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Controlled captive bubble transport on plastrons: Supplementary material

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Superhydrophobic surfaces

Materials and preparation: Two copper samples were used. The first was a plate of 5 mm thickness, and the second a foil of 0.025 mm thickness (Sigma-Aldrich 349208). Superhydrophobic surfaces were created using an electroless galvanic deposition process. This process allowed the rough tuning of wettability depending on the variables in the preparation process. Polished copper surfaces were first cleaned with absolute ethanol and allowed to dry. They were then immersed in a solution of aqueous $AgNO_3$. After this, the surfaces were cleaned with absolute ethanol and dried with compressed inert gas. They were subsequently immersed in a 1 mM solution of the surface modifier $CF_3(CF_2)_7CH_2CH_2SH$ in absolute ethanol. The samples were then thoroughly rinsed using at least 100 mL of distilled water, followed by rinsing with absolute ethanol. They were then allowed to air dry.

Surface characterization:

The surfaces prepared were placed into an SEM (Helios NanoLab) and observed at various magnifications. No metallic coatings were applied on the samples as charging was found not to be a problem. For all images, the voltage was kept at 5 kV in which no tilting of the sample was applied. Dendritic and well as granular structures were observed (see Fig. S1). The attendant micro and nano structures allow for Cassie wetting states to be exhibited by the surfaces.

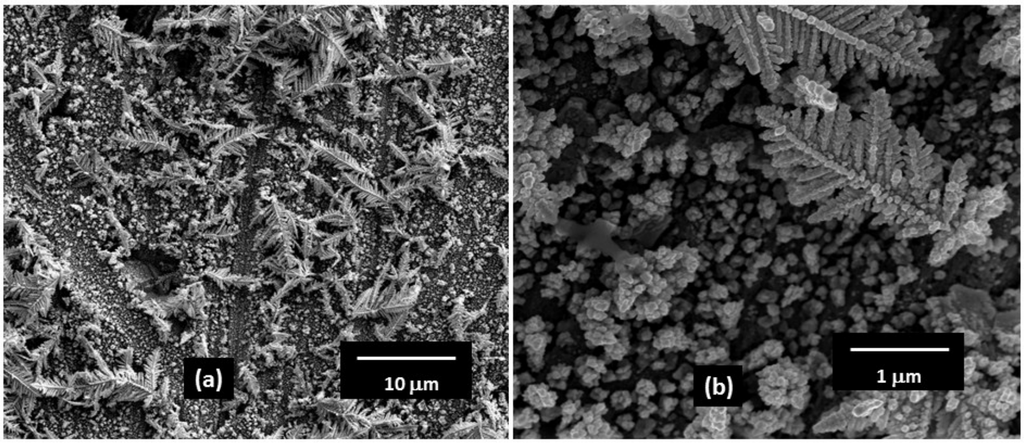

Figure S1

Numerical simulation of mass transport from captive bubble

Shape of captive bubbles:

Two captive bubbles of 100 and 200 μL volume were used for investigation. The cross sectional profile was imaged from which a shape tracing algorithm was used to obtain the coordinate points of the air-liquid interface. The coordinates were determined by applying 9 degrees of freedom polynomial fitting in order to create a smooth geometry. By assuming axis-symmetry, this allowed the 3D shape of the captive bubble to be constructed.

Numerical grid:

Free tetrahedral elements were first used to mesh the fluid domain. From this, a mesh refinement process was then applied to create the plasmon and bubble surface. As it is expected that high resolution will be needed at the interfaces, boundary layer elements comprising 8 layers each were applied on the captive bubble surface to accurately simulate the ensuing diffusion. Due to symmetry, we were able to reduce the simulation time by using only one half of the full model. Under this grid configuration, the velocity field far from the bubble will be rendered uniform. The velocity can be also visualized as entering the domain through the cells at the one boundary and leaving it through the cells at the opposite boundary.

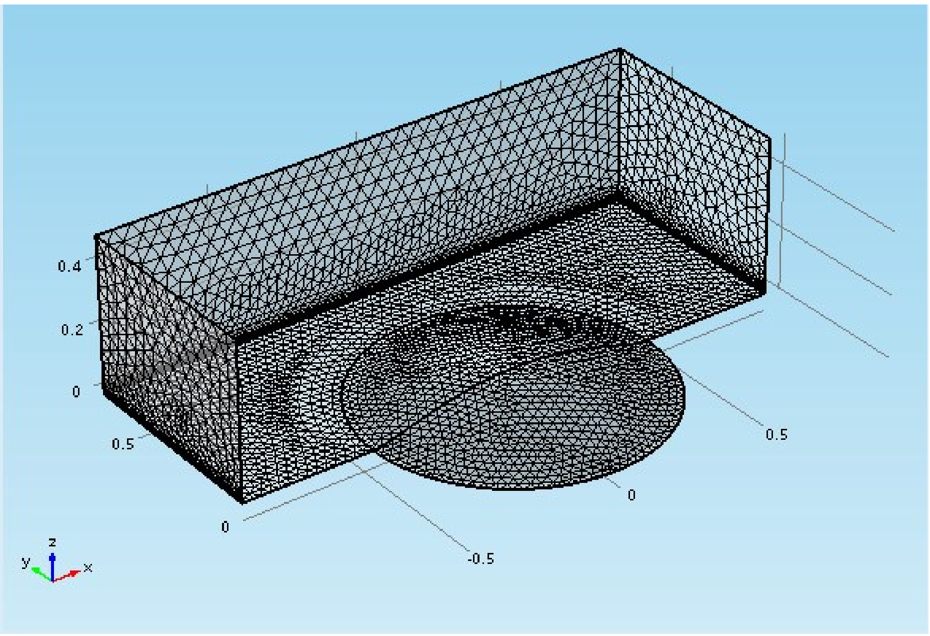

Figure S2

Preliminary verification test:

It was necessary to confirm that the numerical code that solves the Navier–Stokes equations and the diffusion–advection equation for the gaseous concentration was used to characterize the mass transport from the bubble to the surrounding liquid phase. To do this, mass transfer was studied for the case of a spherical bubble rising through a stationary liquid. The results obtained were found to correspond closely with results previously obtained [B. Figueroa-Espinoza, D. Legendre, Chem. Eng. Sci. 65 (2010) 6296–6309].