

## Complex Liquid Crystal Emulsions as a Versatile Platform for Multifunctional Shape-Changing Microactuators

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Liquid crystalline networks (LCNs) are soft actuating materials that undergo reversible, stimulus-induced shape changes arising from the coupling between molecular order and macroscopic deformation.[1] When processed as emulsions, LCNs offer a powerful route to fabricate microscale actuators with programmable shape, responsiveness, and internal architecture. However, achieving complex, multiphase LCN microactuators in a scalable manner remains a significant challenge.

In this work, we report the fabrication of complex LCN emulsions using a bulk emulsification strategy, as well as microfluidic approaches. By emulsifying reactive LCs and silicone oil in water, we obtain polydisperse double (Janus) emulsions with controlled interfacial organization, while microfluidics enables the preparation of monodisperse counterparts. Subsequent photo-initiated radical polymerization yields solid multicompartment LC microparticles that exhibit reversible, thermally induced actuation. At room temperature, the particles exhibit a spherical Janus morphology, whereas heating above the nematic-isotropic transition induces anisotropic deformation into oblate shapes. This strategy is further extended to the preparation of triple emulsions by introducing a fluorinated oil compartment, yielding more complex architectures that retain robust and reversible thermal shape actuation. Beyond thermal responsiveness, light-induced actuation is achieved by incorporating photoresponsive azobenzene units and light-absorbing nanoparticles within the LCN phase, allowing remote and spatially resolved shaped changes.

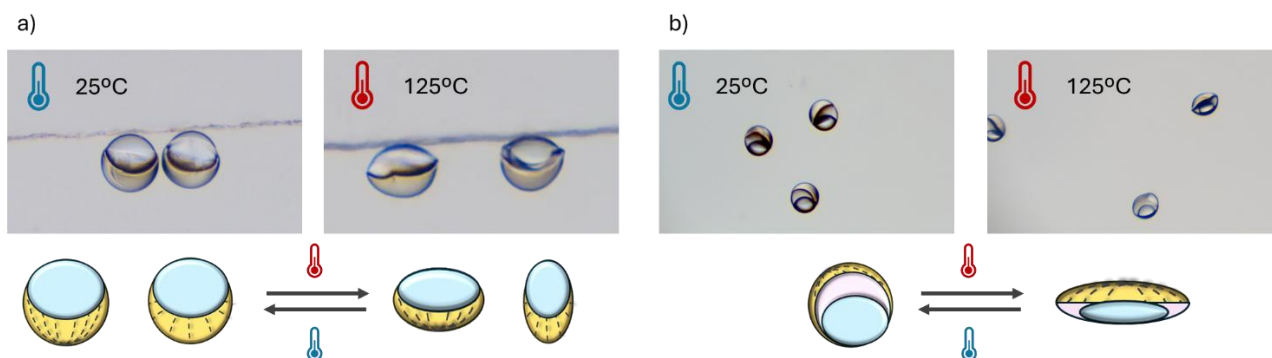


Figure 1. Thermal response of: a) double LC emulsions with monopolar alignment, showing a shape change from spherical to oblate morphology, and with radial LC alignment, exhibiting a transformation from spherical to vase-like shape; b) triple LC emulsions with monopolar LC alignment, displaying a transition from spherical to eye-like morphology upon heating.

### References

[1] M. Abad, A. Martínez-Bueno and A. Concellón, Adv. Mater. Technol. **10**, e01236 (2025)

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