Vb024

Manufacture of monodisperse oil-in-water emulsions at high droplet formation rates using novel asymmetric silicon microchannels

([1]NFRI, [2]Loughborough Univ., UK) ○ G.T. Vladisavljević[1,2], I. Kobayashi[1], M. Nakajima[1†]

1. Introduction

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

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. The channel depth was 70 μm and the slit depth was 30 μm. The dispersed phase was soybean oil, MCT (middle-chain fatty acid triglyceride) oil or tetradecane with a viscosity at 293 K of 50, 20, and 2.7 mPa·s, respectively. The continuous phase was 2 wt% Tween 20 dissolved in Milli Q water. The particle size distribution was measured using a commercial light scattering instrument (Beckman Coulter LS 13 320, Miami, FL).

3. Results and discussion

Uniform tetradecane droplets with span = 0.22-0.27 = $(d_{90} - d_{10})/d_{50}$ can be generated at the flux of up to 2,300 $Lm^{-2}h^{-1}$ and the mean droplet generation rate from active channels ranges from 17 s^{-1} at 10 $Lm^{-2}h^{-1}$ to over 250 s^{-1} at 2,300 $Lm^{-2}h^{-1}$. The fraction of active channels increased with increasing the tetradecane flux (Fig. 1) and was in the range from 5 to 59 %, as the flux increased from 10 to 2,300 $Lm^{-2}h^{-1}$. At the same capillary number, the mean droplet generation rate from a single active channel was significantly lower for MCT and soybean oil (Fig. 2). On the other hand, the fraction of active channels at the same oil flux was much higher for MCT and soybean oil.

The particle size slightly increased with increasing the oil flux up to the critical flux and then strongly increased with the further increase in flux. Below the critical flux, the droplet uniformity was superior for soybean oil with a span value typically in the range of 0.21-0.23. The critical flux decreased with increasing the oil viscosity.

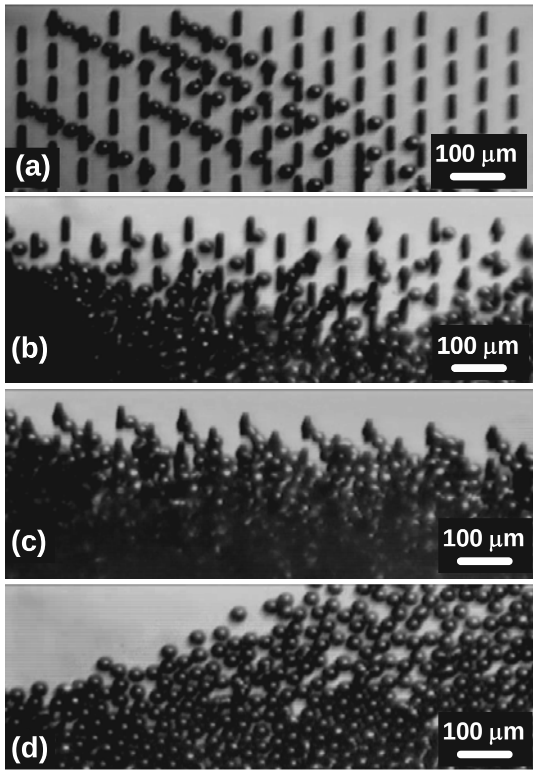

Fig. 1. Generation of tetradecane droplets at different fluxes, J: (a) J = 10 $Lm^{-2}h^{-1}$; (b) J = 500 $Lm^{-2}h^{-1}$; (c) J = 700 $Lm^{-2}h^{-1}$; (d) J = 1700 $Lm^{-2}h^{-1}$.

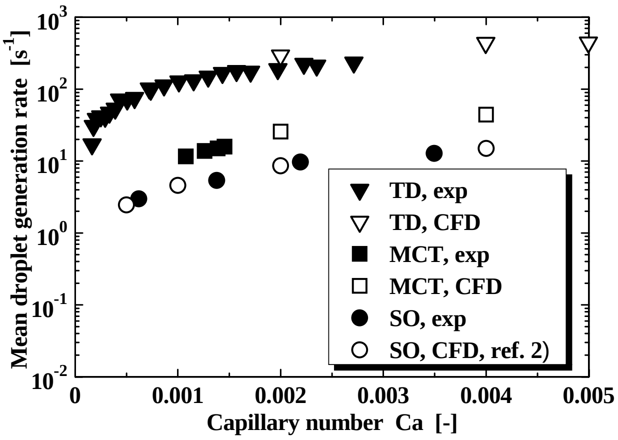

Fig. 2. Mean droplet generation rate from active channels vs. capillary number for tetradecane (TD), MCT oil (MCT) and soybean oil (SO).

4. References

1) Kobayashi *et al.*, *Langmuir*, **21**, 7629 (2005).
2) Kobayashi *et al.*, 38th Autumn Meeting of the Society of Chemical Engineering, Japan, A125 (2006).

†M. Nakajima, Tel: 029-838-8014, Fax: 029-838-7996, E-mail: mnaka@affrc.go.jp