1Pb-46

Proceedings of Symposium on Ultrasonic Electronics, Vol. 31 (2010) pp. 233-234
6-8 December, 2010

The condition of an emulsion generation by using an ultrasonic vibration and a microchannel
超音波振動マイクロ流路デバイスによるエマルション生成条件

Yoshiyuki Tominaga[1‡], Takuya Harada[1], Takefumi Kanda[1], Koichi Suzumori[1], Tsutomu Ono[1], Sotaro Iwabuchi[1], Kazuyuki Ito[1], Ken-ichi Ogawara[1], Kazutaka Higaki[1] and Yuta Yoshizawa[1] ([1] Okayama Univ.)
富永宜幸 [1‡], 原田拓也 [1], 神田岳文 [1], 鈴森康一 [1], 小野努 [1], 岩渕草太郎 [1], 伊東一行 [1], 大河原賢一 [1], 檜垣和孝 [1], 吉澤雄太 [1] ([1] 岡山大)

1. Introduction

In fields such as paint, food, cosmetics production and medical science, a generation of emulsion has been an important subject. Therefore there is a demand for generation of emulsion which has small and uniform droplets. A lot of emulsification techniques have been studied.[1)]

Some ultrasonic vibration devices have been studied to generate emulsion.[2, 3)] However, the noise by driving the devices was made loudly. Furthermore, these processes are batch process and the devices are large.

We have studied the generation of emulsion by using an ultrasonic vibration and a microchannel.[4)] This device was smaller and realized flow process. Then, this paper reports the condition of an emulsion generation by using an ultrasonic vibration device.

2. Emulsion generating system

Schema of the emulsion generating system is shown in **Fig. 1**.[4)] Once oil and water are supplied by syringe pumps to Y-type microchannel, emulsions are generated.[5)] After that, droplets are broken by an ultrasonic vibration in a microchannel.

The ultrasonic device consists of two plates.[4)] One is microchannel plate and the other is vibrating plate on which a piezoelectric element is bonded. **Figure 2** shows schematic view of the ultrasonic device and photograph of the microchannel.

The microchannel is 0.711mm wide and 0.35mm deep. The microchannel plate is 50mm long, 80mm wide and 5mm thick. The piezoelectric element is 20mm long, 60mm wide and 5mm thick.

The materials used for generating emulsion were aqueous glycerol solution as water phase, tricaproin, tricaprylin, Tween 80 and egg yolk lecithin as oil phase.[6)]

----

tominaga8@act.sys.okayama-u.ac.jp

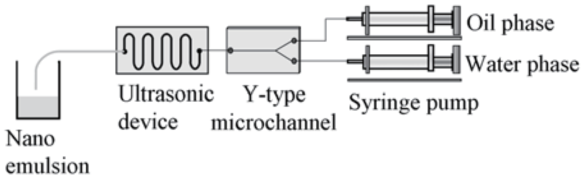

Fig. 1 Schema of the emulsion generating system

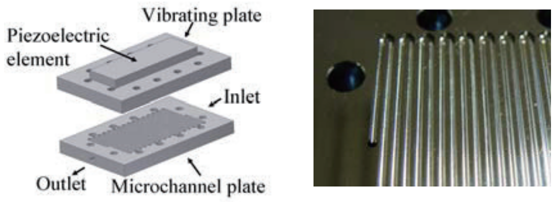

Fig. 2 Schematic of the ultrasonic device (left), photograph of the microchannel (right)

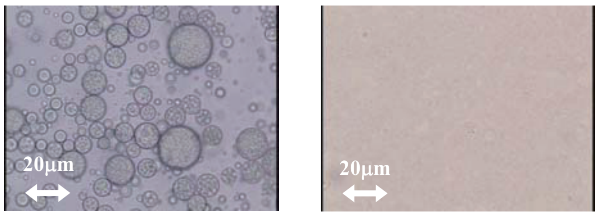

Fig. 3 Optical microscope photographs of generated emulsions by the Y-type microchannel (left) and the ultrasonic device (right)

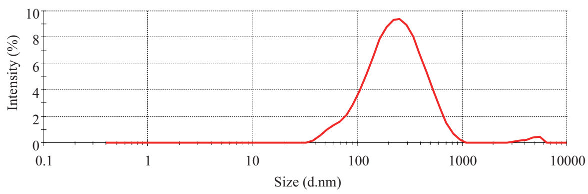

Fig. 4 Relationship between droplets diameter and intensity measured by DLS when using the ultrasonic device

3. Experimental results and consideration

The flow rate of the water phase, the flow rate of the oil phase, the applied voltage and the resonance frequency were 100μl/min, 1μl/min, $100V_{p\text{-}p}$ and 2.25MHz, respectively. **Figure 3** shows the optical microscope photograph of emulsions. **Figure 4** shows the distribution of the diameter of oil droplets measured by dynamic light scattering (DLS). According to Fig. 4, the diameter of oil droplets became about 200nm. From these results, we realized the generation of emulsion which has small and uniform oil droplets.

