Effect of Particle Size and Surface Hydrophobicity on Critical Pinning Concentration of Coffee-Ring Formation

Kai-Chieh Yang*, Shih-Yao Lin, Li-jen Chen

[1]*Department of Chemical Engineering*
National Taiwan University, Taipei 10617 Taiwan

** r04524042@ntu.edu.tw.*

When a nanofluid droplet dries out on homogeneous surfaces, a ring-like deposit of particles develops at the edge of the droplet. This phenomenon, known as the coffee ring effect, usually occurs whenever drops containing nonvolatile solutes evaporate on a solid surface. The evaporation process of nanofluid droplet on homogeneous surface generally comprises: (1) the constant contact radius mode, (2) the constant contact angle mode, (3) the mixed mode, and (4) the last pinned mode [1]. The critical pinning concentration was defined as solute concentration when nanoparticles start to pin at the edge of the droplet. That happens to be in the beginning of last pinned mode in the evaproation process. The critical pinning concentration increases along with the surface hydrophobicity, which can be identified by the receding contact angle. The critical pinning concentration is linearly dependent on the receding contact angle for a fixed nanoparticle size (400 nm in diameter), and there exists a critical receding contact angle (33˚) [1]. A droplet containing silica nanoparticles placed on self-assembled monolayer silaned silicon wafer with its receding contact angle smaller than the critical receding contact angle would always pin immediately to trigger the coffee ring formation. The critical pinning concentration decreases with an increase in particle size. For larger particles (such as, 700 and 1000 nm in diameter), the linear relationship between the critical pinning concentration and the receding contact angle still remains intact but shifts downward.

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[1] Lin S. Y., Yang K. C. and Chen L. J., *The Journal of Physical Chemistry C*, 2015, **119(6)**, 3050-3059.