SHIMADZU

Application News

Nano Particle Size Analyzer: SALD-7101 No. 4

Size Measurement of Microbubbles and Nanobubbles

Recently, there is great expectation that so-called microbubbles and nanobubbles will play ever-increasing roles in applications throughout various fields and for a variety of purposes, as shown in Table 1. Accordingly, research and development into methods and instruments for generating such bubbles are now underway. In fact, one could say that this trend is turning into somewhat of a boom. In part, there are already efforts to put these to practical use and to bring them to market. However, the reality is that various uncertainties still remain with respect to these bubbles, one of which is the matter of bubble size.

In this respect, use of the Nano Particle Size Analyzer SALD-7101 enables seamless bubble size measurement of bubbles from 10 nm to 300 m, measurement that has been unachievable up to now. Moreover, it is now possible to observe bubble size changes in 1-second intervals, and to conduct bubble size measurement for bubble concentrations from a few ppm to 20%.

Table 1: Microbubble and Nanobubble Application Fields and Purposes

DDS (Drug Discovery Systems)	A drug is adsorbed to the surface of a bubble consisting of carbon dioxide, etc., which is then introduced into the body so as to reach the diseased site. It is expected that the drug concentration at the diseased site will be high, and therefore effective, however, since the total amount in the body is small, side effects should be decreased. In addition, as time passes, the gas used to form the bubble is absorbed into the body. Since there is a possibility that particle agglutination may occur inside the capillaries, control of the particle (bubble) size is required.
Angiography contrast agents	Minute blood vessels develop in cancer cells, making it easy for fine bubbles to become trapped in these vessels. This characteristic is utilized in angiography contrast agents for use with ultrasonic diagnostic equipment.
Cleaning	Detergent is adsorbed to the surface of bubbles. This increases the contact area between detergent and dirt, allowing a small amount of detergent to clean effectively. The finer the bubbles, the greater the surface area becomes, thereby increasing the total area that comes in contact with the dirt.
Sterilization	A gas with bacteriocidal activity such as ozone is used. The local impact and heat generated when the bubble breaks also improve the effect of sterilization.
Purification	Polluting substances rise to the surface and are decomposed due to the microbubbles, thereby helping to cleanse the water of lakes and marshes.

The effect and properties of a bubble greatly depend on the size of the bubble, that is, the bubble diameter. Therefore, the size of the bubble diameter must become known, and this is achieved by conducting bubble size distribution measurement. For relatively large bubbles, measurement is possible by image processing using an optical microscope and video camera, however, for bubbles that reach only up to a few μm in diameter that are the focus of great attention these days, measurement using an optical microscope and video camera is extremely difficult. For this application, the laser diffraction method is coming into use.

Generation of bubbles (microbubbles, nanobubbles) can be accomplished using a bubble generating agent or by using a bubble generator. Moreover, surfactants are also used to obtain bubble stability. In state-of-the-art application areas, there is demand for bubbles (nanobubbles) ranging in size from a few hundred nm to 100 nm (0.1 μm), however, there is much to be understood about the properties of such bubbles, including their size.

As bubbles readily “bubble up” to the surface, their measurement would seem to be difficult, however, just as sedimentation of small particles is slow, small bubbles (microbubbles and nanobubbles) rise to the surface extremely slowly. It may even take several minutes for such a bubble to float up a distance of 1 cm, due to the principle that the smaller the bubble, the longer it takes to rise to the surface. Therefore, if the bubbles can exist in a stable state, they can be adequately measured using the batch cell shown in Figure 1, and if the bubble concentration is excessively high, the bubble liquid medium can be diluted.

Moreover, a method of measurement can be devised in which a bubble generator is connected to a flow cell, as shown in Figure 2.

If the bubble concentration is high, a “crater cell” like that shown in Figure 3 can be used. Moreover, this type of “crater cell” can be especially effective when only a small amount of bubbles are produced, such as when using an expensive bubble generating agent.

