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Development of High Density Micro-bubble Generator for Environmental Technology

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Introduction

Micro-bubble is used in engineering field as well as wide range fields, such as agricultural, fishery and medical field [1]. Especially, remarkable characteristics are high solubility in liquid; self pressurized effect, resolution into liquid by pressure and crush, electrification and so on. These characteristics are caused by very small diameter of micro-bubble. Then, these characteristics depend on diameter of micro-bubble and an optimum diameter may exist.

Therefore, control of diameter of micro-bubble is very important technique. It has been presented that diameter of micro-bubble depends on generation method and device [2 – 4].

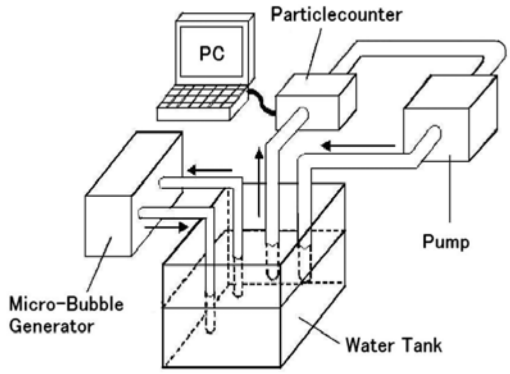
This paper has focused on fluid properties in the area where micro-bubble is generated. Especially, kinetic viscosity ν and boundary tension force coefficient σ are focused on. The effect of ν and σ on distribution of diameter of micro-bubble is demonstrated experimentally.

Experimental apparatus and method

Fig. 1 shows experimental apparatus. In water tanks filled with various fluids, micro-bubble jet nozzle and induction nozzle of micro-bubble generator are fixed. Micro-bubble generation method of the apparatus is pressurized dissolution method. Distributions of micro-bubble diameters are measured by laser particle counter. Water including micro-bubbles is fed into measuring instrument from induction pipe. Then, water is turned into tank from drainpipe after measuring.

In experiment, distribution of micro-bubble diameter in pure water is measured. Then, fluid properties of water are changed and distribution of micro-bubble in such water is measured.

Condition where the maximum volume of micro-bubble is generated is used. In this case, bubble feed pressure is 0.4MPa and velocity of water is 11.6L/min. Experiments using various fluid properties in this condition are performed.



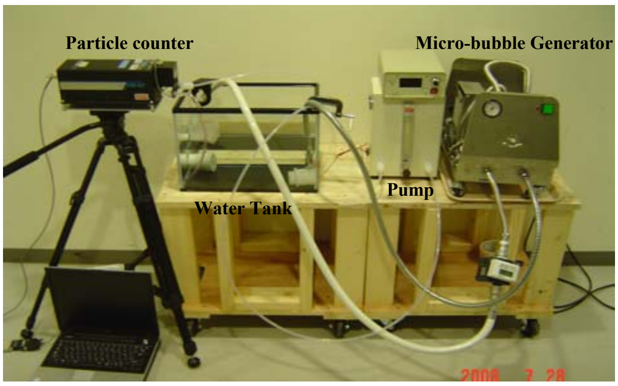


Fig. 1. Experimental apparatus

Table 1 shows experimental conditions. Glycerin is mixed in order to increase kinetic viscosity. Chloride sodium is mixed in order to increase surface tension force. Sodium Dodecyl Sulfate (SDS) is mixed in order to decrease surface tension force. For measurement of kinetic viscosity and surface tension force, Ubbelohde Viscometer and DuNouy Tensiometor are used, respectively. Diameters of micro-bubble are measured at 2μm and from 4 μm to 56μm ever 4μm. Temperature of water is controlled at 25 degree considering temperature dependency of solubility of air.

Table 1. Experimental conditions

Surface Tension Co-efficient	35,45,60,72.8,76,80 [dyn/cm]
Kinematic viscosity	0.87,1.22,1.68,2.44.2.85 [cst]
Liquid	Pure water
Bubble	Air
Surfactant	Triton X, SDS
Thickener	Glycerin, Ethanol
Trial times	More than 20
Temperature	25 [℃]

Results of experiment and discussions

Fig. 2 shows particle size distribution of micro-bubble in pure water. After 5 minutes generator was stopped, micro-bubble is decrease extremely. This graph shows characteristics of micro-bubble generation device. Fig. 3 shows relation between particle size distribution and surface tension force. Fig. 4 shows relation between particle size distribution and kinetic viscosity. From these figures, number of micro-bubble increases, when kinetic viscosity and surface tension force increase. This means that volume of air resolved in water increases.

