

Advanced Membrane Reactors: Applicability of Hydrotalcites as CO₂ Selective Membranes

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Introduction

Global warming increased a lot these last decades mostly due to greenhouse gases effect like CO₂. The aim of this work is to selectively separate and capture CO₂ from SR/WGS gas mixtures. Hydrotalcites are known to be good adsorbents for CO₂ and the aim of this presentation is to show whether or not this material is suitable as a CO₂ selective membrane in the presence of hydrogen at around 400°C.

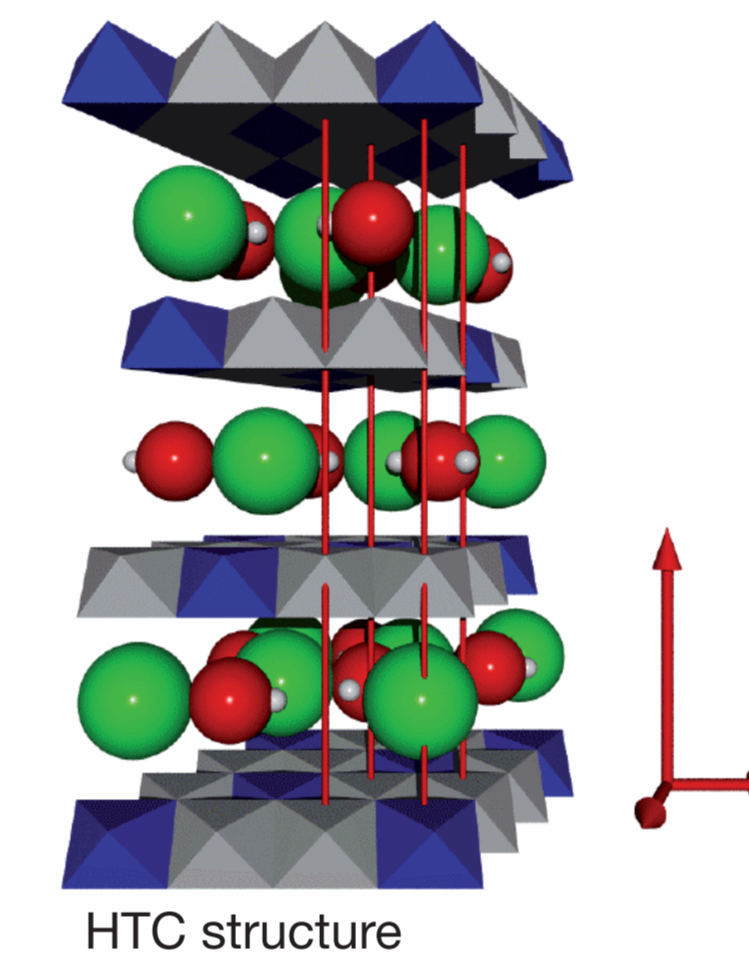
The reactions involved are the following:



Synthesis

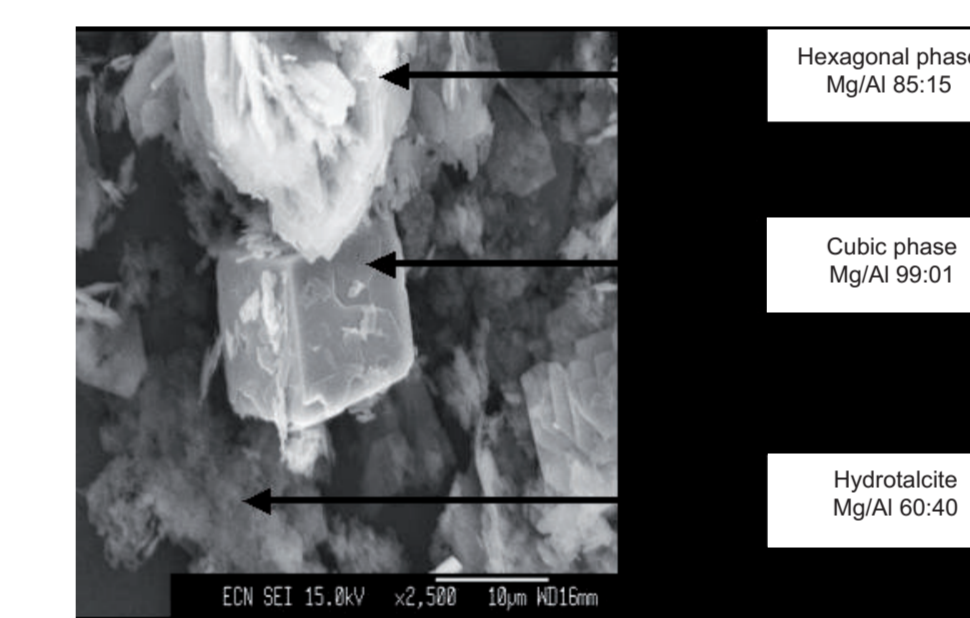
To increase crystallinity we used hydrothermal synthesis in an autoclave at 180°C under 13 bars. We used this method for all the homemade samples.

