Water Purification by Atmospheric Microplasma Treatment

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Introduction

In recent years, associated with industrial development, water pollution became a serious problem. Plasma could be used as water treatment technology such as decomposition of organic compound and sterilization of bacteria.

Conventional technologies requires expensive processes or the usage of chemicals for water treatment. Microplasma is an ecological and economical technology to be applied for water treatment due to the low cost and low discharge voltage.

Methods

Microplasma Electrode for water treatment

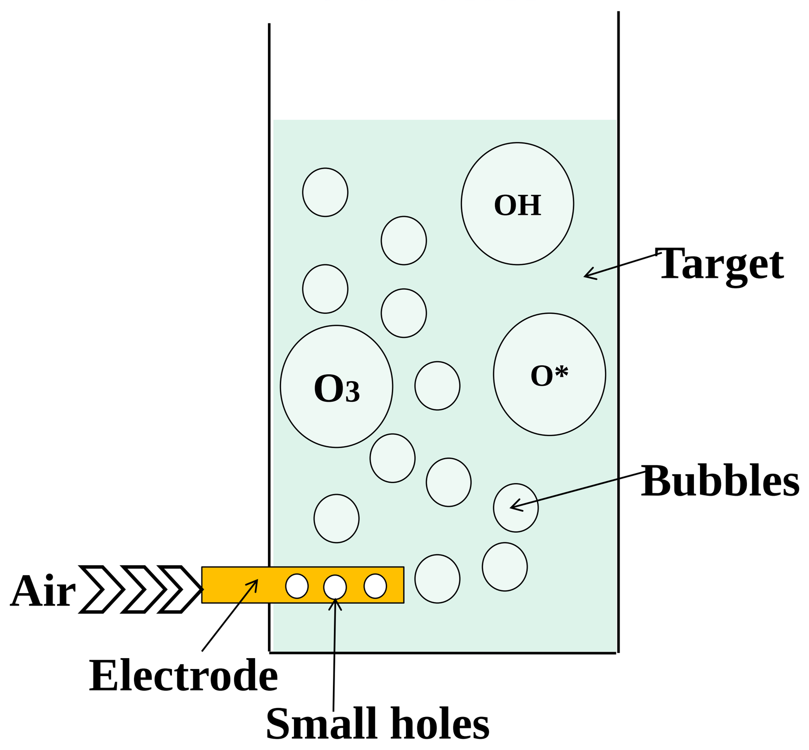

Fig. 1 Mechanism of water treatment by microplasma.

Microplasma electrode was placed under the water to fit in the plastic container. Air was flow inside the case to generate inside bubles. Thus surroundings of the electrode was Keeping gas phase due to the carrier gas.

Various active species such as ozone, OH radical etc. were generated by microplasma as shown in Fig. 1[1].

Fig. 2 The photograph of the electrode.

Microplasma is a typical dielectric barrier discharge.

