Rhamnolipid Coacervate Microdroplets via Microfluidics: Generation, Morphology, and Interfacial Properties

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Rhamnolipids are microbial glycolipid biosurfactants composed of one or two rhamnose units linked to β-hydroxy fatty acid chains. Commercial samples exhibit significant chemodiversity, consisting of mixtures of mono- and dirhamnolipids with variable chain length and unsaturation [1,2]. Their amphiphilic architecture promotes spontaneous self-assembly in aqueous media leading to supramolecular structures such as micelles and anisotropic aggregates whose properties depend on concentration, pH, and ionic strength [1,2].
Under specific solution conditions, surfactant solutions may undergo liquid–liquid phase separation (LLPS), generating dense liquid phases known as coacervates, where solute-rich droplets coexist with a dilute continuous phase [3,4]. In surfactant systems, coacervation can be triggered by variations in ionic strength, as salt addition screens electrostatic repulsion between charged headgroups and enhances intermolecular association.
In this work, rhamnolipid-based coacervate droplets were generated under high ionic strength conditions using microfluidics. Experiments were performed with a Dolomite flow-focusing junction chip, where the rhamnolipid solution flowed through the central channel while saline solutions were injected from two lateral channels. Hydrodynamic shear at the junction breaks the central stream into discrete droplets, enabling precise control of droplet formation. The microfluidic setup produced monodisperse coacervate droplets in the micrometric range with controlled morphology and reproducible size distribution. The systems were investigated using optical and confocal microscopy to observe droplet morphology and dynamics, while electron paramagnetic resonance (EPR) provided information on internal organization. ζ-potential and rheology measurements further characterized interfacial properties and interparticle interactions, enabling the establishment of structure–property relationships.

Keywords:
rhamnolipids; coacervates; microfluidics; biosurfactants

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