A Pinch of Sodium: Rapid CO_2 Uptake with MgO-based CO_2 sorbents upon promotion with Na_2CO_3 seeds

A. Landuyt[1], I. Kochetygov[2], M. Krödel[1], P. M. Abdala[1], W. L. Queen[2]*, C. R. Müller[1]*

[1]Laboratory of Energy Science and Engineering, Department of Mechanical and Process Engineering, ETH Zürich, Leonhardstrasse 21 Zürich 8092, Switzerland, [2]Institut des Sciences et Ingénierie Chimiques, École Polytechnique Fédérale de Lausanne (EPFL), Valais Wallis, CH-1951 Sion, Switzerland

There is an urgent need to develop and engineer functional materials that can capture and release CO_2 on demand. Solid oxide materials such as MgO and CaO constitute a promising family of materials for CO_2 capture, utilization, and storage, considering their favorable thermodynamics, high theoretical CO_2 uptake capacities and earth-abundance. However, despite favorable carbonation thermodynamics, MgO suffers from a limited CO_2 uptake due to very slow carbonation kinetics. The carbonation kinetics can be enhanced by adding an alkali metal nitrate promoter such as $NaNO_3$, which dissolves surface carbonates in the form of [$Mg^{2+}\cdots CO_3^{2-}$] ion pairs and thereby facilitates $MgCO_3$ crystallization.[1,2] Moreover, it was found that the addition of Na_2CO_3 seeds to $NaNO_3$-promoted MgO further increases the CO_2 uptake rate by a factor of 10.[3] We investigated the promotional effect of Na_2CO_3 via in situ synchrotron-based X-ray powder diffraction (XRD) with a high time resolution (1 s) complemented by electron microscopy characterization. We demonstrate that Na_2CO_3 rapidly transforms into $Na_2Mg(CO_3)_2$ in the presence of MgO, CO_2, and $NaNO_3$. The $Na_2Mg(CO_3)_2$ phase acts as an effective nucleation seed that boosts $MgCO_3$ growth. Our In-situ XRD measurements prove that $MgCO_3$ nucleates onto the $Na_2Mg(CO_3)_2$ seeds while TEM imaging of the $Na_2Mg(CO_3)_2$-$MgCO_3$ interphase reveals that the $Na_2Mg(CO_3)_2$ seeds promote MgO dissolution and thereby facilitate $MgCO_3$ growth. Taken together, the insights obtained here will help the development of more effective MgO-based CO_2 sorbents.

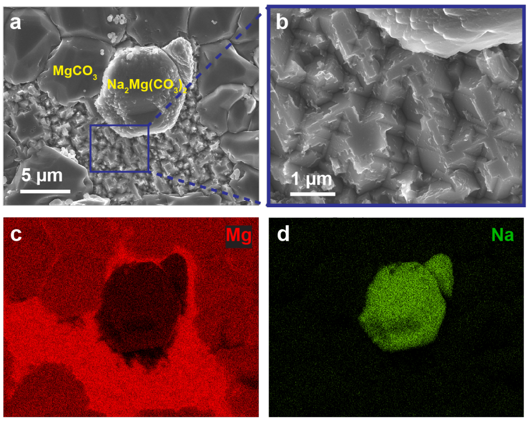

Figure 1. SEM-EDX analysis of a carbonated $NaNO_3/Na_2Mg(CO_3)_2$-promoted MgO(100) single crystal. (a) SEM image of a $Na_2Mg(CO_3)_2$ crystals surrounded by $MgCO_3$ crystals. (b) zoom focusing on the etching pits formed in the MgO(100) surface. (c) Corresponding Mg and (d) Na elemental maps.

[1] Annelies Landuyt, Priyank V. Kumar, Jodie A. Yuwono, Alexander H. Bork, Felix Donat, Paula M. Abdala, Christoph R. Müller, *JACS Au*, **2022**, 2, 2731–2741
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[3] Anh Tuan Vu, Keon Ho, Seongmin Jin, Chang Ha Lee, *Chem. Eng. J.* **2016**, *291*, 161–173.