Abstract

[Project Information]

Project Title :	Research and Development of the Carbon Fixation Technology by Synthesis of Calcium Carbonates from Seawater Mimicking the Biomineralization
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Keywords :	biomineralization, calcium carbonate, carbon dioxide, seawater

[Abstract]

This study aimed to develop a technology for dissolving atmospheric CO_2 in seawater and synthesizing calcium carbonate ($CaCO_3$) as a form of carbon sequestration. The research is divided into three sub-themes addressing (1) the characterization and recovery of $CaCO_3$, (2) optimization of CO_2 absorption using fine bubbles and additives of amines, and (3) process scale-up and cost evaluation.

Characterization methods were established to evaluate the $CaCO_3$ produced from dissolved atmospheric CO_2 in Subtheme 1. These included calcium ion concentration in solutions during the $CaCO_3$ synthesis process using ICP-MS, identification of $CaCO_3$ polymorphs and observation of crystal morphology using X-ray diffraction (XRD) and scanning electron microscopy (SEM), $CaCO_3$ recovery rate from the reaction system, and measurements of sedimentation velocity of the precipitated $CaCO_3$ particles.

When biomineral powders such as seashells were used as seed crystals, extremely large $CaCO_3$ particles formed, and the $CaCO_3$ recovery rate improved to over 95%. To further increase efficiency, the role of organic molecules in the calcification ($CaCO_3$ biomineralization) process and the progression of organic–inorganic interactions were investigated. This investigation led to more effective utilization of biomineral seed powders for $CaCO_3$ formation. Additionally, the synthesis of $CaCO_3$ with unique morphologies, such as nanofiber structures, was also successful.

Subtheme 2 focused on enhancing CO_2 absorption from the atmosphere using fine bubbles and

chemical additives of amines. Although the sustainable fine bubbles in the reactor can inhibit the dissolution of atmospheric CO_2 into the solution, bubbles of an optimal diameter increased the efficiency of CO_2 transfer from air to liquid. Furthermore, various polyamine additives were evaluated to improve the CO_2 absorption and mineralization process. An optimal polyamine was identified, and the recovery rate of this amine exceeded 95%.
In Subtheme 3, a process design was developed for an industrial-scale system (100 tons-seawater/hour) using the data from subtheme 1 and 2. The design study demonstrated that CO_2 could be mineralized and fixed as $CaCO_3$ at an estimated cost of less than ¥1,000/ton- CO_2 sequestration. This result indicated that the proposed CO_2 capture process has the potential to be economically viable at scale, providing a feasible route for large-scale atmospheric CO_2 sequestration via $CaCO_3$ formation.

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