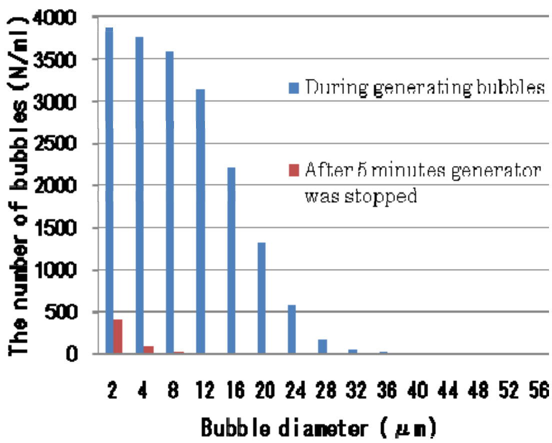


Fig. 2. Time variation of bubble size distribution

Above mentioned results show volumes of air in turned water are different when σ and ν are different. Then, in order to examine particle size distribution in detail, ratio of number of particle size to total number of micro-bubble is obtained. Represented results are shown in Fig.5 and Fig. 6. From these figures, when σ and ν are small, reduction of number of particles decreases from 2μm to 20μm.

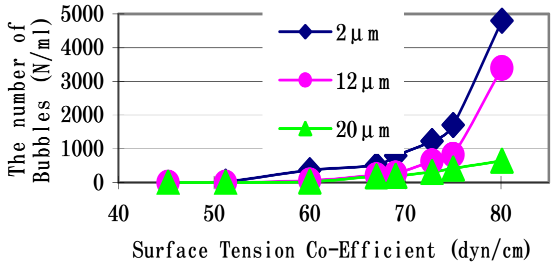


Fig. 3. Effect of change of surface tension co-efficient

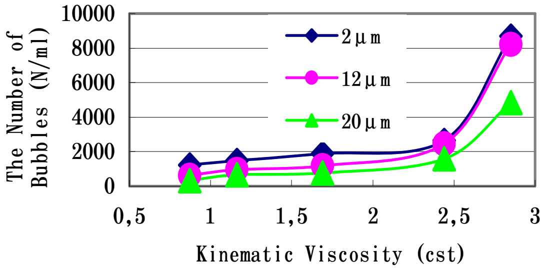


Fig. 4. Effect of change of kinematic viscosity

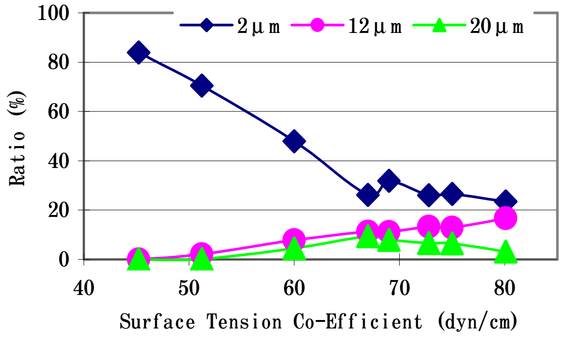


Fig. 5. Effect of change of surface tension co-efficient

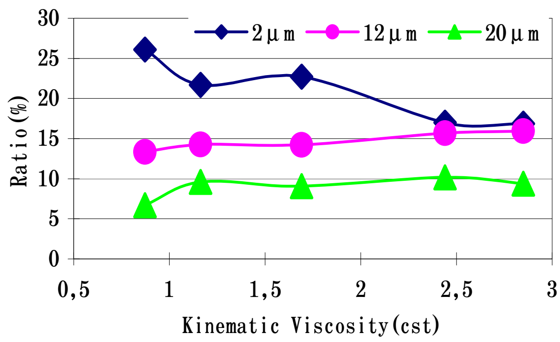


Fig. 6. Effect of change of kinematic viscosity

When σ and ν increase, distribution of particles in water is uniform. When particle size is 20μm, number of particles does not depend on σ and ν.