Starting materials: Al and Mg nitrates.

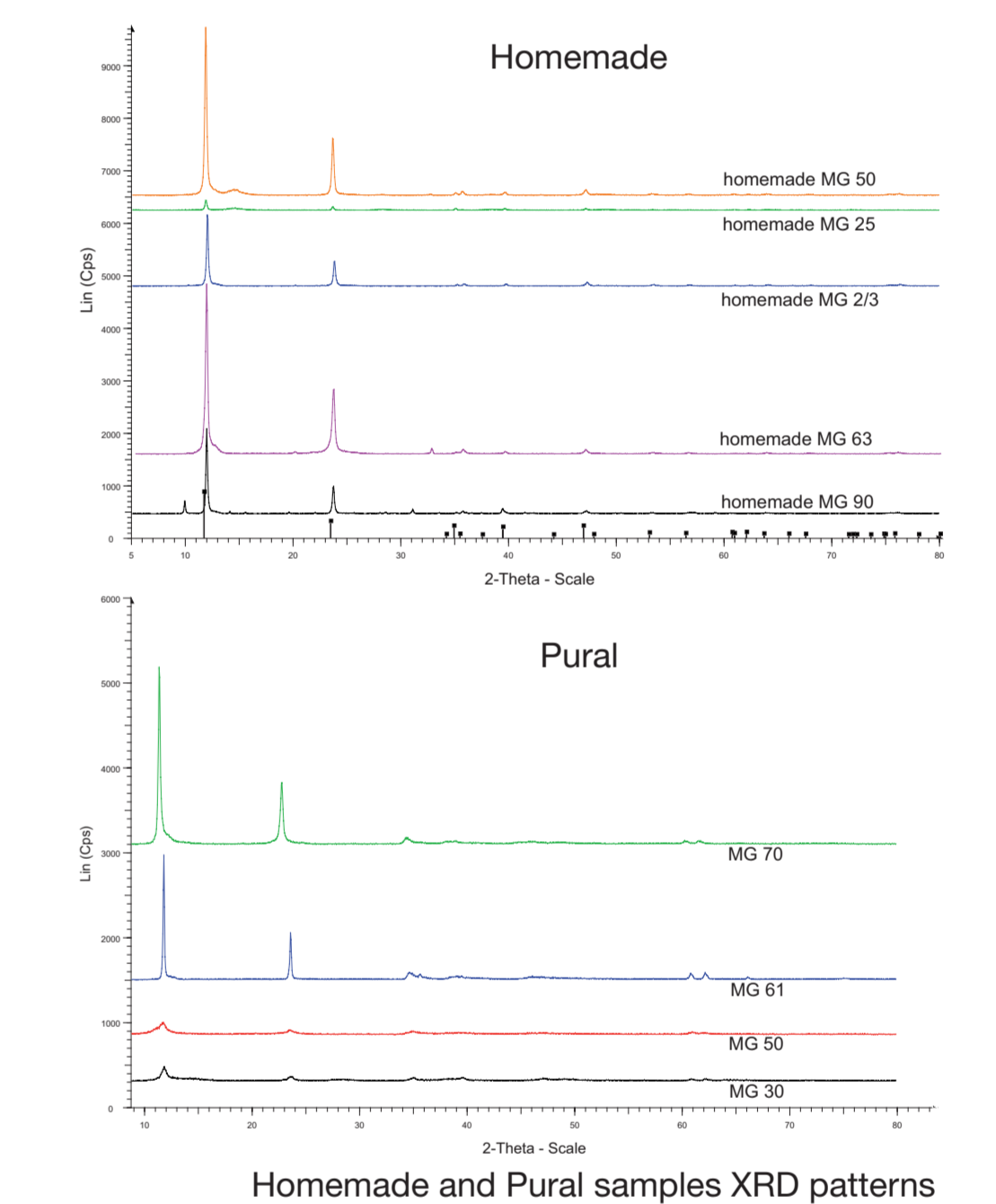


Characterization of HTC powders

Homemade samples are more crystalline than the Pural ones. Deviation from Mg/Al of 2 gives Mg or Al rich by-products.

