Synopsis of Original Research Paper

Preparation of monodisperse double emulsions in microfluidic channels on a piezoelectric substrate

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Monodisperse double emulsions (also referred to as multiple emulsions) have numerous potential applications in various fields, such as cosmetics, pharmaceutics, food, and colloid science. In conventional two-step mixing technique, however, it is difficult to produce monodisperse double emulsions. Here, we propose a novel microfluidic technique to produce monodisperse double emulsions by applying surface acoustic wave (SAW) streaming. The microfluidic device consists of two planar substrates: a piezoelectric substrate with interdigital transducers (IDTs), and a polymethyl metacrylate (PMMA) plate with microfabricated grooves. The IDTs were fabricated on a planar piezoelectric ($LiNbO_3$) substrate by conventional lithographical technique. The microgrooves on the PMMA substrate were fabricated by mechanical machining. The microchannel geometry consists of a Y-shaped junction to infuse aqueous and organic phases and to generate a water-in-oil (W/O) emulsion by SAW, and a sheath-flow geometry to form water-in-oil-in-water (W/O/W) double emulsions by shear-rupturing mechanism. First, by generating SAW, we could produce polydisperse W/O emulsion droplets of 1-10 μm in diameter at the Y-junction. Then, at the sheath-flow junction, organic droplets encapsulating fine aqueous droplets (i.e., W/O/W emulsion droplets) could be reproducibly formed in the external aqueous stream. The breakup rate was approximately 200 drops / s^{-1}. The produced W/O/W droplets were highly monodisperse, with a mean diameter of 150 μm and a coefficient of variation (CV) below 5 %.