Experimental Setup

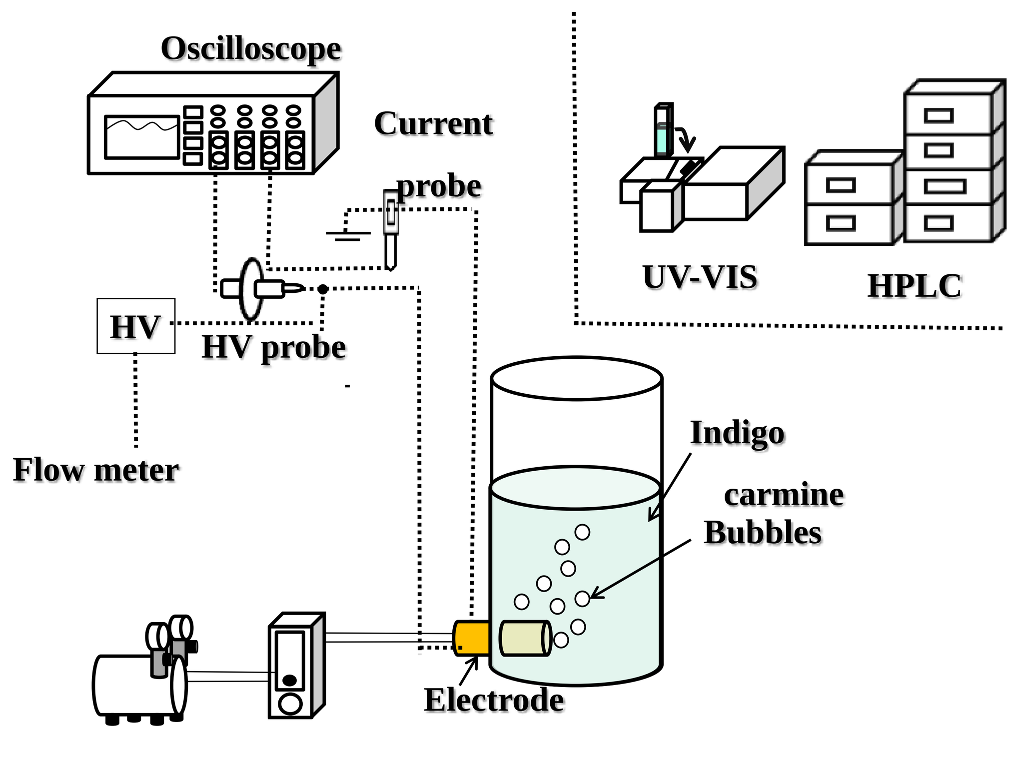

Fig. 3 An experimental setup.

Table.1 Experimental parameters.

Power supply	AC
Carrier gas	Air
Flow rate [L/min.]	2-4
Target	Indigo carmine
Concentration [mg/L]	10
Treatment volume [ml]	150

A neon transformer was used as the AC high voltage power supply. Air was supplied from an air pump as the carrier gas. It flows in the reactor, pass through the holes of electrodes and generates bubbles. The position of the electrode at the bottom of the reactor promotes the generation of active species in the bubbles and furthermore the reaction of these active species with the target to be decompose: indigo carmine diluted in water. The treated sample was analyzed by UV-VIS, and HPLC.

Fig. 4 show the typical waveform of discharge voltage and discharge current.

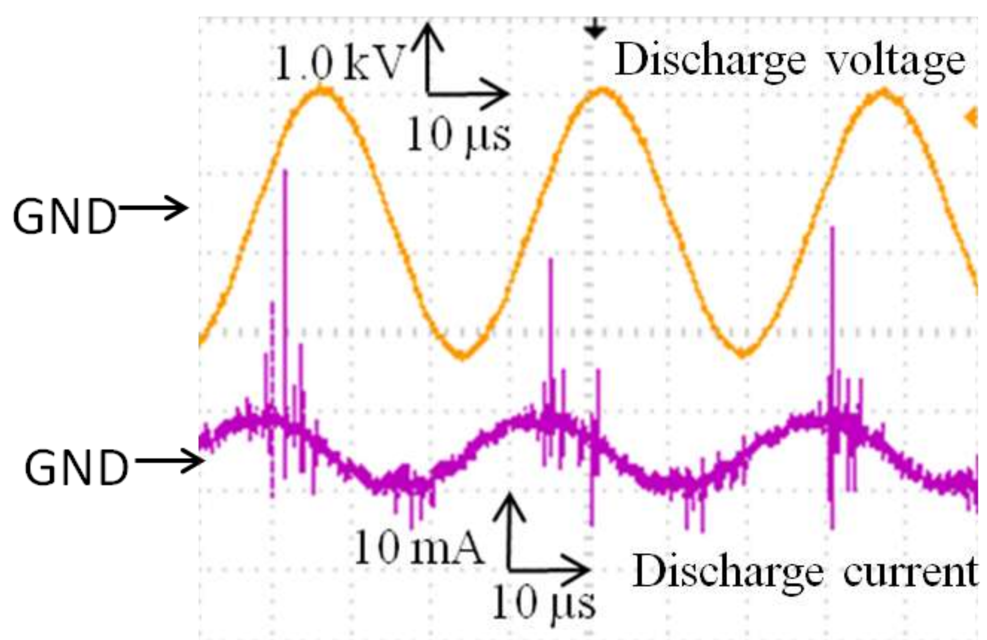

Fig. 4 Typical waveform of discharge voltage and discharge current.

The spike current was observed at the discharge rise point. This is the feature of the dielectric barrier discharge.

