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A Study on Micro Droplet Generation by Using an Ultrasonic Torsional Transducer and a Micropore Plate

超音波ねじり振動子と微小孔板による微小液滴生成における生成条件に関する研究

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1. Introduction

In fields of electrionic material, medicine and cosmetics production, there is a need for a generation of small droplets[1,2]. In this study, we have designed a micropore plate which is applicable to high viscosity liquids, and generated droplets by using a torsional bolt-clamped transducer and the micropore plate. We have evaluated the relationship between the droplet diameter and some values which affect droplet formation.

2. Structure

The cross-sectional view of ultrasonic torsional transducer and micropore plate for droplet generation is shown in **Fig. 1**. This transducer consists of circumferentially polarized piezoelectric elements, a micropore plate, metal blocks and a bolt[5]. The micropore plate attached at the tip of the transducer vibrates in vertical direction against the flow of liquid. When the micropore plate vibrates, droplets are generated regularly by ruffling liquid surface[3-6].

The diameter of this transducer is 24mm and the length is 81mm[5]. The transducer is fixed at the flange which is placed at the node of the vibration. Cross-sectional view of micropore and SEM photographs of micropore are shown in **Fig. 2 (a)** and **(b)**. The micropore plate is made of stainless steel. The diameter of this micropore plate is 16mm, thickness is 500μm. Micropore places 5mm distance from the center. The tip of micropre is nozzle shape and the flexion angle is 25degrees. As shown in **Fig. 2**, the micropore has a taper. The diameter of the larger aperture is 300μm and that of the smaller apertuer is 50μm. The liquid flow direction is from the larger aperture to the smaller aperture.

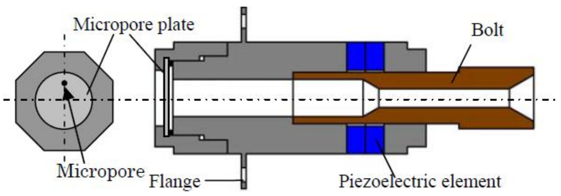


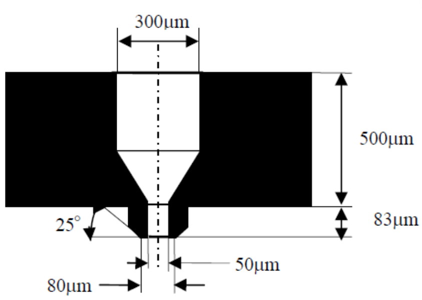
Fig. 1 Cross-sectional view of ultrasonic torsional transducer and micropore for droplet generation

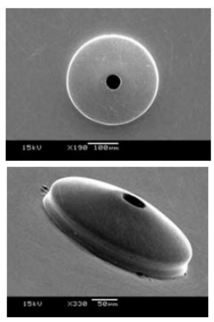
3. Droplet generation

Pressured liquid is supplied to the transducer by a constant pressure pomp. Ejected droplets are observed by using a high-speed camera and a microscope[5]. The supplied liquids were pure water and silicone oil (5, 10, 30 and 100cSt(mm^2/s)).

First, we evaluated micropore shape effect to droplet generation using high viscosity liquid. Photographs of ejecting silicone oil from the flat micropore and from the nozzle sharp micropore are shown in **Fig. 3**. In this experiment, viscosity of silicone oil and the applied pressure were 100cSt and 0.7MPa, respectively. The liquid column wasn't generated by using the flat micropore. On the coutrary, by using a micropore with a tapered nozzle , liquid column were generated. From this result, we comfirmed that a micropore with a tapered nozzle prevented liuid from spreading around the micropore. Therefore, nozzle shape micropore make generateing liquid column easy against high viscosity liquid.

Photographs of droplets, when viscosity of silicone oil were 5, 10 and 30cSt when applied voltage is $100V_{p\text{-}p}$ and driving frequency is 32kHz, are shown in **Fig. 4**. From this experiment, we comfirmed that the droplet diameter increase with increasing the applied air pressure.