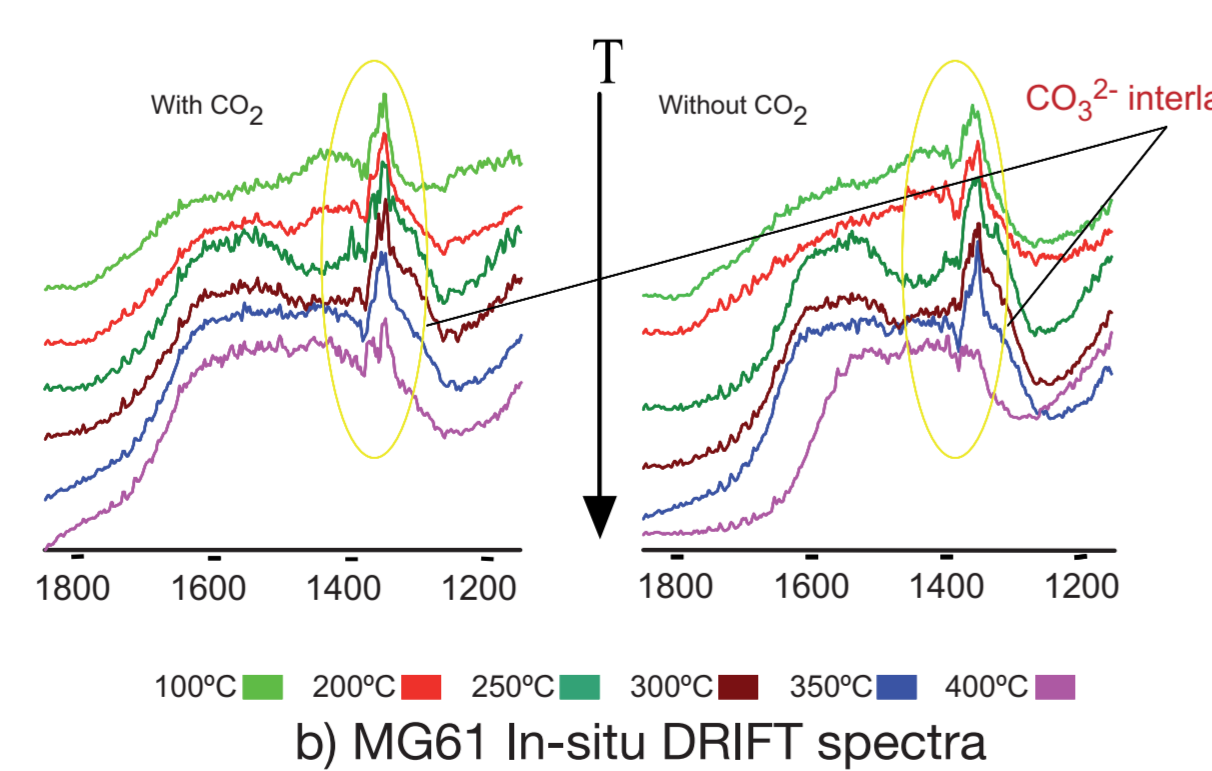
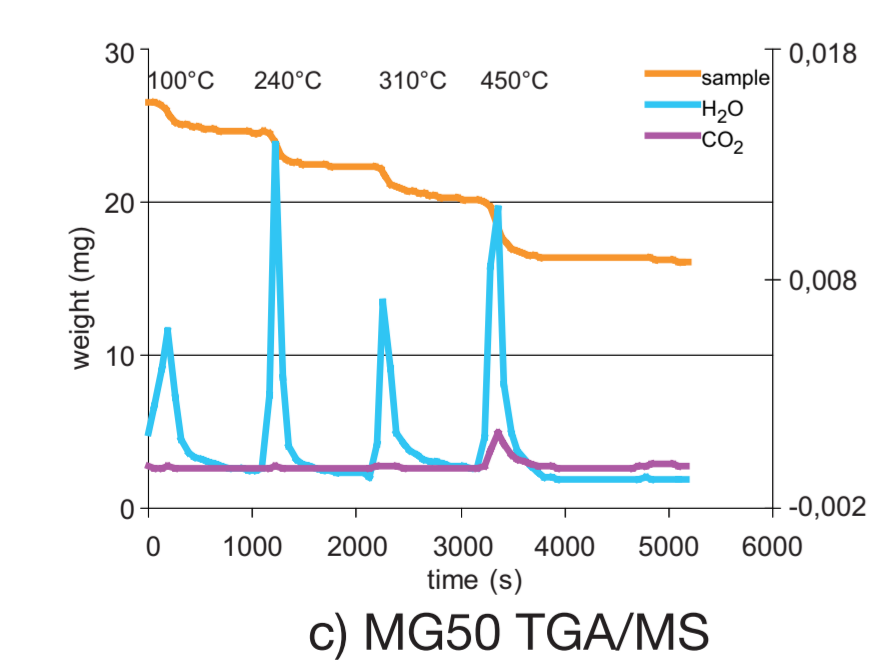