Results and Discussion

(1) indigo carmine absorbance

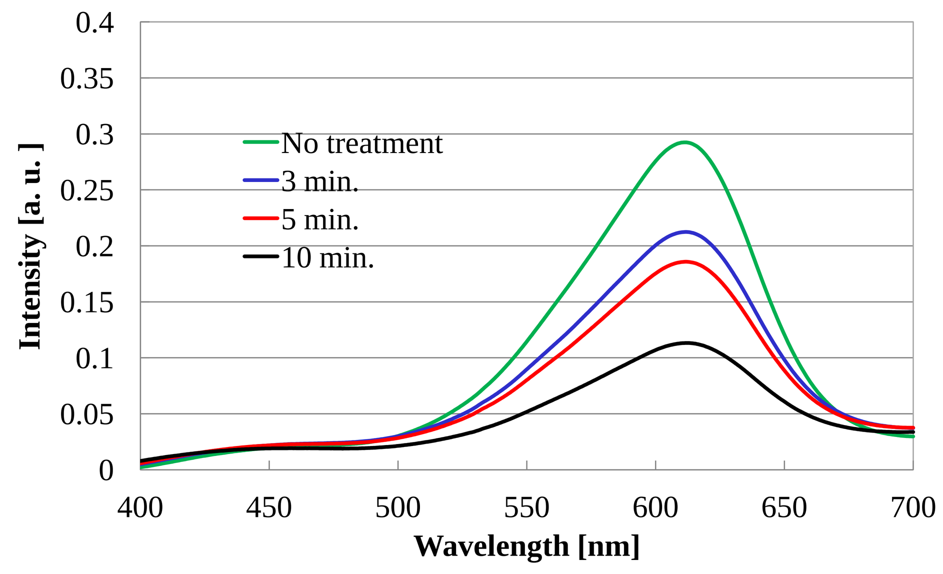

Fig. 5 The analysis of absorbance using spectrum photometer(Vd=1.9kV).

Decrease of 610 nm peak suggests that organic compounds contained in indigo carmine solution was decomposed during microplasma treatment.

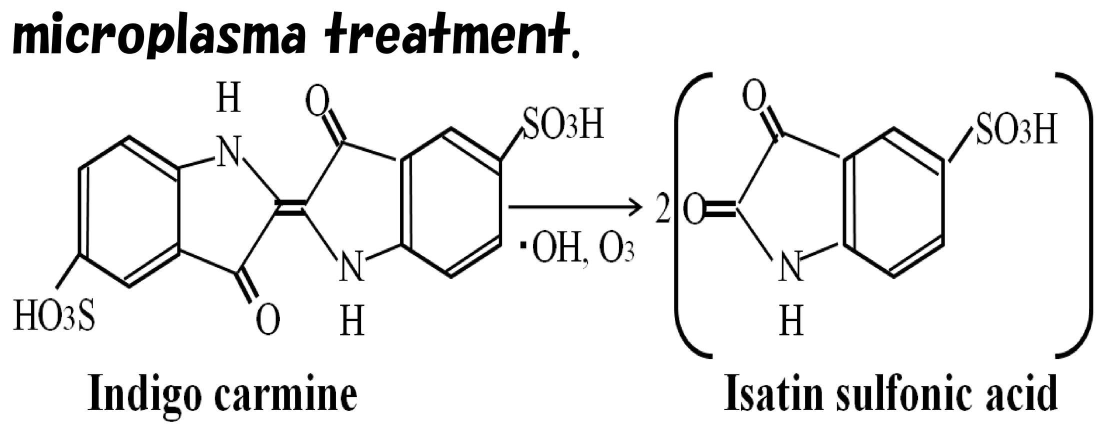

Fig. 6 Chemical reaction of indigo carmine by microplasma treatment.

Indigo carmine has the H type chromophoric group which gives the blue color. Double bond (C=C) was cut thus OH radicals and ozone presence lead to the formation of a new bond 2(C=O). As a result, Indigo carmine was decomposed to isatin sulfonic acid.

