Universal Double Emulsions Made Simple

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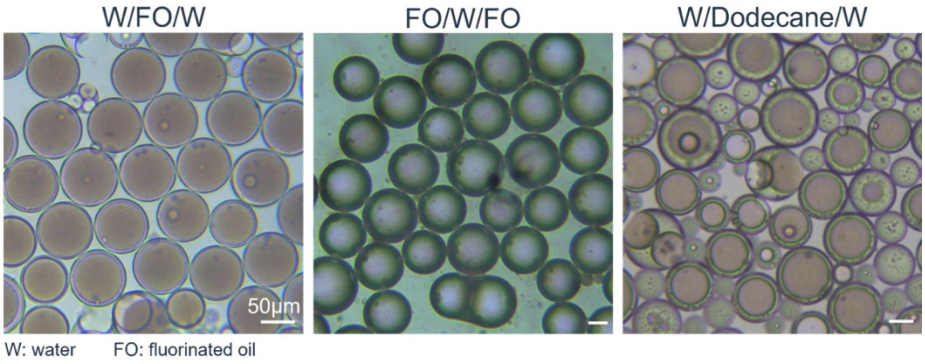
Double emulsions are defined as a fluid encapsulated within another immiscible fluid, dispersed in a continuous phase. This configuration is used for encapsulation, controlled release, or templating of advanced materials. While many applications require only the presence of an internal phase regardless of its structure, in some cases, it is important to have defined inner cores. In particular, single-core double emulsions are useful as very defined model systems, for example, to study confinements and crystallization processes [1,2], or for cell culture and tissue engineering [3].

The most widely used method for producing well-defined single-core double emulsions relies on sophisticated microfluidic devices. While microfluidics allows for precise control of the design of double emulsions (4), it requires the design of complex devices and laborious surface functionalization. A simple double emulsification method has been previously proposed, but it is limited by the density differences between the involved phases, which constrain the range of applicable formulations [2].

Here, we present a universal, scalable, and simple technique to generate single-core double emulsions using a syringe-based emulsification method. Our approach eliminates the need for complex equipment, and it is independent of the density gradients of the involved phases, enabling a broad range of fluid configurations. We investigate the method's tunability of droplet size and demonstrate its scalability capacity. This work offers a practical alternative to microfluidic methods for the production of double emulsions and provides a simple pathway towards the production of double emulsions using accessible, low-cost techniques.

Keywords:
double emulsion, single-core, microfluidics, organic solvent, fluorinated oil



Multiple double emulsions configurations. Double emulsions from left to right: water/fluorinated oil/water, fluorinated oil/water/fluorinated oil, and water/dodecane/water.

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