

CO₂ capture and revalorization as carbonate crystals using membrane technologies

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Abstract

Climate change is clearly an urgent challenge nowadays. The constant accumulation of greenhouse gases and their drastic consequences have led to intensified research aiming to reduce the impact of human activities on the environment. As carbon dioxide (CO₂) is the primary greenhouse gas emitted through human activities, numerous projects focus on the reduction of CO₂ emissions. Carbon capture and storage are considered, but this strategy considers carbon dioxide as a waste. Carbon capture and utilization, on the other hand, gives a sustainable answer by giving value to the carbon by transforming it into another reusable product. Several revalorization routes are being explored, and mineralization (crystallization) seems to be an efficient methodology as it is thermodynamically favorable. Several carbonate compounds can be produced and marketed. Sodium bicarbonate (NaHCO₃) is an interesting candidate as it can be used for numerous applications in the chemical, food, pharmaceutical, and textile industries.

Such a carbon capture and revalorization process is currently under development in our group in UCLouvain. The process makes use of membrane technologies to capture and convert carbon dioxide into sodium bicarbonate as a final product. The process is divided into two steps: first, the CO₂ is captured in a membrane base absorption process using a solvent promoted by enzymes or amino acids. Then, the resulting solution is concentrated up to crystallization in a membrane contactor. The different promoted solvents and routes for crystallization are being optimized. [1-4]

The results are the following: In the first step (absorption), the CO₂ absorption efficiency was evaluated, observing the enhancement of the mass transfer when enzymes or amino acid salts were used. In the second step (crystallization), we were able to obtain crystals with high purity. The morphology of the crystals is shown in Figure 1. Ongoing research is focusing on the study of the presence of other gases such as NO and SO₂. A life cycle assessment is also a critical point of study that is helping to identify the optimal operation conditions from an environmental point of view.

Up to this point, this project is demonstrating that technical development alone is not the way to follow. The environmental impact has to be considered since the process conception and not as a verification tool. In this way, technical and environmental aspects play the same role in the development of a novel process for CO₂ capture. The social dimension is indirectly considered via the multidisciplinary research involved in the project. Up to date, a mechanical engineer, several process engineers, a chemist specialized in crystallization, and a bioengineer, have participated in the research work. The main researchers addressing this research are female, which is a positive point for further career development of female engineers. Finally, the process has already generated interest in the industry, and a patent has been approved (European Patent EP 20 211 693.5). [5]

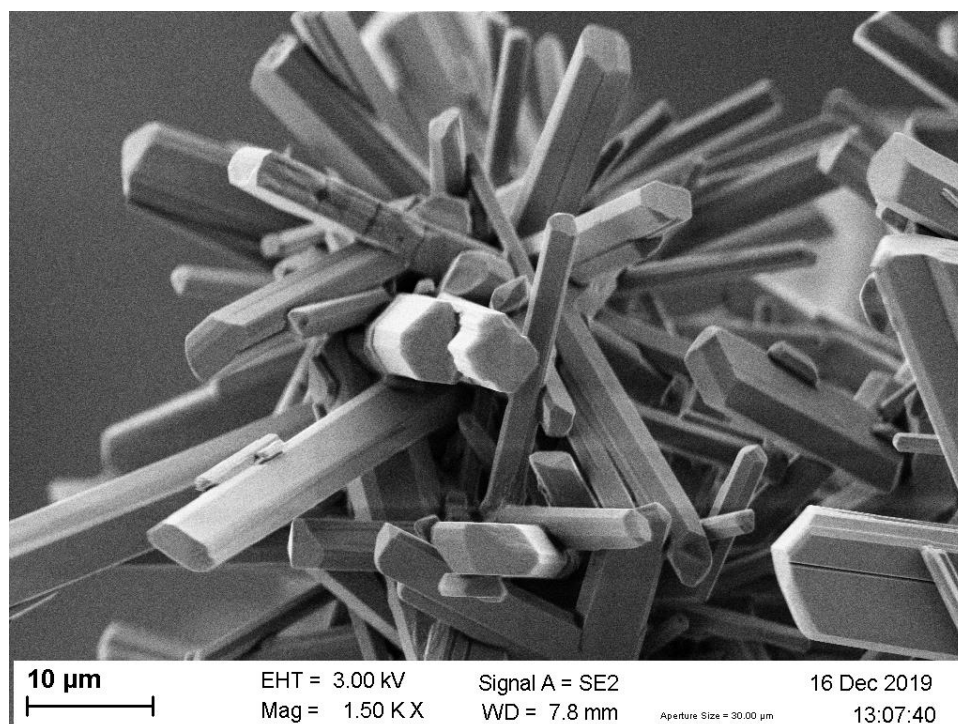


Figure 1: Typical carbonate crystals that can be obtained using membrane distillation-crystallization.

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