Vitamin C as a green high-performance CO₂ scrubber

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Carbon dioxide is a greenhouse gas and a natural component of the atmosphere, essential for plant life. Natural reservoirs (oceans, soils, etc.) regulate its geochemical cycle, but the anthropic activity disturbs this balance. In order to control the concentration of carbon dioxide in the atmosphere, many synergic CO₂ capture and sequestration methods (Aresta and Dibenedetto, 2007; Bachu, 2008; Baker et al., 2007; García-España et al., 2004; Lively et al., 2015; Rosa et al., 2018; Stenhouse et al., 2009) coupled with the reduction of carbon dioxide emissions in the atmosphere, have been proposed.

In an early paper (Pastero et al., 2019), we proposed the ascorbic acid (vitamin C) as a high-performance and green CO₂ scrubber. We hypothesized a red-ox reaction involving calcium ascorbate as the sacrificial reductant. As a result, the reduction of carbon from C(IV) to C(III) leads to the formation of oxalic acid and, in the presence of calcium as the counterion, to the precipitation of calcium oxalate. Calcium oxalate is an almost insoluble salt that doubles the capture efficiency with respect to calcium carbonate. The reaction's performance in terms of carbon capture efficiency was evaluated under different experimental conditions. Depending on the experimental setup, the yield of the capture and sequestration reaction reaches very high values, up to 80%. The return of the system depends on the total surface exposed to the reaction, the CO₂/vitamin C mixing mode, the presence of oxygen in the reaction vessel, and the stoichiometry of the solution.

The products of the reaction are limited to calcium oxalate dihydrate (weddellite), while no monohydrate (whewellite) or trihydrate (caoxite) oxalates were detected. The chemistry of the system was intentionally kept far from the stability field of the carbonates to avoid the co-precipitation of both calcium carbonate and oxalate and, accordingly, the competition between the two phases on the carbon capture process.

The technological finalization of a carbon capture system exploiting this reaction will trustfully increase further the effectiveness of the method, pointing towards the zero CO₂ emission.

References


