Effects of Viscosity on Laser-Induced Cavitation Bubble Studied by High-Speed Laser Stroboscopic Videography

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Experimental interest on the cavitation bubble arose from the finding that cavitation is a cause of erosion problem in hydraulic machinery. Although several studies have focused on the laser-induced cavitation bubble dynamics, no detailed study has been done on effects of liquid viscosity on dynamical behavior of laser-induced cavitation bubbles. The liquid viscosity is expected to affect damping and loss of mechanical energy during both growth and collapse process. Consequently, it would be expected that increase in viscosity will decrease the maximum cavity size and rates of growth and collapse. Minsier et al. have carried out numerical simulation on the effects of viscosity on bubble dynamics [1]. They reported that the liquid viscosity has influence on the bubble dynamics.

The aim of this study is to investigate the effects of viscosity on the bubble dynamics experimentally with our developed custom-designed high-speed laser stroboscopic videography system. This system is able to acquire images continuously at intervals as short as 1 μs and at high time resolution of less than 0.1 ns [2, 3].

We used pure water and silicon oils with wide range of kinetic viscosities from 10 to 10000 cSt and laser pulse energy with range of 10 to 50 mJ. Silicon oils have approximately the same density and refractive index and have similar chemical composition and structure, poly-(di-methyl silicone), except for molecular weight and viscosity. We can expect that if there were any changes in the bubble dynamics, it would be the effects of viscosity.

A 10 ns laser pulse of designated pulse energy was focused in liquid filled in rectangular cell. A laser-induced bubble was formed at the focus, grew to reach the maximum size, shrank to collapse and then the second bubble grew again, as shown in figure 1. The lifetime of bubble decreased and the bubble became ellipsoidal shape along irradiation direction with increase in the kinetic viscosity of the liquid.

Figure 2 shows the maximum diameter of the first bubble in water and silicon oils. The maximum diameter of the first bubble decreases with increase in the kinetic viscosity of the liquid.

These results indicate that the viscosity of liquid affects the bubble shape and its lifetime.

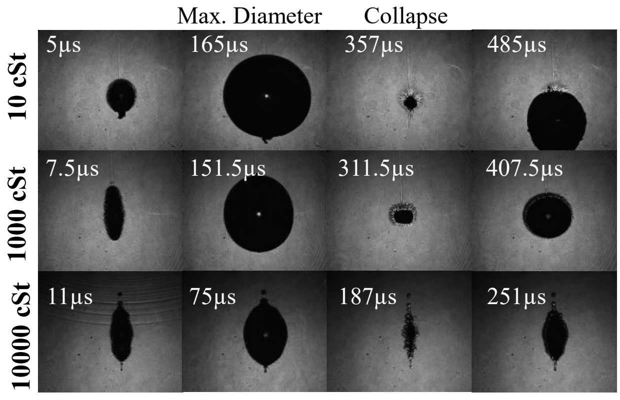

Fig. 1 *Shadowgraph images obtained for silicon oils with 10, 1000 and 10000 cSt irradiated at 30 mJ pulse energy.*

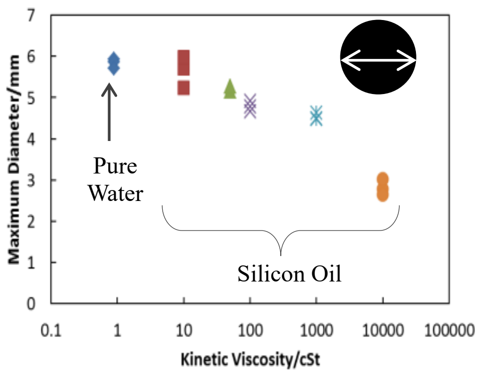

Fig. 2 *The maximum diameter of first bubble in water and silicon oils with 10 to 10000 cSt at 50 mJ pulse energy.*

References

[1] V. Minsier *et al.*, Journal of Applied Physics **106**, 084906 (2009)

[2] R. Tanabe *et al.*, Physics Procedia **83**, 83-92 (2016)

[3] R. Tanabe *et al.*, Appl. Surface Science **351**, 327-331(2015)