Evaporation of nano-suspension drops on soft and structured substrates

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The evaporation of droplets is dictated by the nature of the three phases it is part of i.e. liquid, vapour and solid. The properties of these phases as well as the environmental conditions are known to play a crucial role in the kinetics of evaporation as well as the dynamics of the droplets profile and in particular the three phase contact line. This study investigates the evaporation of sessile pure water and nano-suspension drops on viscoelastic polydimethylsiloxane (PDMS) films. We varied the viscoelasticity of the PDMS films by controlling the curing ratio, and categorised them into three types: stiff (10:1, 20:1, 40:1), soft (60:1, 80:1), and very soft (100:1, 120:1, 140:1, 160:1). The complete evaporation of nano-suspension drops of stiff substrates leads to particle deposition patterns similar to a coffee ring with cracks and deposition tails. On very soft substrates the initial spreading is followed by a mixed mode in which a wetting ridge is pulled up by the vertical component of surface tension at the contact line of the drop. As the evaporation proceeds, the contact line attempts to recede due to the decreasing contact angle, which exerts a horizontal force on the wetting ridge. Due to the viscoelastic nature of the very soft substrates, this horizontal force cannot be countered by the substrates themselves, causing the wetting ridge to move horizontally in a viscous-flow way. The contact line continues to be anchored to the wetting ridge, but recedes relative to the bulk of the substrate, resulting in a mixed mode of evaporation. Complete evaporation of nano-suspension drops on very soft substrates leads to finger-like deposits. Furthermore, we explore the evaporation of nano-suspension drops on micro-structured surfaces. The effect of shape and size of the microstructures is found to significantly alter the base profile of the drops. In some cases, a thin liquid film is found to extend beyond the main drop. The evaporation from this thin film is fed from the drop which acts like a ‘reservoir’ to compensate for evaporation.