(2)Photograph of the indigo carmine solution

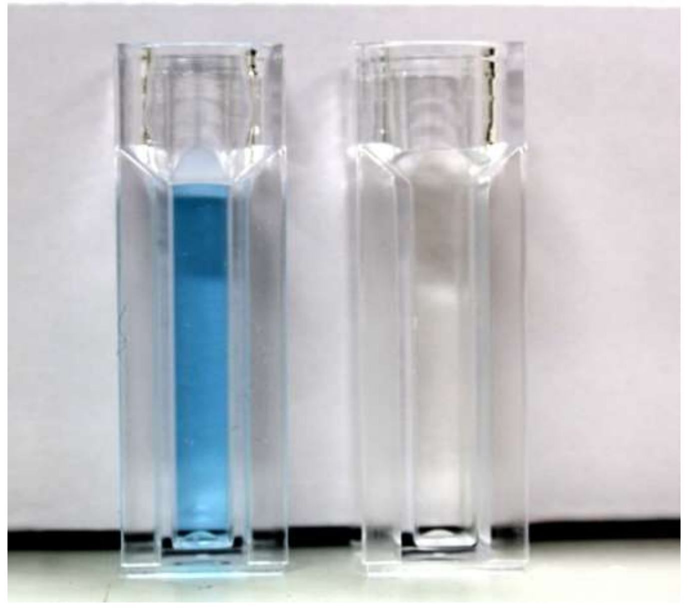

Fig. 7 The comparison of the color between before and after treatment.
(Left: before treatment,
Right: after treatment.)

The color was changed almost transparence after the plasma treatment.

(3)HPLC analysis

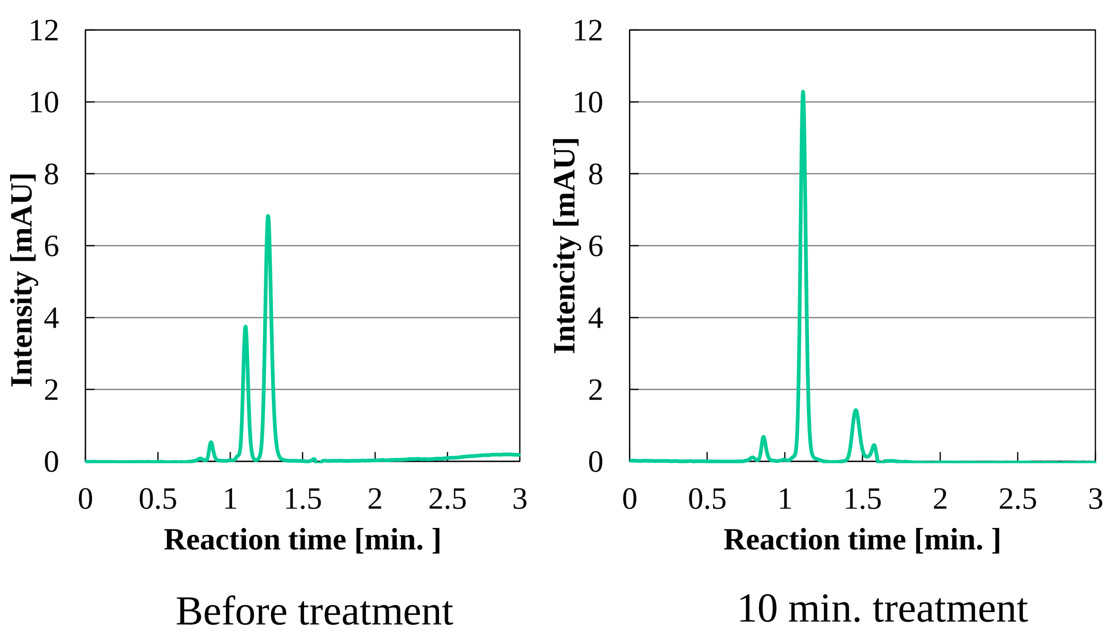

Fig. 8 The analysis of component of indigo carmine by HPLC.

Acetonitrile, ammonium acetate and water were used as the solvents to separate the component of indigo carmine. The first peak is the isatin sulfonic acid and second peak is the indigo carmine.

After the microplasma treatment, the peaks of the isatin sulfonic acid increased thus indigo carmine concentration decreased.

Conclusions

Microplasma could be used as an ecological and economical technology for water treatment :.

1. Indigo carmine was decomposed after microplasma treatment. Decomposition rate was improved to 61% with the increase of the treatment time.
2. The decomposition rate depends on the gas flow rate which determines the bubble size and quantity and furthermore affects the indigo carmine.
3. HPLC analysis showed that the decrease of the indigo carmine peak was strictly correlated with the increase of the isatin sulfonic acid peak due to the microplasma treatment.

Reference

[1] K. Takahashi, Y. Sasaki, S. Mukaigawa, K. Takaki, IEEE, Trans. on Plasma Sci. Vol. 38, pp. 2694-2699(2010).