Tuning the wettability of surfaces

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Abstract

The wettability of surfaces is determined by the chemical composition as well as the roughness of surfaces. One promising technique for controlling the roughness of surfaces is to pattern them with monodisperse colloids. In this project, monodisperse Water-in-Oil single emulsion droplets are produced using microfluidics. The macromonomers in the droplets can be crosslinked through the photoinitiated radical polymerization. Thereby, droplets are converted into microparticles. The droplets and microparticles are used to pattern surfaces. Big-area monolayer patterning is obtained. By modifying the glass surface with chemicals possessing acrylate or methacrylate functional groups, the microparticles are immoblized on the substrate.

Experimental

Figure 1: Scheme of the experimental process. After we make monodisperse droplets with microparticles, two strategies are compared: (i) off-chip and (ii) on-chip polymerization.

Results and discussion

I: Off-chip strategy

Production of droplets

Figure 4: Optical microscopy images of (a) a droplet formation at the outlet feed tube of a flow focusing microfluidic device and (b) the formed droplets in the water channel. (c) Size distributions of droplets containing oil with PEGDA, a in the oil phase. The flow rates of oil, water, and gas are 20, 120, and 200 µL/h, respectively. The depth and width of outlet channel is 20 µm.

Monodisperse droplet can be easily made using microfluidics.

Figure 5: Scheme of patterning the glass surface with droplets. The glass is immersed with a Czerny-Turner setup for illumination. The microparticles are dispersed on it. Upon UV illumination, they are crosslinked into microparticles and then covalently immobilized on the glass substrate.

Figure 6: Polymerization process of the droplets containing an 80% PEGDA on MPS-coated glass surface. During the polymerization, some droplets are observed to burst.

II: On-chip strategy

To reduce the possibility of bursting, the droplets are immediately solidified into microparticles at the outlet tube of microfluidic chips. Then the PEGDA particles are suspended into water and this suspension is used to pattern the surface.

Figure 7: Scheme of patterning glass surface with microfluidic microparticles. Surfaces are modified by (a) 3-methacryloxypropyltrimethoxysilane (MPTMS), (b) polyethylene glycol dimethacrylate (PEGDA), and (c) MPS. In the case of MPS, after immersion, the isopropyl or ethanol, are added into the particle water suspension to lower the surface tension. This enhances the wettability of the suspension on the surface. The evaporation of solvent generate a convective flow of particles and cause their arrangement into a hexagonally close-packed structure.

After patterning, the substrate is illuminated with UV light to immobilize the microparticles on the surface.

Conclusion and outlook

- Monodisperse single emulsion droplets and microparticles composed of PEGDA, are produced using microfluidics.
- Surfaces can be patterned with a monolayer of monodisperse microparticles by carefully controlling the surface tension of solvent and the evaporation rate.
- The particles are immobilized on the surface by covalently linking them to the acrylate groups of ETPTA and the methacrylate groups of MPS.

- The deposition process of particles must be optimized to minimize the defects in monolayer.
- The mechanical properties and wettability of surfaces should be characterized.
- To increase the surface-to-volume ratio of surfaces, microparticles can be coated with nanoparticles.