SVI-3

気液混相プラズマとその応用
Gas-liquid mixed phase plasma and its application

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1. Introduction

Water pollution is one of the most serious environmental problems. Recently, plasma discharge in water has attracted much attention for water treatments [1-5]. Discharge in water enhances active species, such like ozone (O_3) and OH radicals, and ultraviolet (UV) rays also irradiated. Strong electrical field and shock waves are also generated in the discharge and they work effectively for water treatment [6].

In this study, we have investigated a gas-liquid mixed phase plasma using pulsed high voltage with the pulse width of several tens of nanoseconds. We utilized it to decompose organics and to sterilize bacteria in water. Active species, O_3 and OH radials are generated in the discharge. In order to investigate the effect of water purification, decolorization of indigo carmine (organic dye with blue color) solution and sterilization rate of *Bacillus Subtillis* (spore-forming bacteria) were used as indicator.

2. A high voltage pulsed power supply and the plasma reactor

2.1 *High voltage pulsed power supply*

Figure 1 shows an electric circuit of the high-voltage pulsed power supply. The circuit consists of a capacitor C, a gap switch GS, an inductor L, and SOS (semiconductor opening switch) diodes. When the gap switch was shorted after the capacitor was charged by DC power supply, current started to oscillate in the LC circuit. When the current was interrupted by the SOS diodes, the sudden interruption of current resulted in the generation of high voltage pulse V_o with a short pulse width of 40ns typically [7-10]. The pulse repetition rate was variable.

2.2 *Gas-liquid mixed phase plasma reactor*

Figure 2 shows the plasma reactor for gas-liquid mixed phase discharge. The upper part (liquid phase) of the reactor was filled with water, and working gas was fed from the lower part (gas phase) through multiple holes drilled in the separator. Electrodes were placed below the holes and in liquid. Pulsed high voltage was applied between them. The discharge was formed between the electrode placed in the lower part and surface of bubbles above the small holes in water [9, 10].

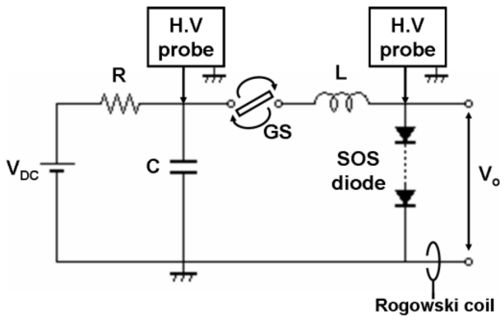

Fig. 1. The electric circuit of the high voltage pulse generator

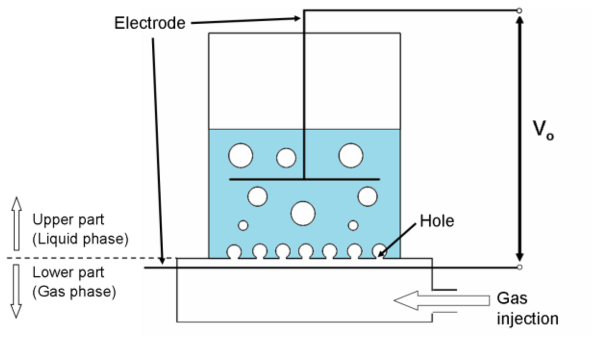

Fig. 2. Schematic diagram of the reactor

3. Water treatment in a gas-liquid mixed phase plasma

3.1 *Observation of gas-liquid plasma*

Figure 3 shows the photos of a bubble formed above a hole of the separator and lightning in discharge in the bubble by using a high-speed camera. Discharge extended along the surface of the bubble. The shapes of bubbles and discharges were different according to working gas species.

Figure 4 shows the production rate of active species (O_3 and OH radical) in various gases. O_3

production rate was the highest when oxygen was used as a working gas. OH radical production rate was evaluated from H_2O_2 concentration according to recombination of OH radicals [11], and it was highest when He was used as a working gas.