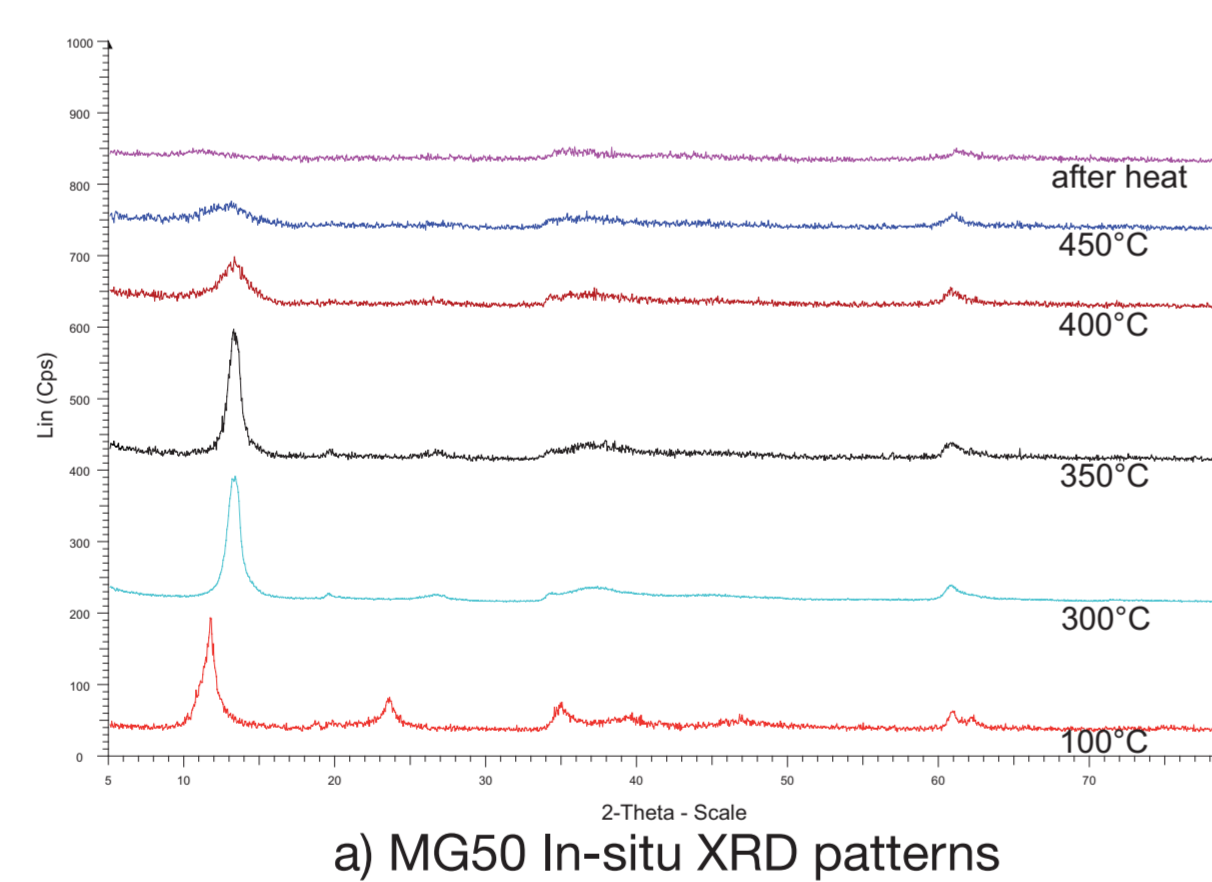