Then, we conducted the test to ascertain the effect of cavitation. We checked whether an aqueous solution of potassium iodide (KI) colored yellow by the oscillation of the ultrasonic vibrator.

Firstly, we tested the absorbance of the solution when a conventional probe was used (the driving frequency was 20 kHz). This type of probe has been used for the generation of emulsion in batch process.[6)] **Figure 5** shows the result of absorbance measurement. According to Fig. 5, an aqueous solution of potassium iodide colored yellow by cavitation.

Next, we tested the absorbance of the solution when the ultrasonic device was used (driving frequency was 2.25MHz). The change of color was not observed in the aqueous solution. **Figure 6** shows result of absorbance measurement. According to Fig. 6, the plots of absorbance were also flat after ultrasonic irradiation.

From these results, the droplets were not broken by the effect of cavitation. Therefore emulsion was generated by other effect such as capillary wave.

4. Stacked-type device

Because the ultrasonic device and the Y-type microchannel consist of some plates, downsizing is possible by the stacking them. Then, we generated emulsion by using a stacked-type device. This device consists of Y-type microchannel, vibrating plate, micro channel plate, shield plate and base plate. **Figure 7** shows schema of the stacked devices and photograph of the Y-type microchannel plate. Microchannel plate has the channel on the both sides and the depth of channel is 0.35mm. The stacked-type device is 50mm long, 80mm wide and 20.6mm thick

The flow rate of the water phase, the flow rate of the oil phase, the applied voltage and the resonance frequency were 100μl/min, 1μl/min, $100V_{p\text{-}p}$ and 2.25MHz, respectively. **Figure 8** shows the distribution of the diameter of oil droplets measured by DLS. According to Fig. 8, the diameter of oil droplets became about 200nm. This result means that the oil droplets of emulsion by using the stacked-type device became smaller at the same level by using the ultrasonic device and the Y-type microchannel.

5. Conclusion

In this paper, we consider the condition of an emulsion generation by using the ultrasonic vibration and the microchannel. Therefore, we realized the generation of emulsion which has small and uniform droplets by the stacked-type device.

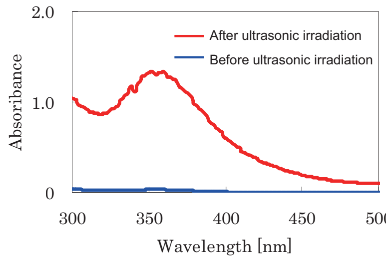

Fig. 5 Relationship between wavelength and absorbance using a conventional ultrasonic probe

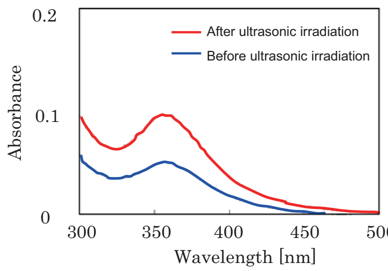

Fig. 6 Relationship between wavelength and absorbance using the ultrasonic device

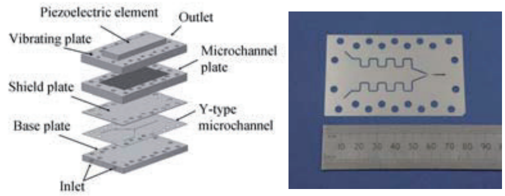

Fig. 7 Stacked-type device; schematic view (left), photograph of the Y-type microchannel plate (right)

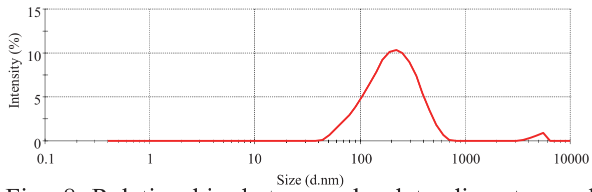

Fig. 8 Relationship between droplets diameter and intensity measured by DLS when using the stacked-type device

Reference

1. F. L. Calderon, V. Schmitt and J. Bibette: *Emulsion Science* (Springer, New York, 2007) 2nd ed., p.5.
2. S. Freitas, G. Hielscher, H. P. Merkle and B. Gander: Ultrasonic Sonochemistry. **13** (2006) 76.
3. T. Hielscher and H. GmbH: Proc. European Nano Systems. 2005, p.138.
4. T. Harada, T. Kanda, K. Suzumori, T. Ono, S. Iwabuchi, K. Ito, K. Ogawara and K. Higaki: Jpn. J. Appl. Phys. **49** (2010) 07HE13.
5. J. Kubota, A. Kato and T. Ono: AIChE Annual Meeting. 2007, p.332.
6. Y. Fukuoka, K. Ogawara, K. Higaki and T. Kimura: 21st JSSX Annual Meeting, 2006, p. 224.