

“Bootstrap” Deposition of Solid poly(ethylene oxide) Structures From Evaporating Liquid Droplets

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The behaviour of complex fluids under non-equilibrium conditions is of everyday relevance in washing (dilution and shear of surfactants), food preparation (temperature changes, shearing and diluting of emulsions etc.) and ink-jet printing (drying of colloidal suspensions). Investigation of such processes from a fundamental perspective may lead to products with greater functionality, improved efficiency, lower costs or reduced environmental impact.

Deegan et al. [1] investigated the formation of the familiar coffee-ring stain using a model system of microspheres suspended in water. They concluded that enhanced evaporation along the pinned contact line, due to a contact angle less than 90° , must be fed by outward flow of water from the centre of the droplet. Alain and Pauchard [2] used the model system of the aqueous branched polymer dextran to investigate the additional complexities that arise as polymer solutions evaporate. The increase in concentration at the droplet's edge led to the formation of a glassy polymer skin, which buckled on continued evaporation of water.

We present experiments performed on a linear polymer which does not form a glassy phase and shows quite different drying behaviour. Droplets of aqueous poly(ethylene oxide) (PEO) solutions were observed to deposit a solid residue on which the droplet then assumes a very high contact angle. The final solid deposit is sometimes hollow and can be significantly taller than the initial droplet. We believe this behaviour may in part be due to the subtle amphiphilic properties of PEO [3]. We present experimental results over a range of experimental conditions (concentration, molecular weight, substrate) using complementary techniques (surface profilometry, nuclear magnetic resonance, drop shape analysis). We also offer a semi-quantitative theory to explain our observations.

References:

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- [2] L Pauchard and C Allain, *Europhysics Letters*, **2003**, 62, 6.
- [3] B. Hammouda, D. L. Ho and S. Kline, *Macromolecules*, **2004**, 37, 6932.