Homemade Mg90 SEM picture



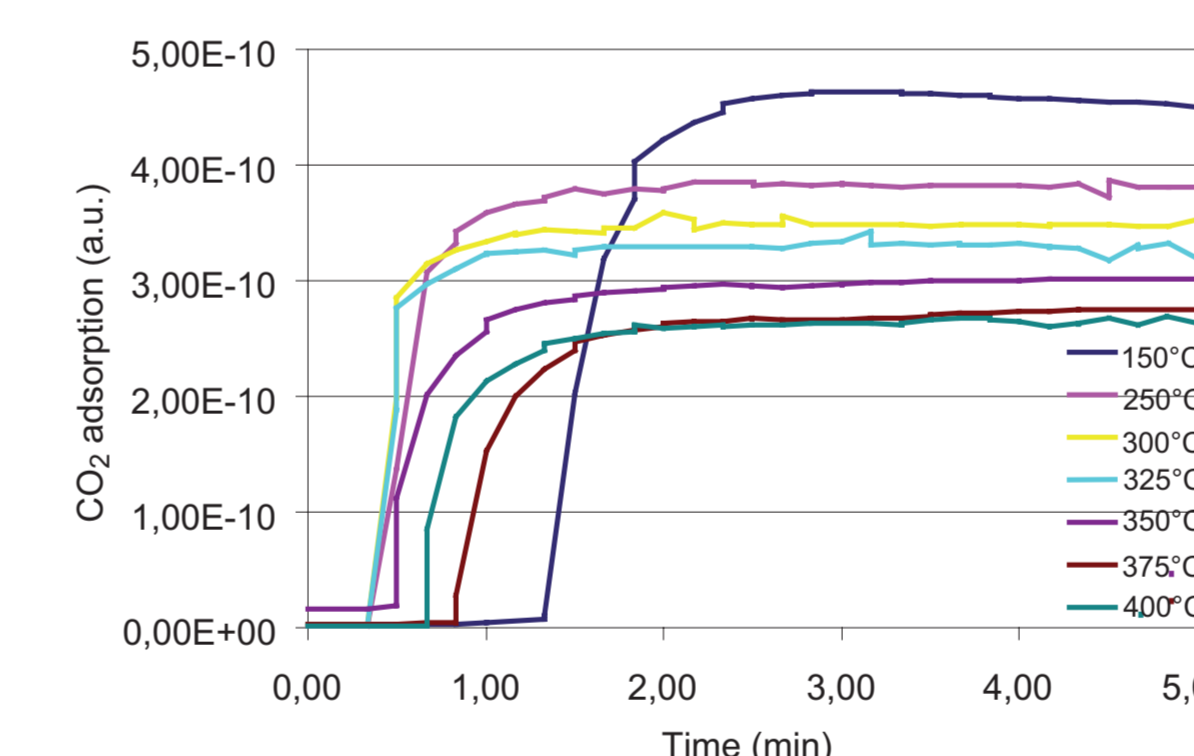
Stability

- When temperature increases the (003) peak is shifted because of interlayer space decrease due to loss of water. Decreasing temperature in the presence of water and CO₂ does restore the structure.
- CO₂ flushing stabilizes the structure to a somewhat higher temperature.
- Four decomposition steps involving water and the last one also CO₂. Decomposition occurs between 300°C and 400°C.

