Shape controllable microparticle formation via microfluidics and droplet impact

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Wax based materials have been widely used in dentistry, food processing, cosmetics, and pharmaceutical applications since they are abundant in nature, biocompatible, and facile to the use of encapsulation of active compounds and ingredients. We recently demonstrated that millimeter size molten wax drops could be solidified into particles with mushroom, ellipsoid, disc, and flake-like morphologies upon striking an immiscible liquid interface. In this project, we propose a two-step method by utilizing a microfluidic platform to produce size-controllable molten wax microdroplets in a flow-focusing channel, followed by subsequent deformation and solidification processes during liquid-liquid impact in an aqueous bath solution to generate non-spherical wax microparticles.

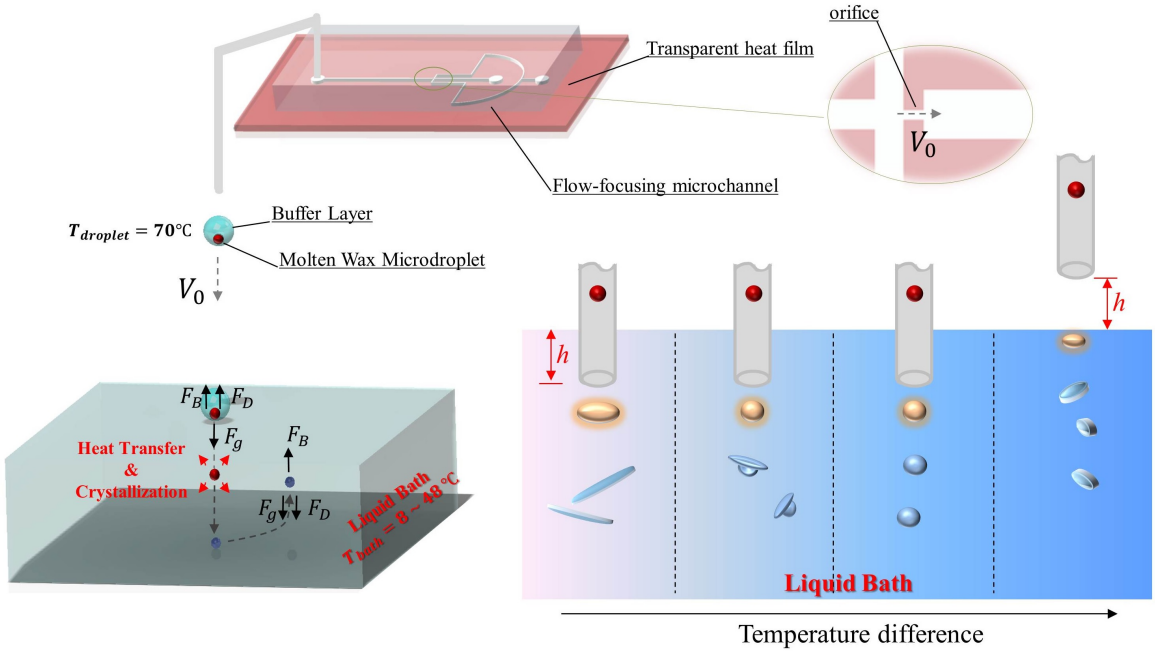

Figure 1: Schematics of the experimental setup of molten wax droplet impacting a cooling aqueous medium.

The droplet motion, heat transfer, and crystallization of molten wax microdroplets were analyzed to investigate the deformation process of molten wax microdroplets impinging on an immiscible interface by using various dimensionless parameters. Sphere, egg-shaped, thin disc-shaped, and flattened ellipsoid-shaped morphologies were controllably generated by varying the viscous and thermal effects, and a cursory phase diagram was depicted. The viscous and thermal effects were found to be more dominant over the gravitational and buoyancy effects, promoting morphologies different from those observed in the millimeter sized molten wax drops. The temperature and the degree of crystallization of the wax microdroplets were examined with respect to time by varying the temperature difference between the wax microdroplets and the aqueous bath liquid. The droplet deformation was hindered by fast crystallization due to heat transfer between the wax droplets and the surrounding bath liquid. These theoretical

and experimental studies are expected to provide in-depth insight into the general deformation and crystallization behavior, and morphological manipulations of soft materials such as droplets, droplet compounds, and cells impinging on an immiscible liquid interface.

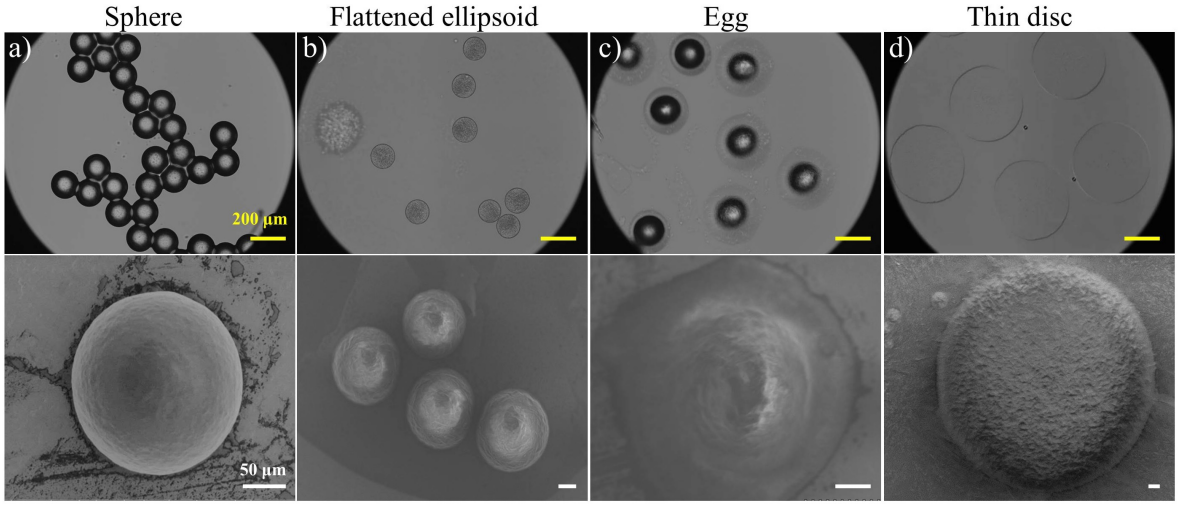

Figure 2: Different morphologies of wax microparticles.