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Supporting Information

Thickness of remaining water layer

In the microfluidic device, after the bulk of the water left the substrate, a thin layer of water ($h_0 \sim 3\,\mu\text{m}$) remains on the surface (Fig. 4 and Fig. 6D). During the experiments, the samples were enclosed in the microfluidic device, therefore the water did not evaporate at a fast enough rate that would allow us to capturing images of the residual layer receding. Therefore, we placed a drop of particle solution ($V = 1\,\mu\text{l}$, 100 mM NaCl) on the Hydrophilic Smooth substrate outside the microfluidic device, and captured images during the process of drying (Fig. S1). The images show, that when the liquid-air interface uncovers the particles, they remain attached to the surface.
**Figure S1: Drying interface on Hydrophilic Smooth substrate.** Consecutive images showing that the particles were not removed, when a receding line of the water-air interface passes over particles on the Hydrophilic Smooth substrates.

**Force vs. distance measurements**

To measure the adhesion force between a particle and a substrate in humid air and aqueous solution, force vs. distance measurements were conducted using the AFM. An exemplary force vs. distance curve is shown in Fig. S1A and S1A’. As the probe approaches the substrate (red curve in Fig.S1), it snaps onto the surface at ~5 nm. Upon retraction from the substrate, the adhesion force $F_{adh}$ has to be overcome by breaking the single or multiple capillary bridges in the case of the smooth and nanotextured substrate, respectively. The values of $F_{adh}$ measured in humid air are shown in Fig. S2B.
Figure S2: Adhesion force measured between a silica colloid and the four different surfaces measured by AFM. (A) Typical force vs. distance measurement in humid air between a silica bead and the Smooth Hydrophilic surface (A’). The inset shows typical force vs. distance curves that were measured between silica bead and the Hydrophobic Nanotextured surface. Snap-out features in the retract curve were observed, corresponding to multiple breakages of capillary bridges formed between the colloid and the nanotexture. (B) Average adhesion forces, $F_{adh}$, based on measurements at 2 different samples and 4 different locations on each sample. (A’) Schematic illustration of a force vs. distance measurement where a silica sphere was attached to a AFM cantilever, and it approached and retracted from the sample.

**Extrema of vertical force, $F_{\gamma,\perp}$, at the liquid-air interface**

The surface tension acting on the particle, normal to the liquid-air interface can be calculated by $F_{\gamma}/R = 2\pi\gamma \sin(\phi) \sin(\theta_{\text{part}} - \phi)$ (Eq. 1). We find the maximum possible detaching force acting normal to the substrate by solving

$$0 = \frac{\partial}{\partial \phi}(F_{\gamma}/R) = \frac{\partial}{\partial \phi} \left(2\pi\gamma \sin(\phi) \sin(\theta_{\text{part}} - \phi)\right).$$

This yields

$$0 = \cos(\phi)\sin(\theta_{\text{part}} - \phi) - \sin(\phi)\cos(\theta_{\text{part}} - \phi),$$

which gives two solutions for the maximum force: $\phi_1 = \frac{\theta_{\text{part}}}{2}$ and $\phi_2 = 90^\circ + \frac{\theta_{\text{part}}}{2}$. For the hydrophilic surfaces, $F_{\gamma,\perp}(\phi_1) > 0$ potentially detaches the particle; for the hydrophobic surfaces, $F_{\gamma,\perp}(\phi_2) > 0$ potentially detaches the particle.