PARTICLE-COVERED DROPLETS

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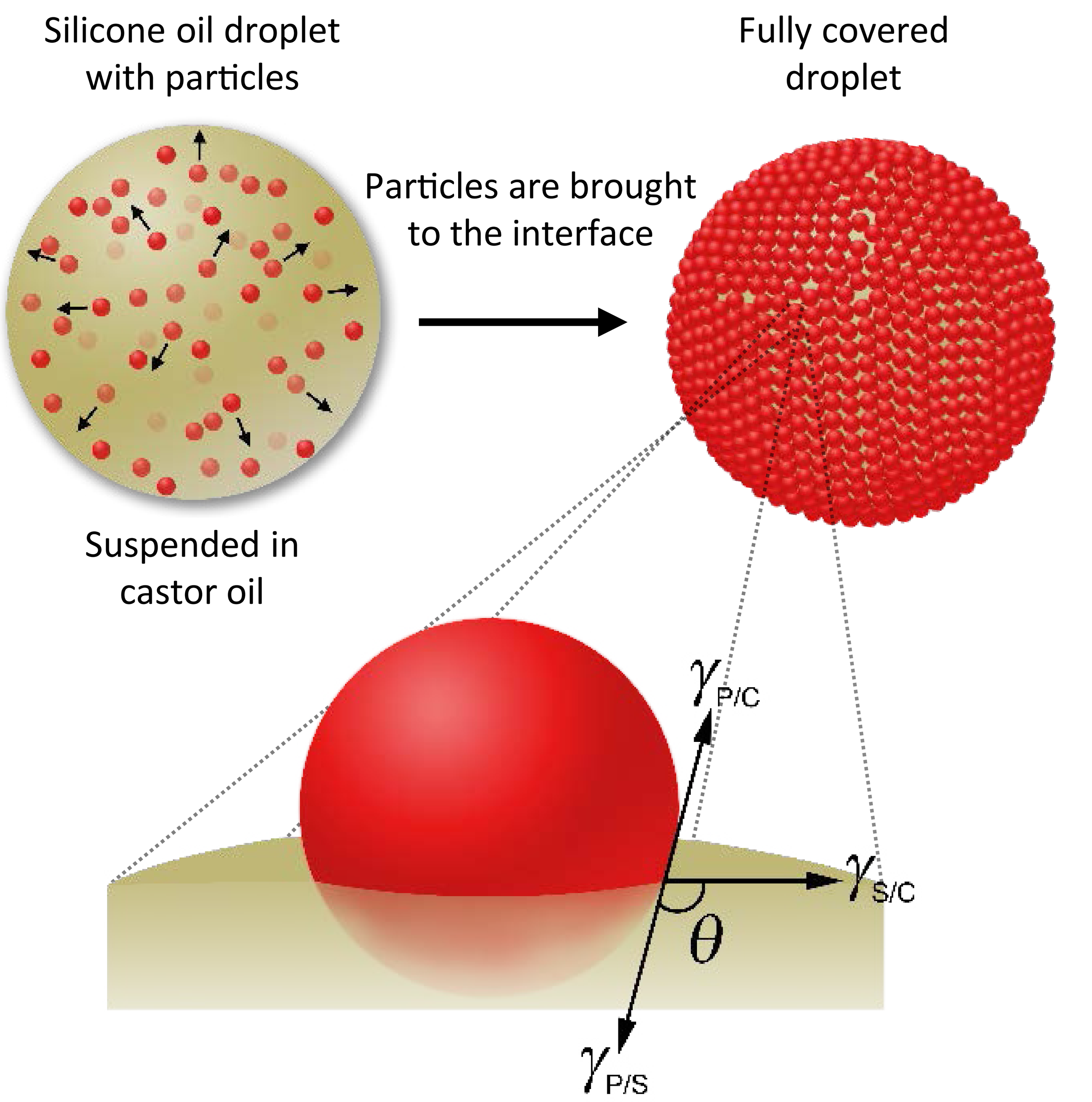
RESEARCH AREA

We investigate droplets that are covered by nano- and micrometer sized particles and suspended in another fluid. By applying electric fields, we can control and structure the particles to fabricate patchy shells, i.e. shells with at least two domains with different material properties. Such shells can be used for encapsulation and targeted delivery of various materials, to stabilize emulsions and are very attractive for material development. By tailoring the physical, chemical or morphological characteristics, colloidal shells can be functionalized and used as building blocks to prepare complex structures with advanced and novel material properties.