However, these results are obtained only for kinetic viscosity glycerin. It may depend on chemical characteristics.

Sewage decolorization using micro-bubble Ozone

Micro-bubble has various characteristics comparing with bubble with same volume, such as large surface area, long stay duration and release of free radical in compressive break. Focusing on these characteristics, in this paper, micro-bubble of ozone gas is applied to sewage decolorization. That is, the purpose is that sanitary sewage is deodorized increasing solubility of ozone in sewage and residual ozone. And unsaturated combination of colored material in sanitary sewage is resolved by ozonized and decolorized.

Before main experiment, optimum outlet pressure and optimum outlet in tank is obtained in a preparatory experiment. Outlet pressure is selected as 0.4MPa in order to generate the most micro-bubble. In main experiment, a cylindrical tank as shown in Fig.7 which volume is 0.03m^3 is used and cooling tank is put around cylindrical tank in order to prevent heating water. Ozone is appended to sewage induced to the tank using diffuser or micro-bubble. The effect of micro-bubble is compared with that of diffuser. Change of color and density of exhaust ozone is recorded by changing appended ozone W as 1.8, 3.6 and 5.4(g/h). Fig. 7 shows experiment using micro-bubble and cylindrical tank for diffuser. It is seen that the former has higher diffusion of bubble than the latter.

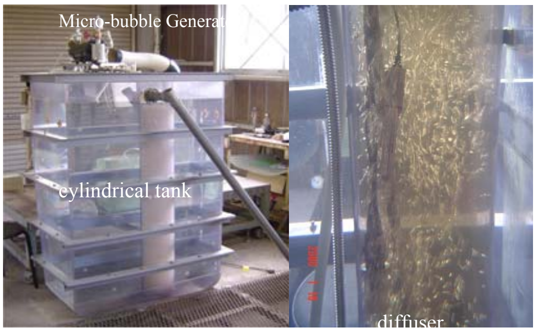


Fig. 7. Experimental Apparatus

Change in color

Fig. 8 shows change of color. Micro-bubble is more effective than diffuser when appended ozone is 1.8 and 3.6g/h. Especially, color of decolorized water using micro-bubble 3 hours is less than 10degree and color of water is not identified

However, when W=5.4g/h, difference between two methods are not large. Because heat is generated from micro-bubble generation device, water temperature rises larger than diffuser. In this experiment, size of the tank is small and when W=5.4g/h, water temperature becomes 30°C after 3 hours using micro-bubble. On the other hand, water temperature becomes 10°C using diffuser. Then, solvability of ozone is low using micro-bubble.

However, rise of water temperature is same when W=1.8 and 3.6g/h. In these cases, good results are obtained in more disadvantage conditions.

Change in exhaust Ozone

From a view point of exhaust ozone, advantage of micro-bubble is clear. Fig. 9 shows change in exhaust ozone. In diffuser, high density of exhaust ozone is measured immediately after the beginning of experiment. When micro-bubble is used, exhausted ozone is measured after some time passed. The reason is that almost of all micro-bubble of ozone is resolved into water and related to reaction of decorolization.

