**Experimental Study on the Dynamics and Thermal Behaviors of Colloidal Droplets in a Freezing-Based inkjet 3D Printing Method**

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This study investigates the thermal and morphological behavior of colloidal droplets undergoing a freezing process on precooled substrates. We employed high-speed imaging and infrared thermography to capture phase change dynamics in droplets with varying concentrations. The experimental results revealed a radial freezing front followed by vertical solidification, significantly influencing particle distribution. A theoretical model was developed to predict freezing time and internal flow patterns based on Marangoni convection and Stefan number. Results suggest that higher colloidal concentration leads to a more compact dendritic core post-lyophilization. These findings offer insights for optimizing deposition patterns in freeze-based inkjet printing.

*Keywords: freezing, colloidal droplet, Marangoni flow, heat transfer, lyophilization*

Graphic Abstract (if any, limit within this page)

A diagram of different types of graphics with Ice hockey rink in the background

AI-generated content may be incorrect.Schematic illustration of deposition morphologies in conventional and freezing-based inkjet 3D printing.