LONG RANGE INTERACTION OF TWO PL- SESSILE DROPLETS ON A SOLID

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Drop are not isolated in printing and spray-coating processes. Sessile drops at a distance can show long-range attraction across a high surface energy substrate, mediated by their vapour[1], or one can chase the other. Drops landing on a wet film can lead to splashing, bouncing, spreading, a coalescence cascade or instant absorption[2]. Recent work on sessile drops next to each other has shown delayed coalescence of miscible liquids[3]. This diversity of behaviour is associated with a wealth of dynamics occurring inside the liquid. The fundamental understanding, prediction and control of the behaviour of sessile droplet interactions and coalescence have drawn growing interests from both academic and industrial communities. Sessile drop coalescence may be desirable in generating a continuous track or uniform film – or undesirable, for example, in inkjet printing process where colour blending is to be avoided. Previous research was heavily focused on μL- drops which may not display the same behaviour as the pL- or nL- droplets that are typical in agriculture spraying or inkjet printing. Vapour-mediated drop motion on a substrate is not fully understood, for example, it is not clear or not a precursor film contributes towards droplet mobility. There have been no detailed measurements on internal flows to determine the contribution of Marangoni flows to the drop motion and coalescence in small drops. We also lack knowledge of the influence of substrate on drop behaviour.

At Durham, we developed a rig to study morphology and internal flow of two pL- sessile droplets printed on a solid with a controlled time delay, spacing and composition at industrial printing time and length scales. We investigated the long-range interaction between a drop of ethanol and a drop of water and between a pair of ethylene glycol (EG)/water droplets with varying EG concentration. Plasma cleaned glass was used in both cases and a hexamethyldisilazane-treated glass substrate with controlled receding contact angle (RCA) was also used in the former case. In the case of ethanol/water droplet pair on the high surface energy substrate, we observed that water droplet is repelled within 1 ms after the ethanol droplet lands, with a shortest edge-to-edge distance of the two droplets of 150 μm. We propose the motion is due to the asymmetric adsorption of ethanol vapour into nearby water droplet and the consequent Marangoni stress along the water-vapour interface. The time and length scales agree well with diffusion-control theory. The motion of the water droplet depended on the RCA of the substrate and the time delay between the water and ethanol droplets. Ethanol adsorption to the water droplet had an indiscernible effect on its volume and evaporation rate. However, we observed flow switching inside water droplet in case of pinned contact line on a silanised substrate before and after the disappearance of ethanol droplet. In the case of two droplets of EG/water mixture at a distance, strong attractive motion or chasing is observed under controlled drop composition and time delay. Experiments have been designed to distinguish between the effects of condensation, suppressed evaporation and enhanced evaporation in inducing asymmetric Marangoni flow and droplet motion.

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