Evaluation of the Adsorption Capacity of Dolomite as a Promising Natural Material Suitable for CO2 Capture

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Abstract:

The annual report of the Intergovernmental Panel on Climate Change summarises the direct impact of CO2 emissions on global warming. If warming between 2030 and 2050 will be increased by more than 1.5 °C compared to pre-industrial times, it will result in irreversible changes to the entire planet. Therefore, (according to the IPCC report) CO2 emissions must be reduced by 65 % by 2035 compared to 2019 [1]. Carbon capture is performed with proven technology on well-known materials such as metal-organic frameworks, polymer membranes, amines [2]. However, a more environmentally friendly form are natural materials such as olivine, zeolites or dolomite.

Nowadays, dolomite as a adsorber for carbon capture storage technology is not deeply explored. The presented work aims to investigate the possibility of CO2 adsorption on dolomite. This possibility is demonstrated by a breakthrough curves, measurement of the adsorption capacity of dolomite, measurement of the specific surface area, and analysis of the composition of dolomite by X-Ray Diffraction (XRD). The analyses were carried out for different activation temperatures of dolomite (800 °C, 850 °C, 900 °C) and for different partial pressures of CO2 (10 %, 12 %, 16 % CO2) in mixture with nitrogen. The reusability and sustainability of the adsorber was investigated for nine capture/regeneration cycles.

Activation and regeneration of the catalyst was carried out at three temperatures, while activation at 800 °C being discarded due to the lower specific surface area compared to the other two samples and the release of incomplete amounts of CO2 from the raw dolomite, which was confirmed by XRD analysis. XRD analysis showed minimal difference between dolomite activated at 850 °C and 900 °C. Therefore more environmentally friendly is activation temperature 850 °C. As the number of cycles increased, the sorbent wore out and thus the absorption capacity of the dolomite was lost. Since the experiment was conducted under normal conditions, marginal amount of portlandite after each

regeneration was observed. When all the examined samples were commercial dolomite, they contained iron ions and aluminium ions, so the formation of small amounts of akermanite and gehlenite was also note and their proportion increased with the number of regenerations increased.

The breakthrough curves was measured on 500 g of dolomite with Sensirion STC31-C and Thermogravimetric analyser NETZSCH 449 F3 Jupiter at ambient temperature. Shape of the breakthrough curves are similar for all cycles. This fact shows that the regeneration protocol used was sufficient to remove all previously adsorbed carbon dioxide molecules. Figure 1 shows that the breakthrough time of 36 minutes is longer for the second cycle than for the first and other cycles. The first regeneration caused the breakdown of dolomite, that lead to higher specific surface area. The downtrend of dolomite adsorption capacity from third cycle was due to surface sintering which caused a decrease of specific surface area. The breakthrough time from the fith to the ninth cycle was similar.

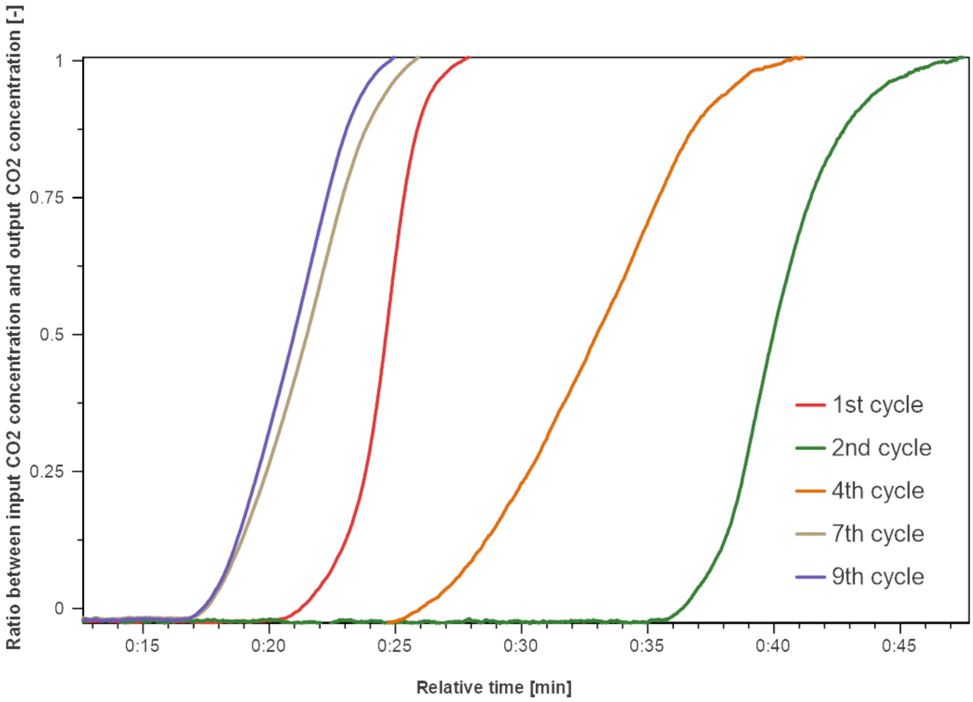

Fig. 1. Carbon dioxide breakthrough curves on dolomite at 1 to 9 cycles, with an inlet carbon dioxide concentration 16 vol. %, at a gas flow rate of 40 ml/min.

Based on these analyses, dolomite appears to be a suitable natural substance for CO2 capture as a cheap and commercially available material with suitable physicochemical properties. Dolomite also showed suitable adsorption properties even after multiple regeneration, indicating potential use in real life applications.