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Third-Generation Structured Amine Sorbent Technology for Direct Air Carbon Capture (DAC): A Case Study, Advantages, and Challenges

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Abstract

In this study, various methods and stages of direct air capture (DAC) of CO_2 are first reviewed. Subsequently, major DAC companies and projects worldwide are examined, with a particular focus on the technologies developed by the Swiss company Climeworks in the field of DAC—especially its latest innovation, the structured amine-based sorbents. The study then compares different DAC adsorption technologies and provides a detailed explanation of third-generation sorbent technology, also known as structured amines. Furthermore, a case study of Climeworks'practical implementation of third-generation structured amine sorbents in the Cypress Project in the United States is presented. Finally, the challenges associated with this technology and potential improvement strategies are discussed. Direct Air Capture (DAC) of CO_2 is one of the most challenging yet vital technologies in combating climate change, since the concentration of CO_2 in ambient air is only about 0.04% (400 ppm), which is much lower than that in industrial flue gases. Among various options, structured amine sorbents are considered highly promising due to their ordered structure, high adsorption capacity, and superior stability. Despite the challenges of low CO_2 concentration, high humidity, and elevated operational costs, these sorbents—through the use of advanced technologies—have achieved significant progress in the field of direct CO_2 capture. The third generation of structured amine sorbents, offering large surface area and optimized chemical stability, has further enhanced the efficiency of this process. In this study, we aim to describe the most recent global project utilizing this type of sorbent and to examine the future potential of structured amine sorbents in CO_2 capture and environmental pollution reduction.

Keywords: Carbon dioxide, DAC, structured amine sorbents, Cypress project, third-generation sorbents

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