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Production of monodisperse oil-in-water emulsions at high production scales using asymmetric microchannels

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1. Introduction

The aim of this work was to study the generation of monodispersed droplets at high production rates using novel asymmetric microchannel (MC) array fabricated on a silicone plate [1]. Monodispersed droplets are preferable both in fundamental studies and industrial applications. Appearance, rheology, stability against Oswald ripening and creaming, and the suitability of emulsion droplets as precursors to the production of solids are strongly influenced by their size uniformity.

2. Experimental

Experiments have been carried out using WMS1-3 plate consisting of 23,348 silicon MCs microfabricated within a 1 × 1 cm square area. Each MC consisted of a circular 10 μm-diameter channel and a rectangular 10 × 50 μm slit with a total depth of 100 μm. Dispersed phase was soybean or MCT (middle-chain fatty acid triglyceride) oil with a viscosity at 293 K of 69 and 26 mPa·s, resp. The continuous phase was 2 wt% Tween 20 or 0.01-2 wt% SDS dissolved in Milli Q water.

3. Results and discussion

Our results show that at low oil flux of 10 Lm⁻²·h⁻¹, the monodispersed soybean oil droplets are generated even at very low SDS concentration of 0.01 wt%. However, the generated droplets tend to attach to the plate surface, as shown in Fig. 1b, which might cause some steric hindrance problems at higher production rates. Using 2 wt% Tween 20 as an emulsifier, monodispersed soybean oil droplets (span = 0.207-0.229) were generated up to the oil flux of 110 Lm⁻²·h⁻¹, as shown in Fig. 2. The mean droplet production rate from active channels increased with increasing the oil flux and was substantially lower for soybean than for MCT oil, which is a consequence of the higher viscosity of soybean oil. For MCT oil, due to smaller viscosity, the mean droplet size was independent on the oil flux over the range of 1-120 Lm⁻²·h⁻¹.

Fig. 1. Generation of soybean oil droplets at high (a) and low (b) emulsifier content. The obtained droplets (c) are in both cases highly monodispersed.

Fig. 2. The mean Sauter diameter, d₃₂, the mean droplet production rate from active channels, DPR, and the span of particle size distribution vs. oil flux for soybean and MCT oil droplets [δ = (d₉₀ - d₁₀)/d₅₀].

References

1) Kobayashi et al., Langmuir, 21, 7629 (2005)

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— 155 —