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C1Po3C-06: Experimental investigation of CO2 desublimation characteristics in flue gas on horizontal copper plate influenced by surface temperature and CO2 concentration

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Cryogenic desublimation carbon capture (CDCC) has attracted widespread attention due to its high capture efficiency, environmental compatibility, and the production of high-purity CO2. However, limitations in cryogenic visualization technology have hindered a comprehensive understanding of CO2 desublimation characteristics in mixed gases, confining the application of CDCC to small-scale experimental stages. To reveal the detailed frosting mechanism, a cryogenic visualization experimental system was developed, integrating a GM cryocooler and heaters for precise temperature control. Frosting experiments were performed on post-combustion flue gases with CO2 concentrations of 5%, 10%, and 15% under surface temperatures ranging from 150 K to 180 K, representing the typical carbon capture scenarios. Frost point data were obtained for pressures ranging from 0.1 to 1 MPa, distributed approximately between 166.3 K and 199.7 K, while the entire frosting process (0-20 minutes) was visually recorded. Image processing techniques were employed to extract the dynamic growth patterns of the frost layer, and sensitivity analyses were conducted to evaluate the effects of CO2 concentration and surface temperature on key indicators, including frost height, growth rate, and roughness. Particular emphasis was placed on the nucleation process (within the initial 0-2 minutes) and the fully developed growth process (over 8 minutes), where the frost crystal morphology transitioned from needle-like structures to plate-like formations. This study elucidates the mechanisms and morphological variations of CO2 frost crystal formation under cryogenic conditions, offering quantitative insights for system design and heat transfer analysis in practical desublimation capture applications.

Author: ZHAO, Bo (Institution of Refrigeration and Cryogenics, Zhejiang University, Hangzhou 310027, China)

Co-authors: QIU, Limin (Zhejiang University); ZHI, Xiaoqin (浙江大学)

Presenter: ZHAO, Bo (Institution of Refrigeration and Cryogenics, Zhejiang University, Hangzhou 310027, China)

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