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MULTI-PHYSICS SIMULATION FOR MICRO FLUIDIC DEVICES USING MOVING PARTICLE SEMI-IMPLICIT METHOD

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ABSTRACT

Fluid-structure interaction problems concerning micro fluidic devices are analyzed by the MPS (Moving Particle Semi-implicit) method [1, 2]. Differential operators in the governing equations are modelled by particle interaction formulae in the MPS methods. Both fluid and solid dynamics are simulated. The interaction is considered by weak coupling. The developed code was applied to three problems: micro droplet generation, micro flow with cell adhesion and micro droplet ejection from an elastic tube.

Water phase and organic phase flow into a junction, and then micro droplets are generated with almost constant size and frequency. The calculation geometry and one of the calculation results are shown in Fig.1. We can see that micro droplet generation is generated at the junction. Figure 2 shows the droplet size with respect to the ratio of the inlet flow rates $R=Go/Gw$, where Go and Gw are flow rates of organic and water phases, respectively. When Go is relatively enhanced, the droplet size increases. The calculation results agree well with the experimental data.

Micro fluidic devices are expected to use for cell culture. We need to analyze micro flow in a labyrinth with cell adhesion and separation. Artificial cells were used in experiments to keep uniform and controlled characteristics. Adhesion patterns were observed using simple micro channels with an obstacle. One case is simulated by the MPS method. Some cell adhesion models are made and tested because the adhesion mechanism is not clarified. One of the calculated cell adhesion patterns reproduces the experimental result (Fig.3). The cell adhesion model which is used in this calculation is concluded as proper.

Micro droplet is ejected when an elastic tube is pushed by piezo actuator. The calculation geometry and the result are shown in Fig.4. We can see water is ejected from the outlet and a droplet is formed by surface tension. The calculated droplet front positions are compared with the experiment in Fig.5. The ejection is delayed due to the elastic deformation of the tube. The fluid-structure interaction is successfully simulated by the present code.

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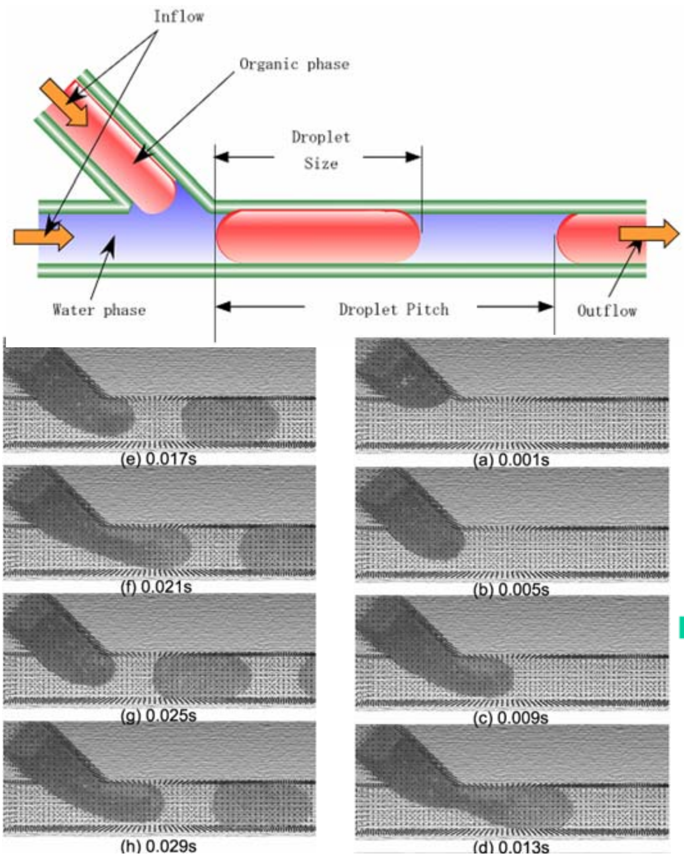

Fig.1 Micro droplet generation

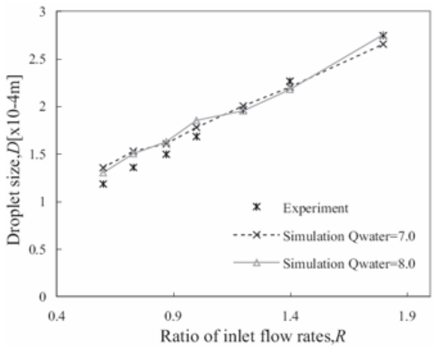

Fig.2 Droplet size

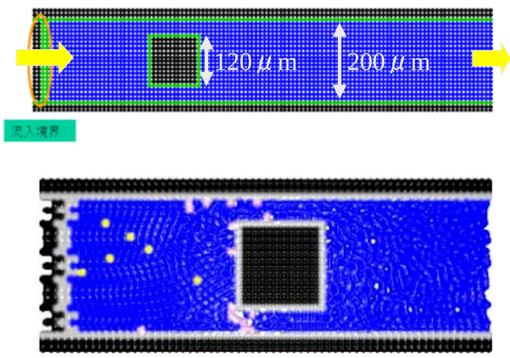

Fig.3 Micro flow with cell adhesion

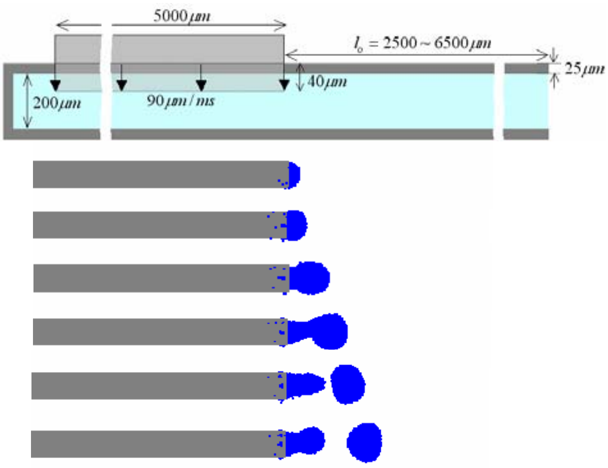

Fig.4 Droplet ejection from an elastic tube

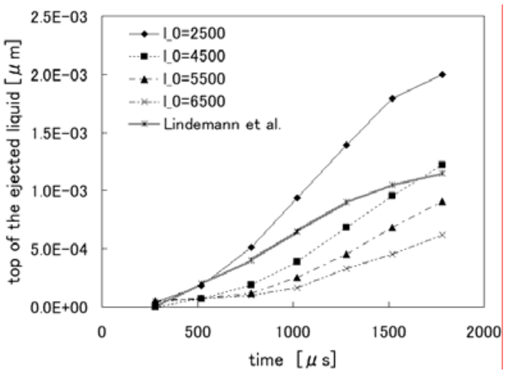

Fig.5 Droplet front position