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Sonochemiluminescence using focused ultrasounds at 1 MHz

1 MHz 集束超音波によるソノケミルミネセンス

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1. Introduction

Sonoluminescence(SL) is light emission from high-pressure and high-temperature conditions inside a cavitating bubble under intense ultrasounds [1,2]. These conditions also produce OH radicals formed by pyrolysis of water molecules. OH radicals diffuse out of the bubbles and react with foreign molecules. The reaction with luminol causes bluish light, called sonochemiluminscence (SCL). The spatial distribution for SCL is known to be similar to that for SL [3], although the temperature for SCL to occur is lower than that for SL.

Aoustic cavitation by focused sound fields has been interested in association with its medical applications. SCL for focused sound fields in water has been studied by several authors [4,5]. The spatial distribution of SCL obtained in these studies was complicated because of acoustic streaming effects. No luminescence was observed at a focal point. We investigated SCL from focused sound fields in cases of standing waves and progressing waves in luminol solution.

2. Experimental

Argon-saturated luminol solution with a concentration of 1 mM at pH 12 was contained in a rectangular glass cell (W=65mm, D=65mm, H=115mm). 1.0 MHz ceramic transducer with a curvature radius of 40 mm was equipped at the bottom of the cell. Height of the liquid sample was 90 mm. A signal from a function generator was amplified by 46 dB using a power amplifier (NF Corp., HSA4052). SCL was captured using a digital camera (Nikon D500) with F1.2, 50mm lens . The liquid surface was deformed due to acoustic radiation force by incident sound, resulting nearly-progressing sound fields. For making nearly-standing sound fields, we put a polypropylene film with a thickness of 0.2 mm on the liquid surface to surpress the surface deformation. The standing sound fields were easily recognised from the fringes in the SCL images.

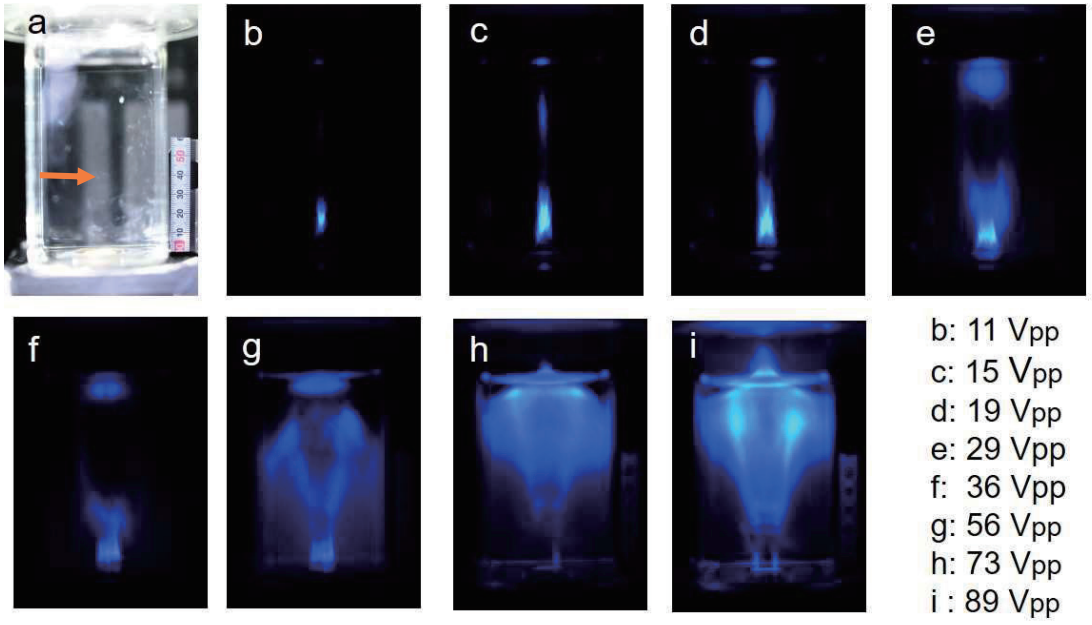

Fig. 1. Sonochemiluminescence by focused ultrasounds at 1 MHz from luminol solution in the case of free liquid surface. a: rectangular glass cell, b-i: SCL images at various pressures. An arrow in image a indicates a focal region. An applied voltage to the transducer is denoted above.

