Effect of droplet superficial velocity on mixing efficiency in a microchannel

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Numerical calculation model

The microchannel was designed with a square cross-section with the dimensions $w_c \times w_d \times h$=100 μm×100 μm×100 μm. When the mesh number was greater than 330000 (No. 5), the mixing efficiency was independent of the mesh number.

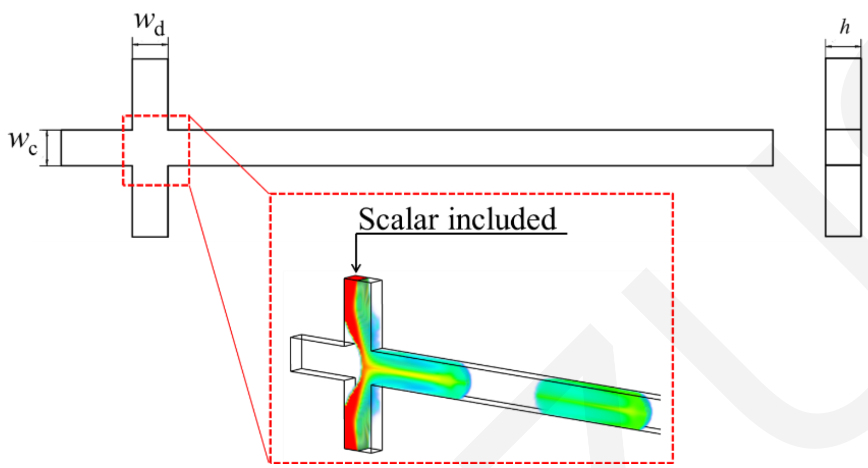


Fig. 1 Schematic diagram of the microchannel

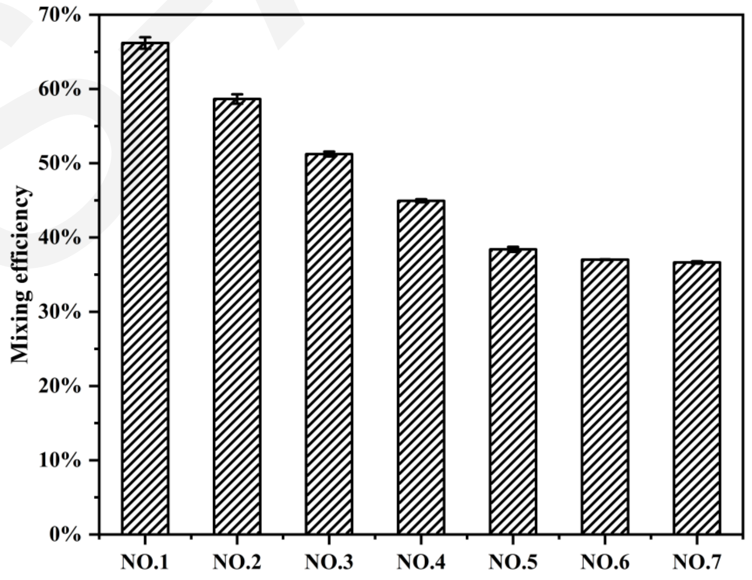


Fig. 2 Dependency of mixing efficiency on the mesh numbers

Effect on droplet length and formation time

The dimensionless droplet length is defined as the ratio of droplet length to the microchannel width. An increase of the dispersed phase fraction led to an increase of the droplet length. The dimensionless droplet formation time was reduced with increasing droplet superficial velocity

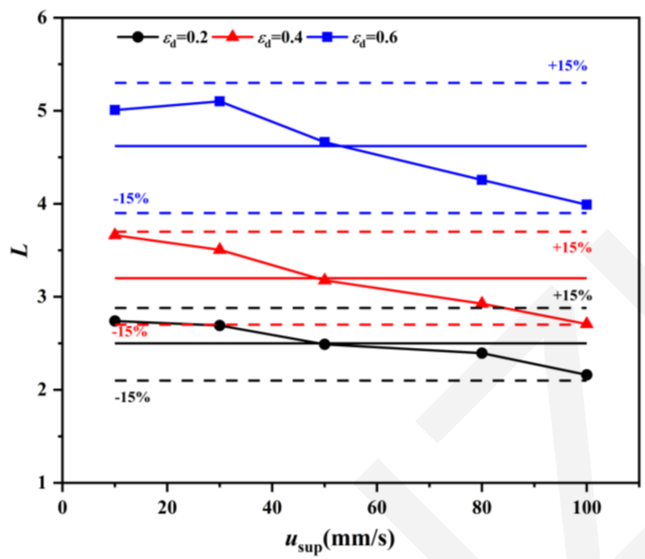


Fig. 5 Variation of the dimensionless droplet length *L* with different droplet superficial velocities