Figure 1: Batch Cell

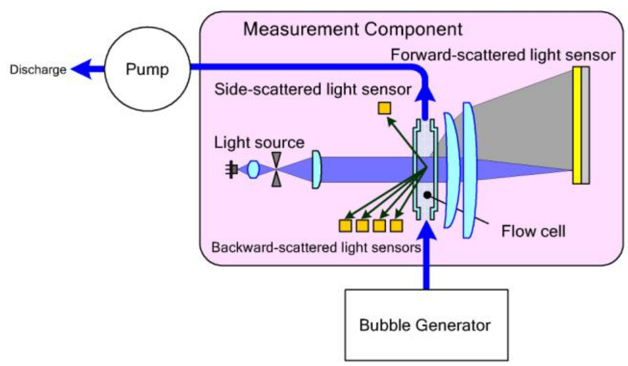

Figure 2: Measurement with Flow Cell Connected to Bubble Generator

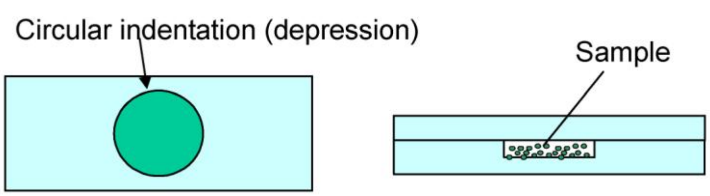

Figure 3: Cell for Extremely Small Bubble Quantities (Crater Cell)

Examples of measurement of microbubbles and nanobubbles using the SALD-7101 are shown in Figures 4 and 5, respectively. These are the results obtained using the bubble generator connected to the flow cell for measurement, as shown in Figure 2.

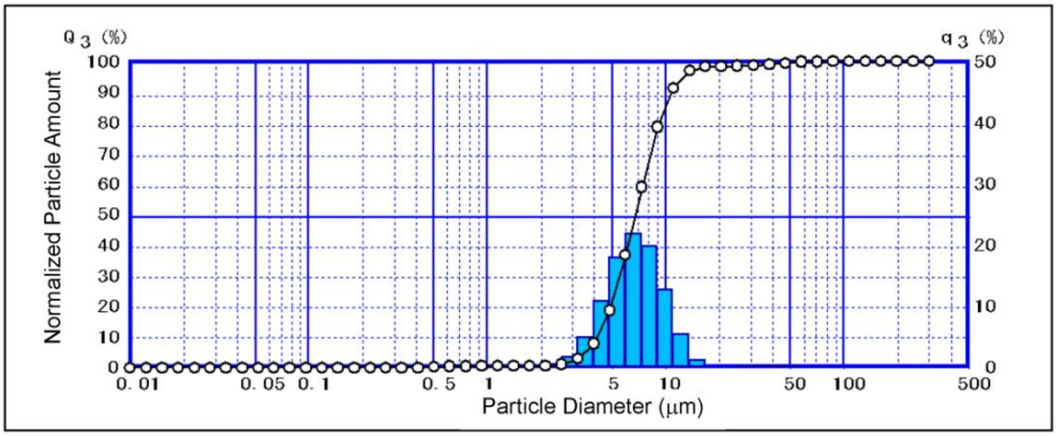

Figure 4: Microbubble Measurement Example

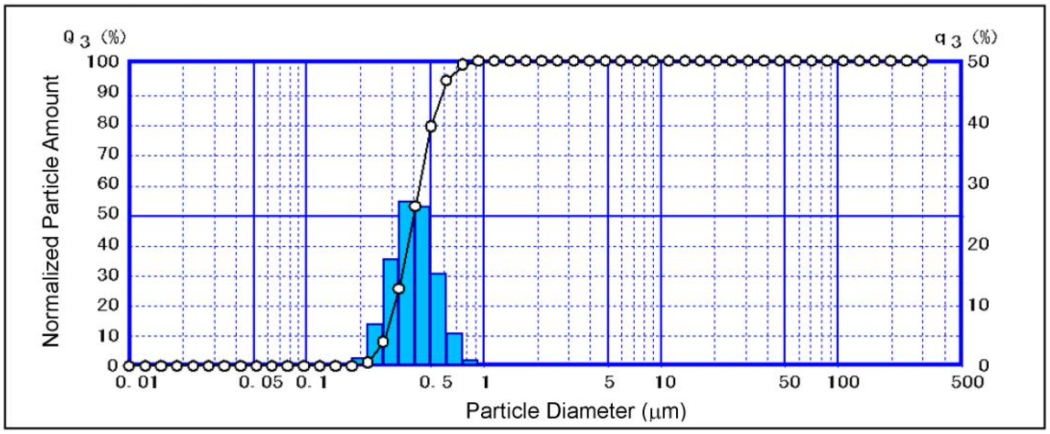

Figure 5: Nanobubble Measurement Example

Shimadzu Scientific Instruments
7102 Riverwood Drive, Columbia, MD 21046
Phone: 800-477-1227, Fax: 410-381-1222
www.ssi.shimadzu.com
webmaster@shimadzu.com