Evaporation processes of sessile droplet and liquid film: Research from the ground to space

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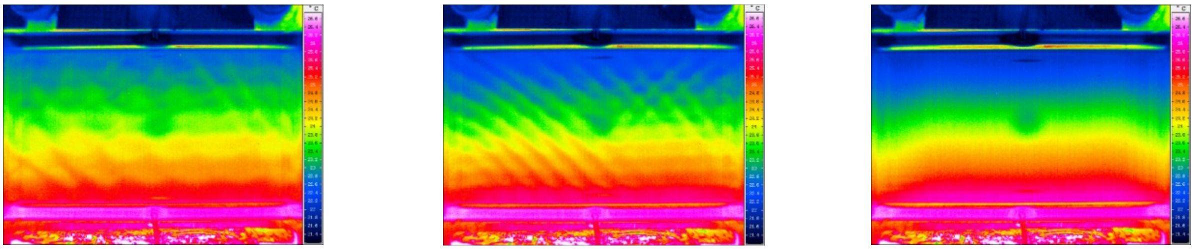
Abstract

The evaporation processes on the ground and in space have recently attracted more scientific interests owing to engineering applications as efficient ways of heat management. In space, the phase change coupling with typical interfacial phenomena of heat and mass transfer will play main role in the process of evaporation, while which are still absent of comprehensive understanding in space where the influence of gravity (i.e. natural convection, buoyancy) can be minimized. In present paper, both droplet evaporation and liquid film evaporation are investigated on the ground and in space by our research team in recent 10 years. We got the space experimental results of droplet and film evaporation in microgravity condition in recent two space flight missions of Chinese Satellite SJ10 and 1st Cargo Spacecraft TZ-1 launched in 2016 and 2017, respectively. The compared results showed that due to the gravity-free constraints, the height of droplets in space would be higher than that on ground for same injection volume. The average evaporation rate of FC-72 droplet in space is much slower than the ground tests in the same working conditions (temperatures, volume and pressures), which was thought of the large contribution of buoyancy convection to evaporation on the ground. On the ground, we performed an experimental study of thermocapillary convection of a ~2mm deep layer of 0.65cSt silicon oil confined in an open rectangular pool. The evaporation rate and the thermal field at evaporating interface were examined by the laser co-focal displacement meter and the infrared thermography. Depth of the liquid layer maintained quasi-changeless with the evaporation rate and liquid-injection rate approximately equal. According to its instability to hydrothermal waves and a steady multicellular, the evaporation processes are divided into three stages. Thermal instabilities at the evaporation interface are shown in Figure 1 for three different stages. Comparative experiments were carried out with different working fluids (FC-72 and HFE7500).



(a) (b) (c)

Figure 1: Thermal field of three different stages: (a) Oscillatory multicellular; (b) Hydrothermal waves; (c) Static thermal convection

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