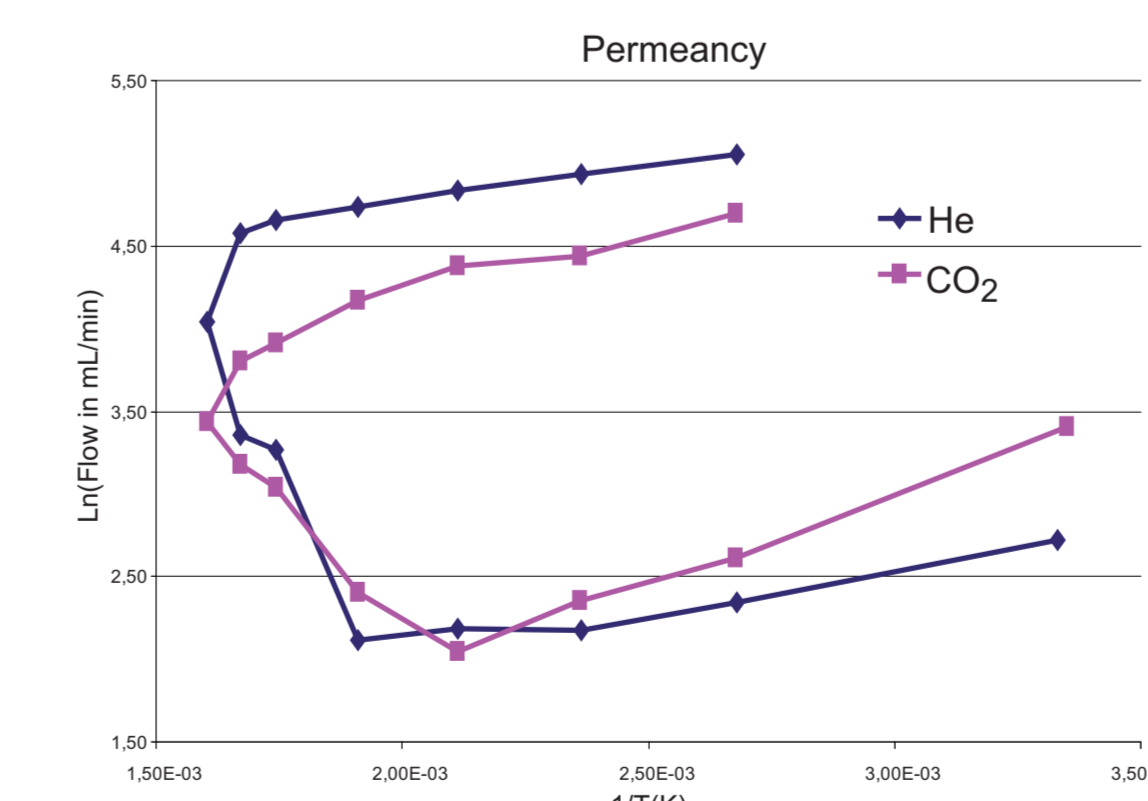


CO₂ adsorption and membrane tests

CO₂ adsorption seems to follow two different mechanisms as a function of temperature. The two different steps at low and high temperature might be due to the two active species contained in the sample.



Membrane permeancy tests on ≈ 2,5 mm thick discs follow Knudsen diffusion for He and CO₂. This shows that there is no bulk transport through hydrotalcites.



MG50 pressed under 2000 bars; permeancy tests with He and CO₂

Conclusions

Hydrotalcite materials only exist in a small Mg/Al ratio window as a pure phase, which is around 2. It is possible to make highly crystalline materials using hydrothermal synthesis. There is no memory effect on decreasing the temperature in a humid gas atmosphere. Hydrotalcite materials are totally decomposed at 400°C and are therefore not feasible as a membrane material in the chosen application. Furthermore they do not show any bulk transport of CO₂.

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