Foreword

Recommendation of UFB

MIZUTANI Masayoshi*

A bubble consists of a liquid envelope containing air. Bubbles have been used since ancient times in a variety of industries, including cleaning, cosmetics, food, and medicine[1]. But did you know that the wave of miniaturization has recently extended to include such bubbles? Invisible bubbles of nanometer order, called ultrafine bubbles (UFB), are now widely used and have just started to show their effects.

The designation of these bubbles is defined by the International Standard Organization (ISO) according to their size. Bubbles with a diameter of 100μm or more are defined as non-fine bubbles and smaller bubbles as fine bubbles[2]. Among the fine bubbles, those 1μm or larger are called microbubbles (MB), while those smaller than 1μm are called ultrafine bubbles (UFB), as mentioned above[3]. Liquids containing MB can be visually identified by their whitish color. This phenomenon is often observed in hot springs and baths. On the other hand, UFB are difficult to identify visually because they are clear and colorless. So why have these tiny, invisible bubbles received so much attention? This is because these bubbles have different properties depending on their size[4]. UFB in particular have several attractive properties.

Firstly, it is known that the surface potential of UFB is between around -30 mV and -40 mV according to measurements using electrophoresis equipment[5]. It has been also shown that the surface potential is almost independent of the bubble diameter[5]. In other words, bubbles smaller than a certain size are basically charged negative. These electric (chemical) characteristics seem unexpectedly useful in industry. For example, they apparently deliver cleaning performance. We are increasingly seeing examples of UFB being used in showers and laundry. Based on the explanations and illustrations shown on the web and in commercials, it might be expected that the negatively charged nature of UFB is the main reason for their use.

There is another possible reason. Tiny bubbles such as UFB can produce physical and/or chemical effects when they collapse (or abruptly shrink) in a liquid. Many researchers have demonstrated the generation of microjets as a mechanical effect[6] and the generation of hydroxyl (OH) radicals as a chemical effect[6]. These properties are expected to be useful for antimicrobial activity and sterilization. In fact, the effects of OH radicals have been demonstrated in various fields, including dental treatment, and their commercialization has been promoted. I have a hunch that, if the generation of OH radicals can be successfully controlled with UFBs, their use would expand to even wider areas.

Of course, UFBs have many other attractive properties, but we should not forget that the phenomena associated with them occurs in the extreme micron range, as explained above. The principle and mechanism of these phenomena have not yet been clarified in many respects, including how UFBs use their properties to produce such effects. That is why I have relied quite heavily on vague expressions like "expect" and "have a hunch", which are qualitative terms that are difficult to use in academic papers. In short, UFB are very attractive, but there is a lot that is not clear. That is why it is really interesting to study them.

Naturally, applications of UFB also include industrial fields. We have seen increasingly more people who attempt to use "unknown" UFB as fluids for grinding, polishing, or other machining processes. Among them is Mr. Yousuke Hatayama from KYB. He, as a working doctor in the laboratory I lead, has conducted research together with me on how UFBs behave, what happens and how they can be applied during machining

*Professor, Tohoku University
Green Goals Initiative Research Center for Green X-Tech
Graduate School of Engineering, Biomedical Engineering

(grinding). What I want to emphasize here is that Mr. Hatayama is proposing a completely new mechanism that does not rely on the so-called "established theories" presented by many researchers so far. I think you are now interested in his research and recommend that you read his dissertation thesis. His ideas on other points have also started to be officially recognized from the academic viewpoint and published in the Journal of JSAT (The Japan Society for Abrasive Technology)[7] and the Journal of JSPE (The Japan Society for Precision Engineering)[8].

Just adding very small bubbles of nanometer size to the fluid for machining will change the behavior of the machining and may even clean the piping and sterilize the fluid for machining. I would like to definitely recommend the use of UFB.

The Japanese title (UFBのすゝめ) of this Foreword is based on An Encouragement of Learning, the famous book written by Mr. Yukichi Fukuzawa, who founded Keio University, from which I graduated. The English title has been adapted to reflect the meaning of the text.

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