Electrolytically supported processes of capture and release of CO2

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CO_2 capture and valorisation are, according to present knowledge, possible solutions, involving economic and industrial challenges, for reducing atmospheric CO_2 emissions. Although chemisorption using amine-based solvents (MEA) is the farthest advanced in terms of industrial development (performances: 0.4 tCO_2/t_{MEA}; energy cost: 1-3GJ/tCO_2), various obstacles to its use must be overcome. Notably health and environmental risks associated with the use and handling of amines must be duly specified and verified for industrial-scale facilities. Given this two-fold challenge, both economic and environmental, the development of alternative eco-compatible and efficient processes is crucial for cost-effective post-combustion CO_2 capture/release.

This research aims at developing a powerful technological breakthrough in the CO_2 capture (Fig. 1A), using Layered Double Hydroxides (LDHs) that have a strong affinity for CO_3^{2-}. The electrochemical control of the oxidation state of the multiple valence cations, constituting the lamellar sheets, is the core process, which also includes CO_2 dissolution reaction to CO_3^{2-} from the gas effluent, as well as, after capture and release of CO_3^{2-}, the CO_2 degassing from released CO_3^{2}.

Synthesis and formulation of chemically co-precipitated Co-based LDH was optimized to perform electrochemical cycling according to:

$$Co^{(II)}_6Fe^{(III)}_2(CO_3)(OH)_{16} + (x/2)CO_3^{2-} \leftrightarrow Co^{(II)}_{(6-x)}Co^{(III)}_{(x)}Fe^{(III)}_2(CO_3)_{(1+x/2)}(OH)_{16} + xe^-$$

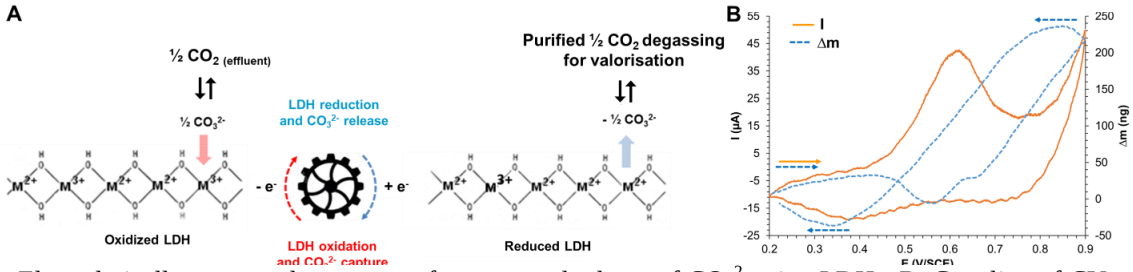

Fig. 1: A. Electrolytically supported processes of capture and release of CO_3^{2-} using LDHs. B: Coupling of CV and QCM, using thin LDHs films, coated on platinum-based quartz electrodes.

The coupling of Cyclic Voltammetry (CV) and Quartz Crystal Microbalance (QCM), using thin LDHs films, coated on platinum-based quartz electrodes (Fig 1B) enabled to (i) investigate the concomitant redox reactions and mass variations, (ii) demonstrate CO_3^{2-} intercalation/ deintercalation and (iii) determine the involved mechanisms. Using LDHs slurries, chronocoulometry, and chemical and physical analyses enabled to determine the kinetics constants associated to the concomitant electrochemical and chemical phenomena. The electrical electrolysis cell consumption of the CO_2 capture/release was evaluated via the applied current and the operating cell-voltage.

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