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C2Po1B-06 [15]: Crystal growth of CO2 at low temperatures: experimental observation and empirical approach

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Carbon dioxide (CO2) cryogenic desublimation separation is an emerging contamination-free carbon capture method. Solid CO2 as an important industrial product is widely used in many fields. So far, there have been few investigations focusing on the detailed desublimation characteristics of CO2 due to the difficulty of visual experiments under low temperatures and the challenge of controlling the growth of solid CO2 accurately and collecting it easily. In this study, the core part of the experimental set-up is a visual tube-in-tube counterflow heat exchanger consisting of a Pyrex glass tube with a larger diameter and a stainless steel tube with a smaller diameter. The CO2 nucleation and crystal growth occurs on the precooled outer surface of the inner tube, and the process is recorded by a camera. According to classical nucleation theories and experiments, an empirical formula for the two-dimensional nucleation rate of CO2 is established. In contrast to the nucleation process in solution, here the flow rate is considered in addition to the supersaturation state and growth temperature. The single crystal morphology of carbon dioxide has been explored for the first time. Under different growth conditions, crystal growth shows four different forms, ice layer with smooth surface and edges, ice layer with branches, dendrite snowflakes and uniformly covering crystals. The thermodynamic mechanisms are analyzed and the distribution pattern of CO2 crystal growth is obtained. Low temperature and high concentration are the main driving forces for the growth of the dendrite branches, since on the gas-solid interface, the part which extends into the supersaturated gas grows and dissipates the latent heat faster than other places. It is beneficial to study the crystal growth morphology of CO2 to control the growth of CO2 solid accurately, understand the properties of CO2 solid, then develop CO2 desublimation capture technology and promote its application.

Key Words：CO2 desublimation; visual experiment; nucleation; morphology of CO2 crystal.

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