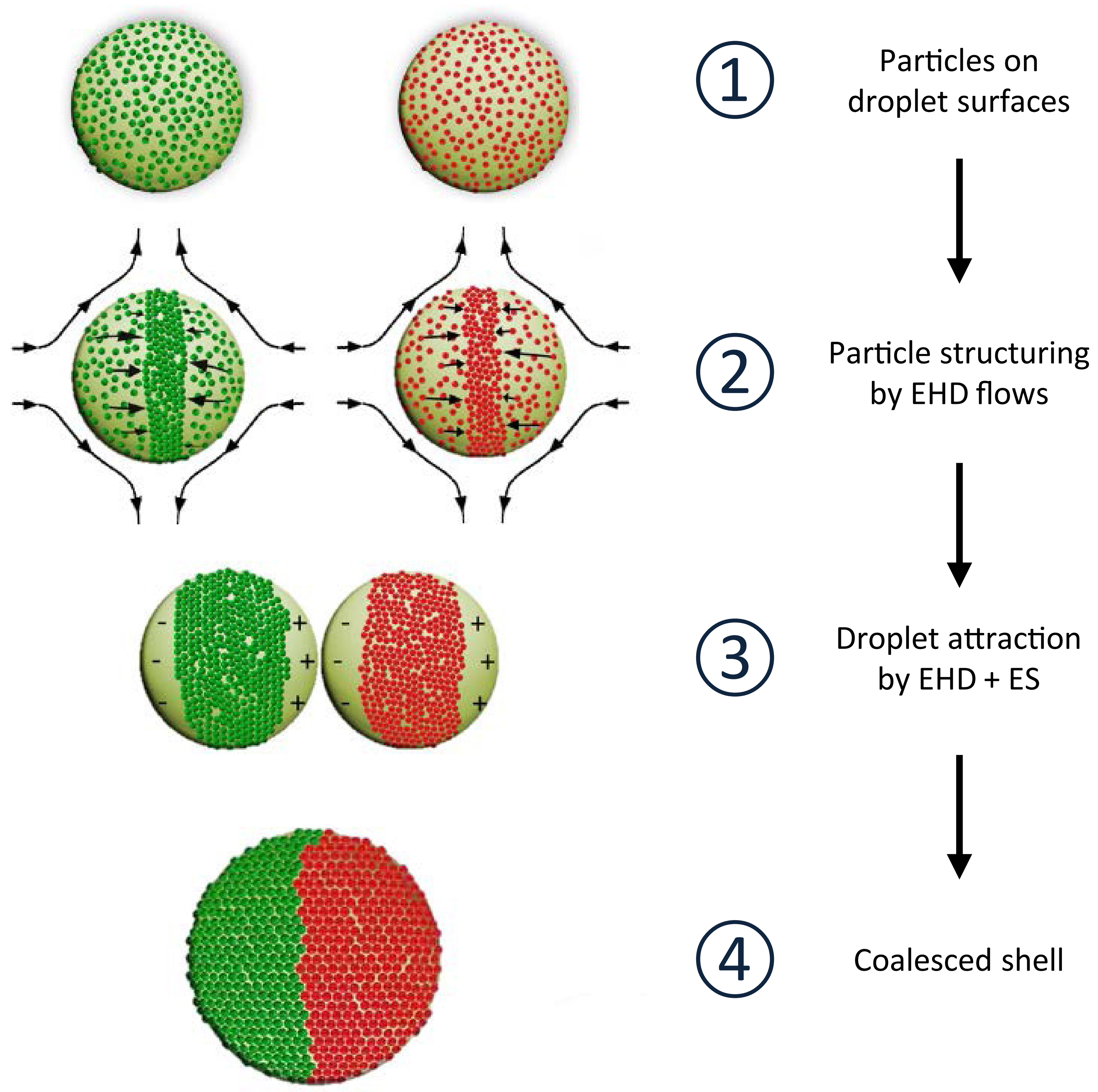
PARTICLES ARE TRAPPED AT DROPLET INTERFACES



The droplets are prepared by adding particles to silicone oil, and by immersing the silicone oil dispersion in castor oil. The particles go to the droplet interface by sedimentation, assisted mechanical stirring or by electric forces.

Once the particles reach the droplet interface, they are energetically trapped there due to strong capillary binding forces. As a results, the particle movement is confined to the interface of the droplet. When the droplet is fully covered by particles, the particles can be locked together to form a rigid capsule with controlled permettivity, i.e. by sintering processes using UV-light or high temperatures.

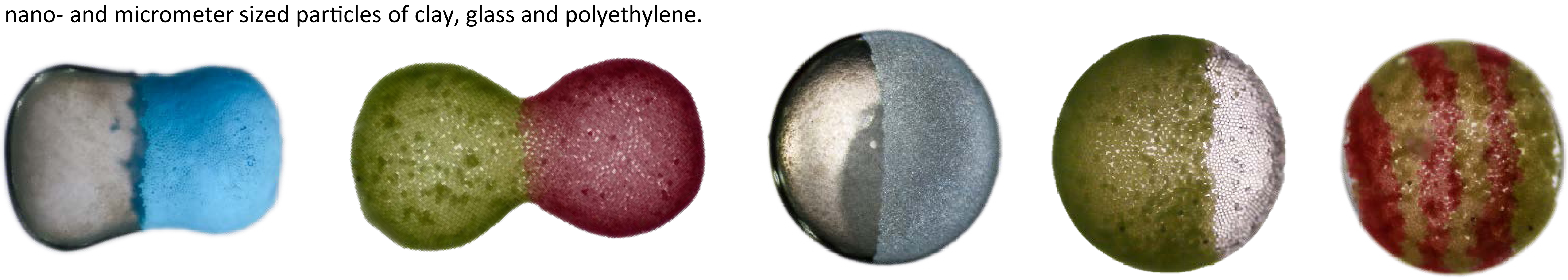
FABRICATION OF PATCHY SHELLS



① Two particle-covered droplets are suspended in another fluid. Before an external direct current (DC) electric field is applied, the particles are randomly distributed at the droplet surfaces. ② By applying a DC electric field induces electrohydrodynamic (EHD) flows in the fluids inside and outside the droplets. The flows transport the particles to the middle of the droplets where they organize themselves in ribbon-like structures. ③ The droplets approach each other due to attractive EHD and electro static (ES) forces. ④ Finally, the droplets coalesce, resulting in the formation of densely packed patchy shell.

TAILORED PATCHY SHELLS

Patchy shells can be tailored by fine-tuning the volume of the droplets before coalescence, the particle material, size and concentration. The coalescence of two droplets of the same size reduces the available surface area by ~20%, leading to a more densely packed particle layer than in the two original droplets. If the original particle concentration on the two original droplets is sufficiently high, the coalescence can lead to arrested coalescence where the particles are jammed at the droplet surface and/or the coalesced shell is non-spherical. Below are examples of tailored patchy shells made out of nano- and micrometer sized particles of clay, glass and polyethylene.



The research receives financial support from the European Union’s Horizon 2020 research and innovation framework programme under the Marie Skłodowska-Curie grant agreement No. 752896 and from the Polish National Science Centre through OPUS programme (2015/19/B/ST3/03055).

For more details see the following research paper: https://www.nature.com/articles/ncomms4945