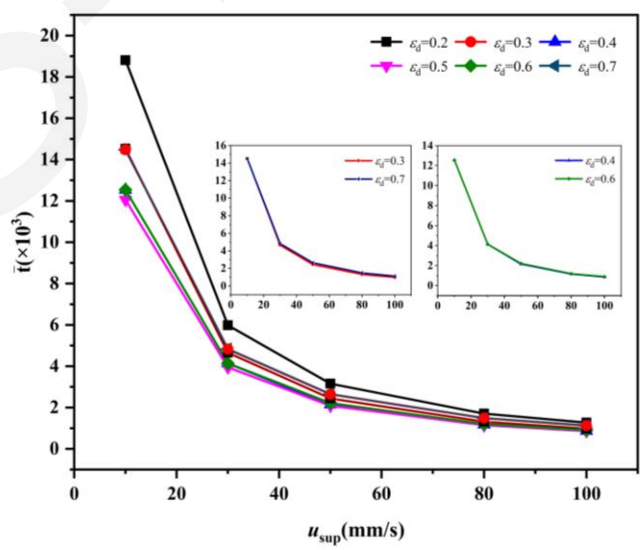
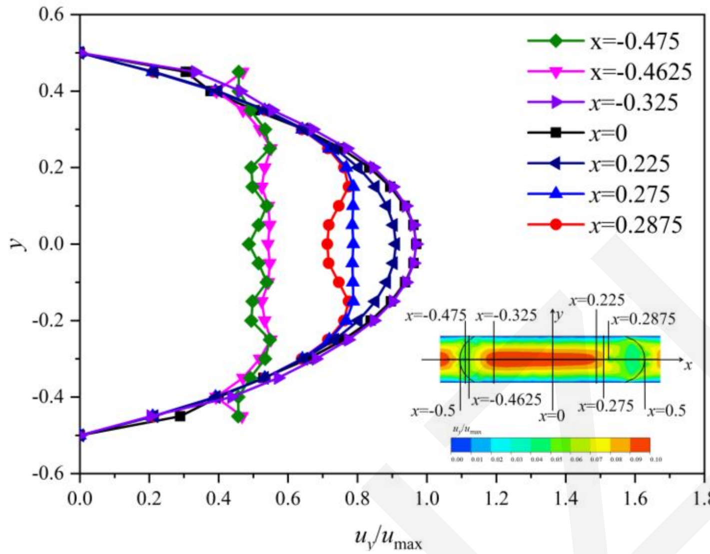


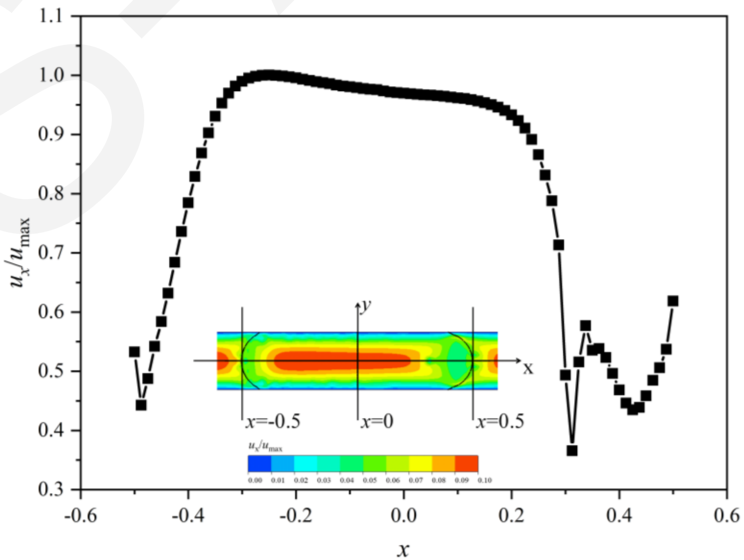
Fig. 6 Variation of dimensionless droplet formation time t^{-} with different droplet superficial velocities

Inner circulation in the droplet

The interaction of the upstream continuous phase with the back part of the droplet and the interaction of the downstream continuous phase with the front part of the droplet induce the velocity gradient in the droplet axial direction. The continuous phase has less effect on the central part of the droplet.



