PARTICLE MIGRATION IN INKJET-PRINTED DROPLETS

Jack G. J. Goodall[1], L. Yang[1], C. D. Bain[1]
1 Department of Chemistry, Durham University, South Road, Durham, DH13LE, U.K
Contact Email: jack.g.goodall@durham.ac.uk

The evaporation of sessile droplets is of great importance to a range of applications from biosensors to graphics printing and crop spraying to printed electronics. Inkjet printing technology is particularly powerful as a method of selectively depositing functional materials with typical inks being complex formulations comprised of solvents, pigments, humectants and surfactants. Therefore a predictive understanding of formulations is necessary in order to achieve desired morphologies and avoid widely reported non-uniform morphologies.[1] Composition or temperature gradients across the liquid-vapour interface have been shown to induce Marangoni flows which can redistribute suspended material to avoid such ring-stains,[2] however studies have mainly taken place on microlitre droplets in which buoyancy-driven convection can feature.[3]

Here we report experiments in which dark-field optical microscopy coupled with high-speed cameras is used to trace the trajectories of light-scattering tracer particles to investigate internal flows through particle image velocimetry. Solutal Marangoni flows are generated in a selection of initially low viscosity solvent mixtures and solutions however at these smaller length-scales different morphologies are observed. Instead of obtaining uniform deposits, particles are seen to migrate across flow streamlines[4] to collect in central groups in ethanol-water mixtures, ethylene glycol-water mixtures and sucrose, lactose, sodium chloride and sodium nitrate solutions, demonstrating the prevalence of particle migration in a disparate range of chemical systems. A weak particle-size dependence to the migration is noted and a diffusiophoretic mechanism of migration in response to composition gradients is proposed.

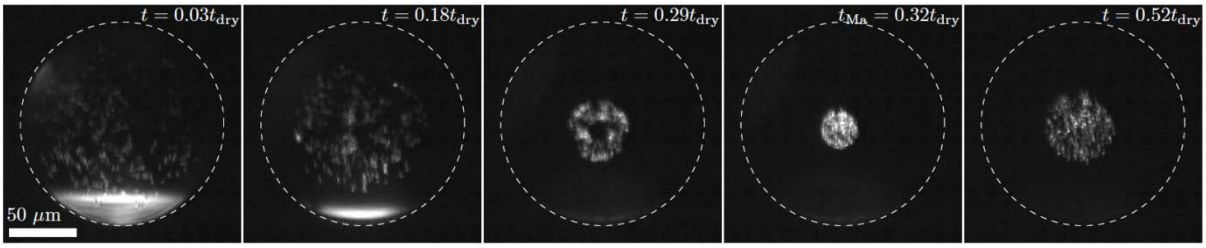

Figure 1. Particle migration towards the centre of an evaporating 50:50%v ethanol-water droplet. The dashed line is the position of the contact line. t_{Ma} is the time when the Marangoni flows ended while t_{dry} = 2.4 s.

ACKNOWLEDGEMENTS: The authors acknowledge support from the Engineering and Physical Sciences Research Council under grant code EP/N025245/1.

REFERENCES:

1. R. D. Deegan, O. Bakajin, T. F. Dupont, G. Huber, S. R. Nagel and T. A. Witten, *Nature*, 1997**, 389**, 827–829.
2. L. Cui, J. Zhang, X. Zhang, L. Huang, Z. Wang, Y. Li, H. Gao, S. Zhu, T. Wang and B. Yang, *ACS Appl. Mater. Interfaces*, 2012, **4**, 2775–2780.
3. Y. Li, C. Diddens, P. Lv, H. Wijshoff, M. Versluis and D. Lohse, *Phys. Rev. Lett.*, 2019, **122**, 114501.
4. E. L. Talbot, H. N. Yow, L. Yang, A. Berson, S. R. Biggs and C. D. Bain, *ACS Appl. Mater. Interfaces*, 2015, **7**, 3782–3790.

Back to Programme