IAF MICROGRAVITY SCIENCES AND PROCESSES SYMPOSIUM (A2)
Fluid and Materials Sciences (2)

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EVAPORATION AND MARANGONI EFFECTS OF LARGE-SCALE DROPLET EVAPORATED ON HEATED SUBSTRATE ON GROUND AND IN SPACE

Abstract

Evaporation of a sessile droplet has widespread applications in industrial applications, such as electronic cooling and ink-jet printing. To meet the requirements of better thermal engineering management, the prediction of evaporation rate of a sessile droplet has attracted a lot of attention. The previous models of droplet evaporation rate were proposed prospectively by Hu et al. [1] for the quasi-steady diffusion and by Chen et al. [2 for the coupling of quasi-steady diffusion and Marangoni convection. Due to the presence of gravity on ground, the shape of large droplet whose characteristic length is larger than capillary length is hard to describe by simple geometry and buoyancy convection inside large droplet can't be ignored. Under these limitations, above two models are established with small water droplet. In microgravity environment, a large scale droplet can be easily formed with almost a half of spherical shape on heating substrates and non gravity-force -induced buoyancy effect present during the evaporation process even with higher heating temperature at substrate. Experiments of large-scale ethanol droplets evaporating on heated PTFE substrate carried out on board Chinese Satellite SJ10 provide the opportunity to study the theoretical model of drop evaporation rate (lifetime) in microgravity condition and compare with previous ground-based evaporation models. In our experiments, droplets were injected from the bottom of substrate and the drop shape is recorded by a CCD camera from side view. Special technique is used to keep the droplet in the mode of constant contact line on substrate. The temperature difference at droplet free surface is simulated using a 2D axial symmetric model of CFD COMSOL with input of measurement parameters obtained in space experiment. In this work, the instant evaporation rate of large ethanol droplet on heated PTFE under different substrate temperatures in microgravity is presented and compared to ground-based theoretical models. In the new model, both the contribution of quasi-steady diffusion and thermocapillary convection effect to the evaporation rate are taken into account. The results show that thermocapillary convection can't be ignored in microgravity when substrate temperature Ts =40. For large droplet, generally evaporation rate decreases with time and the relative contribution of thermocapillary convection decreases with Ts. ACKNOWLEDGEMENTS : This research was financially supported by the National Natural Science Foundation of China (Grants Nos. 11532015, U1738119), and the China's Manned Space Program (TZ-1) . Reference: [1] Hu H and Larson R G. Evaporation of a Sessile Droplet on a Substrate[J]. Journal of Physical Chemistry B, 106(6), 1334-1344(2002). [2] Chen P, Harmand S, Ouenzerfi S and Schiffler J. Marangoni flow induced evaporation enhancement on binary sessile drops[J]. The Journal of Physical Chemistry B, 121(23): 5824-5834(2017).