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Interfacial transport alone accounts for coffee-ring deposition

VAHID VANDADI, SAEED JAFARI KANG, University of Nevada, Reno, JAMES D. FELSKE, State University of New York at Buffalo, HASSAN MASOUD, University of Nevada, Reno — When a colloidal sessile droplet dries on a substrate, the suspended particles usually deposit on the surface in a ring-like pattern. The phenomenon is commonly known as the "coffee-ring" effect and it is widely believed to stem from the transport of solutes towards the pinned contact line by the evaporation-induced flow inside the drop. It is, therefore, assumed that the liquid-gas interface does not play an active role in shaping the deposition pattern. Here, we propose an alternative mechanism for the coffee-ring deposition, in which the particles first intersect the receding free surface and then are transported along the interface until they deposit at the edge. That the interface "captures" the solutes as the evaporation proceeds is supported by a Lagrangian tracking of particles advected by the flow field within the droplet. We model the interfacial adsorption and transport of particles by a one-dimensional advection-generation equation in a toroidal coordinate system and show that the theory adequately accounts for the coffee-ring effect. Using this model, we study the final deposition pattern on hydrophilic and hydrophobic surfaces under diffusive and uniform evaporation fluxes.

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