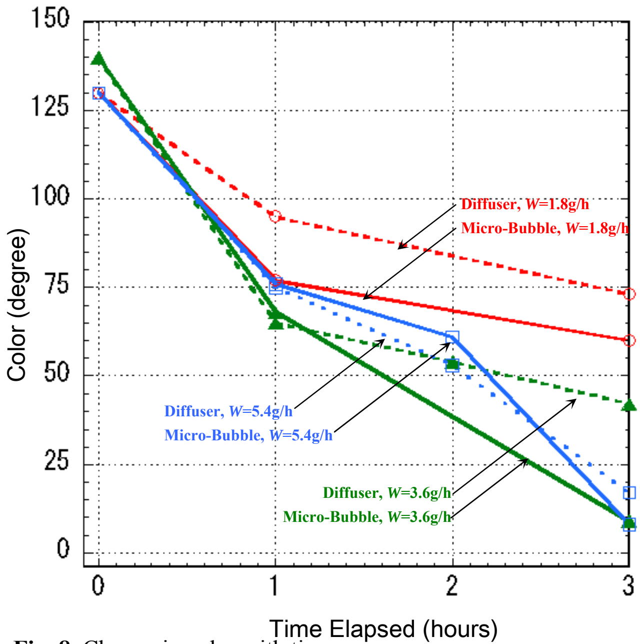


Fig. 8. Change in color with time

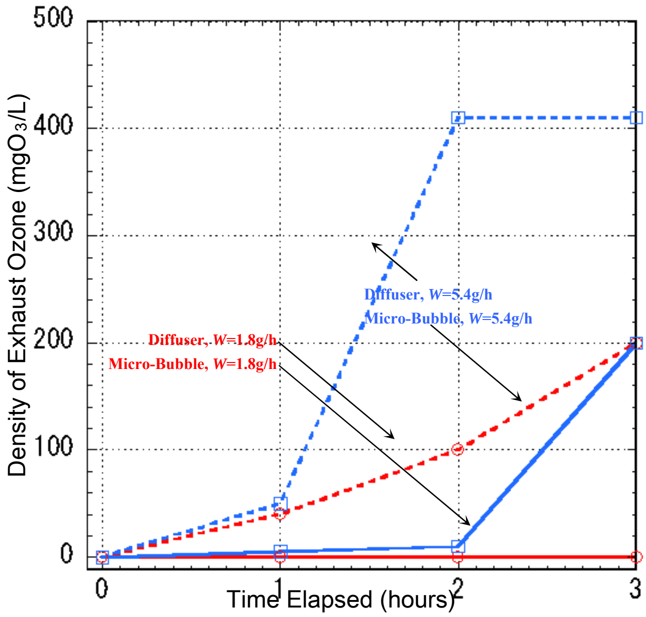


Fig. 9. Change in density of exhaust Ozone with time

Conclusions

The effect of fluid properties on particle size of micro-bubble is focused on. Particle size distribution is measured by changing kinetic viscosity and boundary tension force coefficient. It is found that increase of kinetic viscosity ν and boundary tension force coefficient σ has effect of generation of ever particle size uniformly.

Next, micro-bubble ozone is applied to sewage decolorization. Using micro-bubble ozone decolorizes color of sewage. The problem of exhaust ozone, which has bad effect on human beings, is possible to resolve.

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Micro-bubble is used in engineering field as well as wide range fields such as agricultural, fishery and medical field. This paper has focused on fluid properties in the area where micro-bubble is generated. Especially, kinetic viscosity ν and boundary tension force coefficient σ are focused on. The effect ofνandσon distribution of diameter of micro-bubble is demonstrated experimentally. Ill. 9, bibl. 4 (in English; summaries in English, Russian and Lithuanian).

С. Гирай, М. Кохмура, В. Саехоут, С. Сугая, С. Аоки, Т. Такагаши. Исследование генератора высокой плотности микропузырьков, предназначенного для технологий анализа окружающей среды // Электроника и электротехника. – Каунас: Технология, 2009. – № 4(92). – С. 37–40.

Микропузырьки используются в инженерных областях, а также в широком спектре таких областей, как сельское хозяйство, рыболовство, медицина. Эта статья сосредоточена на анализе свойств жидкости в состоянии микропузырьков. Экспериментально продемонстрирован эффект распределения диаметров микропузырьков. Ил. 9, библ. 4 (на английском языке; рефераты на английском, русском и литовском яз.).

S. Hirai, M. Komura, V. Saechout, S. Sugaya, S. Aoki, T. Takahashi. Didelio tankio mikroburbuliukų generatoriaus technologijos tyrimas // Elektronika ir elektrotechnika. – Kaunas: Technologija, 2009. – Nr. 4(92). – P. 37–40.

Mikroburbuliukai naudojami inžinerijoje, taip pat tokiose srityse, kaip žemės ūkis, žuvininkystė ir medicina. Daugiausia dėmesio buvo skiriama ištirti skysčio savybėms tose vietose, kur generuojami mikroburbuliukai. Eksperimentiškai įrodytas skersmens pasiskirstymo mikroburbuliukuose efektas. Il. 9, bibl. 4 (anglų kalba; santraukos anglų, rusų ir lietuvių k.).