Electric-field-induced deformation and crumpling of non-spherical particle shells formed on droplets

Droplets covered by micro- and nanoparticles, so-called Pickering droplets, have received considerable research interest in recent years. This is because they hold promise for a variety of practical applications, such as in food technology, oil industry, biofuel processing and for improving pharmaceutical products. The particle shell formed on the surface of a droplet can be designed to have different physical characteristics, such as thickness, roughness, porosity, or shape. These features determine several properties of a Pickering droplet, for example, ability to form stable emulsions, the droplet's optical appearance or its mechanical properties. Within this research proposal, I will study the mechanical properties of Pickering droplets subjected to compressional stress (see **Figure 1**).

Several research groups have studied the deformation, mechanics, and rheological properties of particle-covered droplets and described their differences from the behaviour of particle-free droplets under stress. The majority of these studies concern droplets with spherical shells or capsules. However, very little is known about the behaviour of a droplet with a shell made of arrested particles, i.e., non-spherical droplets covered by densely packed particles, and the literature lacks studies on this subject. We aim to change this and contribute to filling the gap in this research area. Therefore, the objective of this work is to understand and describe the behaviour of non-spherical Pickering droplets subjected to compressive stress. We will use an electric field to induce electric stress on a particle shell, which will enable the non-contact exertion of force on it and measurements of numerous mechanical and rheological properties of the particle-covered droplet.

The result of the proposed research will widen the current knowledge and open new areas within the field of soft-matter science related to emulsions, particle-covered droplets and microcapsules. We will answer the following questions: (i) how do the particle shell geometry, particle size, and polydispersity affect the critical electric field strength required for particle shell to collapse; (ii) what is the effect of particle size on the collapsing mechanism of a non-spherical particle shell; (iii) how do particle size and polydispersity affect the bending stiffness of the Janus shell under an applied electric field; (iv) how do the particles' shapes, and polydispersity affect the deformation, wrinkling and crumpling of a particle shell; (v) how the physiochemical parameters of the liquid, e.g., ionic conductivity, viscosity, and wettability, influence the concentration of particles' distribution on the surface of a droplet; (vi) how do the particles' properties, such as electrical conductivity, dielectric constants, and cohesiveness affect the stability and mechanics of Pickering droplets; and (vii) how do the non-spherical Pickering droplets behave under electric-field-induced deformation cycles.

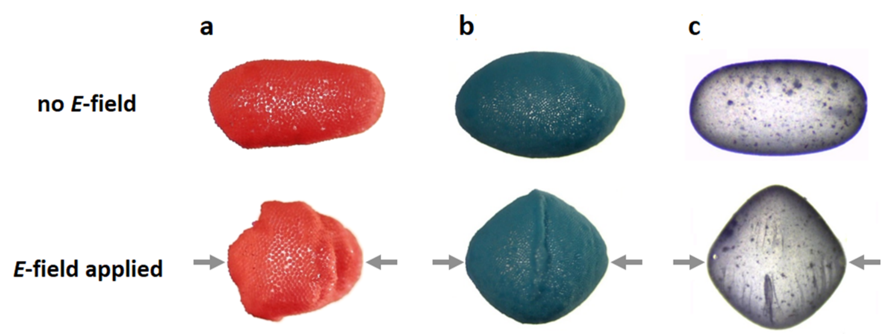

Figure 1. Graphical abstract: Crumpling of non-spherical shells composed of (**a**) 50 µm, (**b**) 30 µm, and (**c**) 2.5 µm particles. The Pickering droplets are subjected to a horizontal directed electric field (bottom raw). The particle shell shown in panel (**a**) crumples through irregular vertical folds and ridges; the particle shell shown in panels (**b**) crumples through one main vertical fold, whereas the shell made of the smallest particles shown in panel (**c**) crumples through wrinkling and folding.