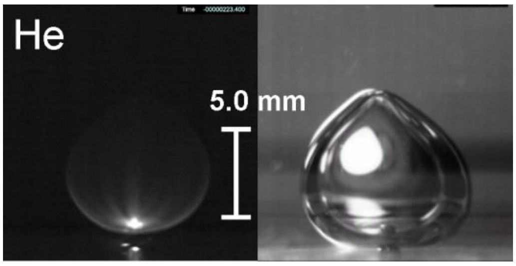

Fig. 3. A bubble and a discharge in the bubble.

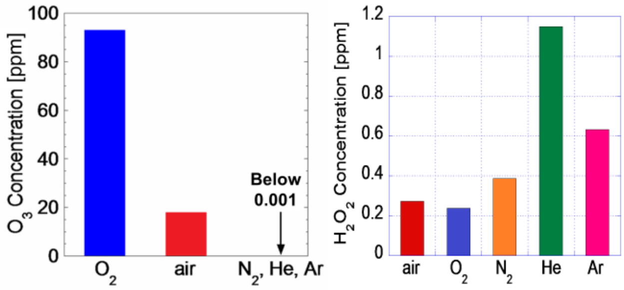

Fig. 4. O_3 and H_2O_2 concentration in various gas species

3.2 *Effect of organics decomposition*

Figure 5 shows decolorization rate of indigo carmine solution in various gas species. Decolorization rate was high when air and O_2 were used as working gas. This result was caused by high O_3 production shown in Fig.4 and high reaction rate between O_3 and indigo carmine. On the other hand, a small change of decolorization rate by OH radical was observed in N_2 and He. Further experiments with persistent organics are performed.

3.3 *Effect of sterilization*

Sterilization effect using this plasma treatment was observed in various gas species as shown in Fig.6. Active species generated with the discharge worked effectively for inactivation. When air was used as working gas, the sterilization effect was high and the decrease of the pH value was large. The dependence on pH value of the solution is shown in Fig.7.

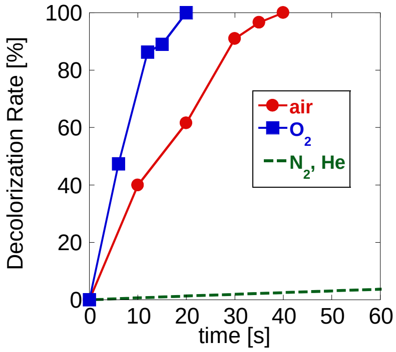

Fig.5. Decolorization rate in various gas species

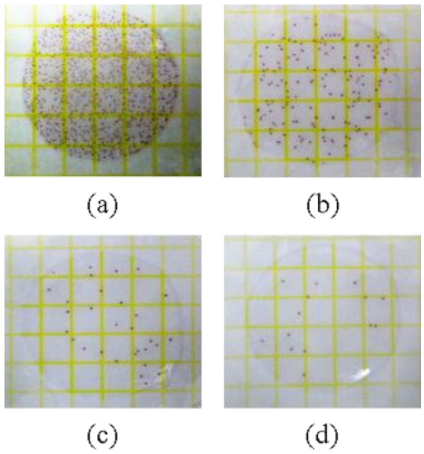

Fig.6. Sterilization effect appeared on the number of the colonies (a) untreated, (b) 5 min, (c) 10 min and (d) 15 min.

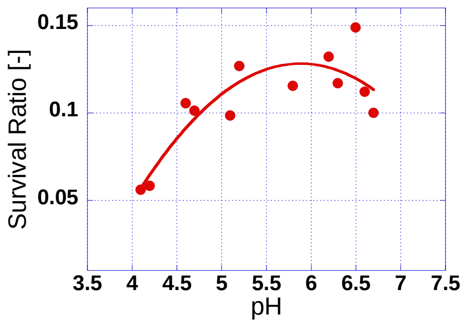

Fig. 7. Survival ratio as a function of pH value of the solution.

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