Ring to mountain transition in deposition pattern of drying droplets

When a droplet containing a nonvolatile component is dried on a substrate, it leaves a ringlike deposition the substrate. We propose a theory that predicts the deposit distribution based on a model of fluid flow and the contact line motion of the droplet. It is shown that the deposition pattern changes continuously from a coffee ring to volcanolike and to mountainlike depending on the mobility of the contact line and the evaporation rate. An analytical expression is given for the peak position of the distribution of the deposit left on the substrate.

We propose a simple Onsager principle model for a drying droplet that accounts for the contact line motion and the solvent evaporation simultaneously. We have clarified how the contact line friction and the evaporation rate affect the final deposition pattern, especially the transition from coffee ring to volcanolike and then to mountainlike patterns.

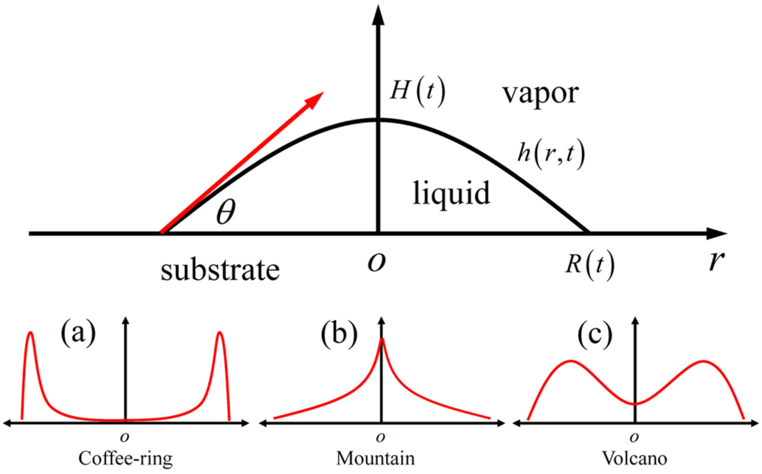

Fig 1. Schematic of a droplet and three different deposition patterns with axisymmetry in a cylindrical coordinate system

We have shown that the peak position of the deposit profile shifts to inward with the decrease of the friction constant between contact line and the substrate, k_{cl}. When it is large, $k_{cl} = 100$, the contact line does not move much from its initial position, and the coffee-ring pattern appears. On the other hand, when $k_{cl} = 0$, most solute is accumulated at the center of the droplet, and a mountainlike pattern appears. Moreover, when the evaporation rate, k_{ev}, is too fast, the peak position is independent of k_{ev}, while it becomes a function of k_{ev} for slow evaporation rate. Our study gives insight to control the deposition pattern of drying droplets, which has various applications in industry.

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Reference

[1] Xingkun Man, Masao Doi, Ring to Mountain Transition in Deposition Pattern of Drying Droplets, Phys. Rev. Lett. 116, 066101 (2016).