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Evaporation Dynamics and Vapor Accumulation of Paired Droplets on Heated Substrates

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Extended Abstract

Droplet evaporation on a solid substrate has attracted much attention in various industrial fields, especially for surface coating applications to produce printed electronics [1]. The characteristics of evaporating droplets have been mostly analyzed through internal flow, vapor field, evaporation flux, evaporative cooling effect, and contact line dynamics. Many researchers have studied the evaporation process for a single droplet with different operating conditions, such as substrate temperature, wettability, and environmental conditions [2]. Recently, there has been broad and practical interest in studying the evaporation characteristics of multiple droplets, exhibiting the complicated interaction between droplets. Physically, the vapor evaporated from the droplets is overlapped with the vapor from the adjacent droplets, yielding a concentrated vapor region. Indeed, the vapor accumulation reduces the local evaporation flux at the adjacent region with neighboring droplets [3]. The suppression of the evaporation flux decreases as the distance between the droplets increases. The present study aims to examine the vapor accumulation characteristics of paired droplets on the heated substrate. The total evaporation time and contact line behaviors are measured for different droplet-to-droplet distances and substrate temperatures. Droplet volume and contact line evolutions are obtained from the side-view images using the shadowgraph method. Together with the experiments, the current study provides numerical predictions of local evaporation flux along the surface and vapor distributions near the droplets. We also compare the vapor fields of the single droplet and the paired droplets to analyze the vapor accumulation characteristics with different substrate temperatures. The results show that the contact diameter and contact angle exhibit similar behavior for single droplet and paired droplets regardless of the droplet-to-droplet distance and substrate temperature, indicating a little effect of vapor accumulation on the contact line behavior of the evaporating droplets. However, the paired droplets reveal a longer total evaporation time than the single droplet case because of vapor accumulation between the droplets, dramatically reducing the local evaporation flux. In particular, as the substrate temperature increases, the total evaporation time decreases because of the enhanced heat conduction from the solid substrate as well as the natural convection effect, clearly showing that the vapor accumulation effect could be minimized by controlling the substrate temperature.

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