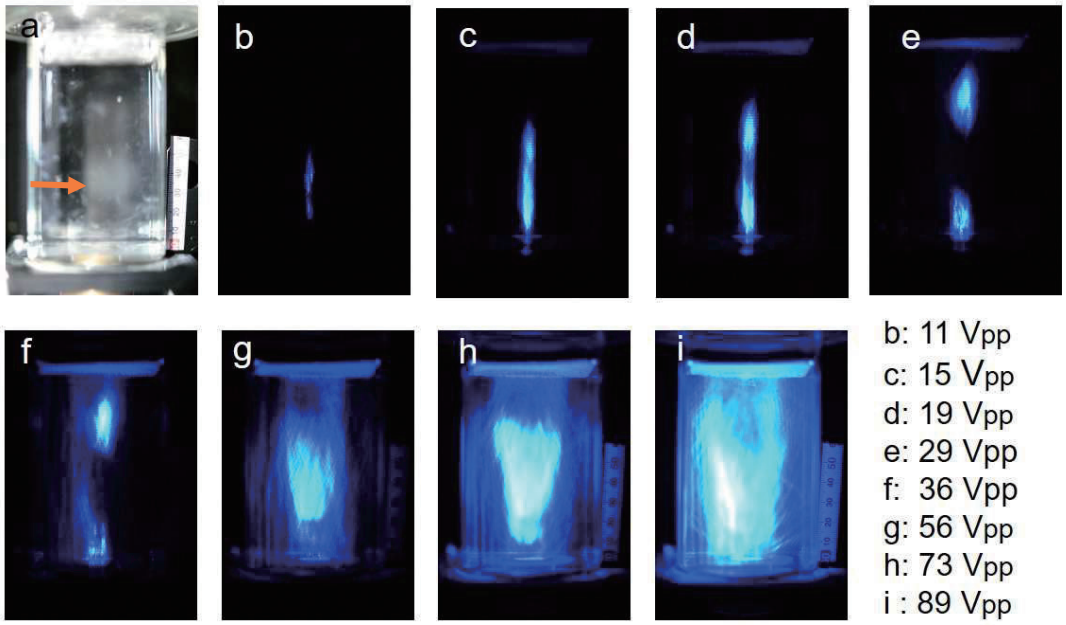

Fig.2. Sonochemiluminescence by focused ultrasounds at 1 MHz from luminol solution in the case of film surface. a: rectangular glass cell, b-i: SCL images at various pressures. An arrow in image a indicates a focal region. An applied voltage to the transducer is denoted above.

3. Results and discussion

Figure 1 shows the results of SCL images at various acoustic pressures. The voltage indicated in the figure is an applied voltage to the transducer. Ultrasound was radiated from the bottom of the cell which is shown in Figure 1a. The liquid surface was free so that the center of surface can be deformed due to acoustic radiation force. A fringe pattern caused by standing wave fields was not observed in the images for voltages over 29 Vpp (e, f, g, h, i), although the fringe was observed in those below 19 Vpp (b, c, d). The surface deformation like a "mountain" is clearly visualized in Figs. 1h and 1i. Also observed in Figs. 1h and 1i is a "wing" like structure, resulting from an ultrasound reflection from the surface deformation.

Figure 2 shows the results of SCL images in the case that the thin film was placed on the liquid surface. Fringe patterns were noticed in all the images. In Figs. 2b, 2c, and 2d, SCL distribution is similar to the free surface case of Figs. 1b, 1c and 1d, except the region around focus. In the film surface case, SCL occurred near the focal region which position is indicated by an arrow in the cell images "a". No SCL occurred near the focal region at higher applied voltages (e, f, g, h). In the free surface case of any applied voltage in Fig.1, no SCL occurred near the focal region. This is explained by the existence of a large acoustic streaming in progressing-wave field [6]. The acoustic streaming pushed cavitating bubbles away from the focal region. We are now progressing the investigation of SCL in agarose gel where no streaming effects is expected.

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