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Evaporation Dynamics and Heat Transfer Characteristics of Droplets Impinging on Nano-Structured Surface of Varying Wettability

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Extended Abstract

The behaviour of droplet on surfaces, particularly the impingement dynamics and evaporation characteristics, have substantial implications on its applications, ranging from enhancing heat transfer in cooling systems to improving fuel efficiency engines [1]. The droplet dynamics on a thermally active surface is an intricate phenomenon depending on the varying interaction of various forces at different time and length scales. The interplay between these forces gives rise to a complex multiscale interaction of fluids with a solid surface. The dynamics of this process are strongly governed by the properties of the fluid as well as the morphology and wettability of the contact surface [2]. While numerous studies have been conducted on the impingement and evaporation of droplets on various surfaces [3–5], there remains a significant gap in understanding the complex interplay between surface wettability, droplet dynamics and heat transfer characteristics during evaporation, especially at low Weber numbers. In this regard, this study aims to investigate the impingement and evaporation dynamics of water and acetone droplets impinging on nano-structured surfaces of varying wettability at low Weber numbers. The study focuses on understanding the influence of surface wettability on the behaviour of droplets upon impact, their subsequent evaporation dynamics, and heat transfer characteristics. The phenomenon of droplet impact is captured through high-speed camera and a high-speed infrared camera triggered simultaneously. The droplet dynamics and evaporation are determined through high-speed imaging, while the subsequent heat transfer characteristics are delineated through high-speed infrared (IR) thermography. The spatio-temporally resolved dynamics of three-phase contact line (TCL), a distinguished feature observed for a droplet on a heated surface, are also delineated where very high heat and mass fluxes are expected. Surfaces with different wettability exhibit varying rates of evaporation due to difference in TCL formation which effects the heat transfer characteristics. Furthermore, the motion of TCL during droplet advancing/spreading phase and receding phase and the evolution of heat transfer rates have been examined at different time intervals. This study represents a comprehensive approach to understanding droplet dynamics on nano-structured surfaces. By combining advanced fabrication techniques with high-speed imaging and IR thermography, it aims to provide a deeper understanding of the complex interplay between surface wettability, droplet dynamics, and heat transfer during evaporation

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