(a) Cross-sectional view (b) SEM photographs

Fig. 2 Schema of micropore

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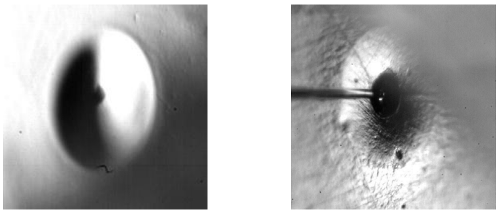

(a) Flat micropore (b) Micropore with a tapered nozzle
Fig. 3 Photograph of ejected silicone oil from micropore

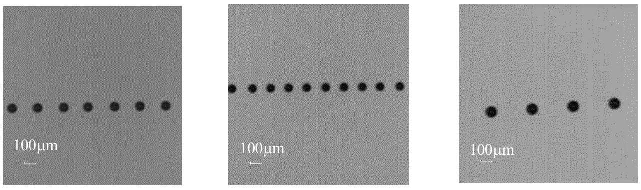

Fig. 4 Photographs of silicone oil droplets when the viscosity were 5, 10 and 30cSt(left to right)

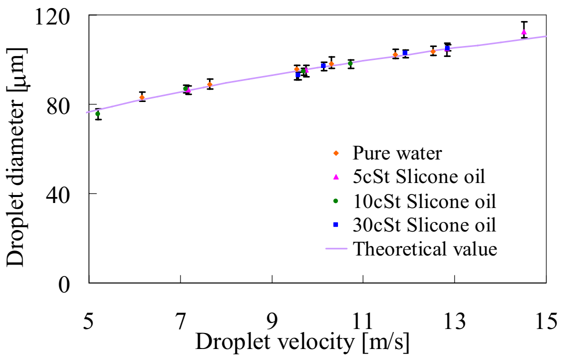

Fig. 5 Theoretical and experimental relationship between droplet diameter and droplet velocity

Additionally, we evaluated the relationship between the droplet diameter and some values which affect droplet formation. The droplet diameter is expressed as

$$D=2(3/4\times 1/f\times R^2\times V_d)^{1/3} \qquad (1)$$

where f is driving frequency, R is radius of liquid column, V_d is droplet velocity. The theoretical and experimental relationship between droplet diameter and droplet velocity is shown in **Fig. 5**. From this result, the theoretical droplet diameter and the experimental droplet diameter differed not more than approximately 3%.

Relationship between droplet velocity and applied air pressure is shown in **Fig. 6**. Therefore, droplet velocity shows a linear relationship with applied air pressure. The relationship between droplet diameter and applied air pressure is estimated by Eq. (1). Theoretical and experimental relationship between droplet diameter and applied air pressure is shown in **Fig. 7**. From this result, the theoretically droplet diameter and the experimental droplet diameter differed not more than approximately 3%.

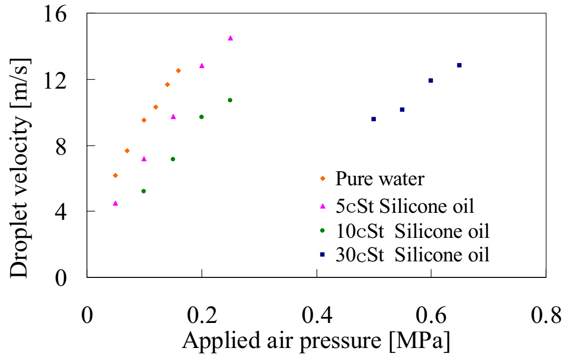

Fig. 6 Relationship between droplet velocity and applied air pressure

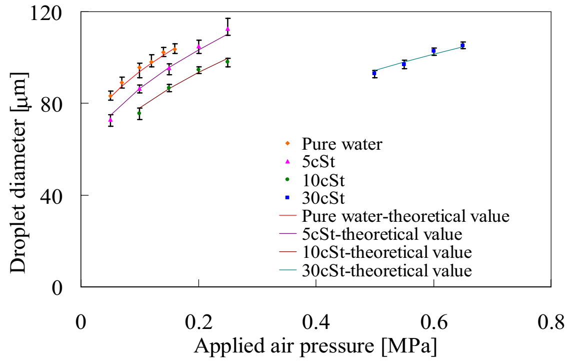

Fig. 7 Theoretical and experimental relationship between droplet diameter and applied air pressure

4. Conclusion

In this paper, we have evaluated micropore shape effect to droplet generation The nozzle shape micropore prevented liuid from spreading on the micropore. Therefore, the micropore with a tapered nozzle make generating liquid column easy when high viscosity liquid is used. We have evaluated the relationship between the droplet diameter and some values which affect droplet formation. As a result, we have succeeded in estimating the droplet diameter from these values.

References

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