(a)



(b)

Fig. 7 Velocity gradient in the droplet with u_{sup}=50 mm/s and ε_d=0.5: (a) velocity gradient in the droplet radial direction;(b) velocity gradient in the droplet axial direction

Analysis of mixing efficiency

At a constant dispersed phase fraction, with increasing droplet superficial velocity, the mixing efficiency first decreases and then increases slightly. In the droplet moving stage, the droplet length and droplet superficial velocity dominate the mixing efficiency in the droplet. With the increase of the droplet superficial velocity, the droplet length decreases.

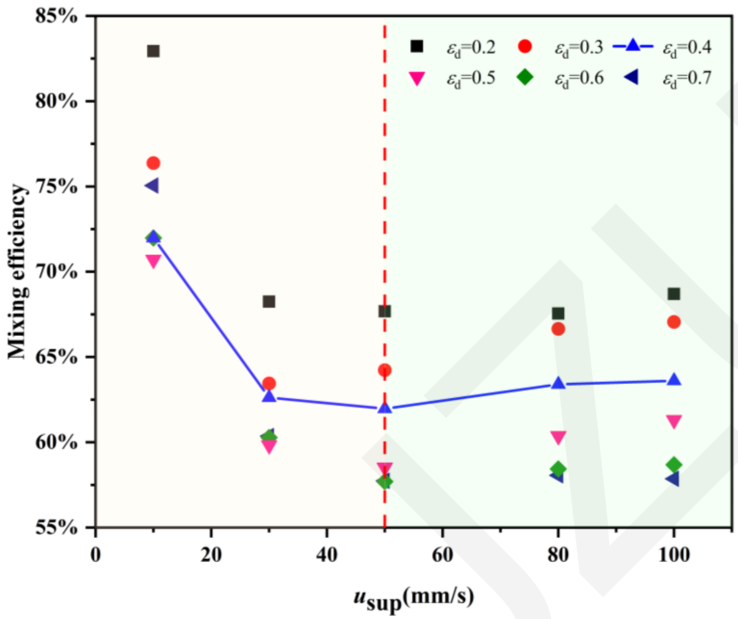


Fig. 10 Mixing efficiency at different droplet superficial velocities at the moment of droplet formation

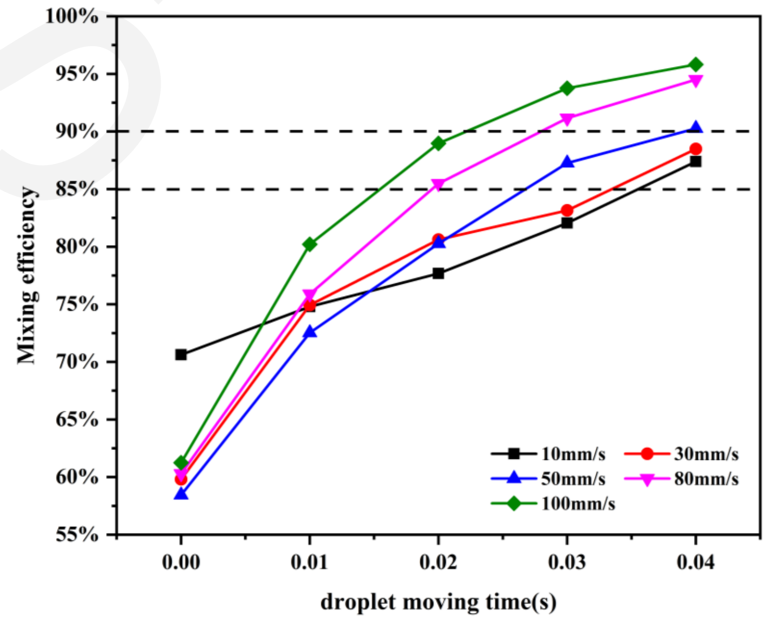


Fig. 11 Mixing efficiency at different droplet superficial velocities in the droplet moving stage with ε_d=0.5