffusion limitations are drastically reduced. The interparticle distances are so large that sintering does not occur. Further, the binding of CO$_2$ is weaker and regeneration can be induced at much lower temperatures. A potential area of application is thus the sorption-enhanced hydrogen production from autothermal reforming and/or water-gas shift reactions in the temperature range between 300-500 °C.

The nano-dispersed calcium oxide can be conveniently synthesized by incipient wetness of a high-surface area support like $\gamma$-Al$_2$O$_3$ with a Ca$^{2+}$-solution. Figure 1 compares the performance in CO$_2$ adsorption (300 °C, 15 % CO$_2$ in N$_2$) of such a dispersed sample (a) with a sample of bulk CaO (b). Obviously the binding mechanism of CO$_2$ to the sorbent is different for the two samples, leading to an easy desorption in the case of nano-dispersed CaO. The differences will be discussed based on TGA and in-situ FT-IR experiments.

A major concern about the use of supported CaO is the inherently lower adsorption capacity as compared to pure CaO. The synthesis and calcination conditions have thus been optimized and their influence on the adsorption capacities has been investigated by TGA, BET, and XRD analysis.

Figure 1: Adsorption efficiency of nano-dispersed CaO (a) and bulk CaO (b) at 300 °C.