Decolorization Study of Indigo Carmine by Atmospheric Pressure Microplasma

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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 for the 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[1].

Methods

Microplasma Electrode and Mechanism

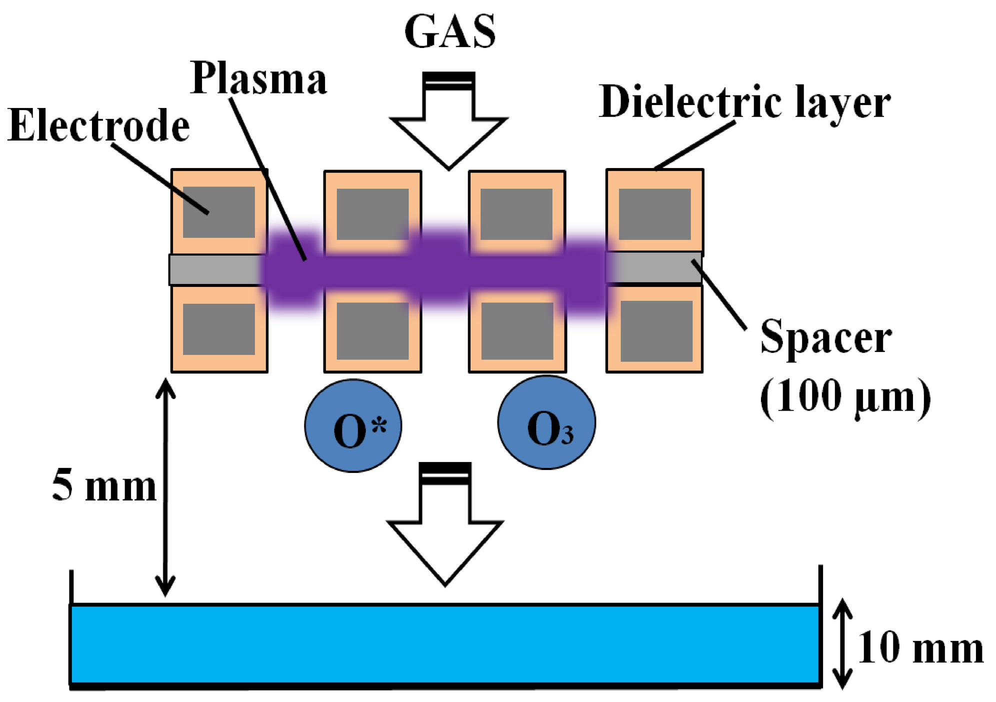

Fig. 1 Mechanism of water treatment by microplasma.

Microplasma electrodes are perforated metallic plates covered with a dielectric layer and faced together with a spacer of 100 μm.

Microplasma electrodes were placed at small distance above the water thus gas is flown towards the water surface to react with the target to be decomposed. Various active species such as ozone, OH radical etc. were generated by microplasma. Microplasma was generated at relatively low discharge voltage as a typical dielectric barrier discharge.

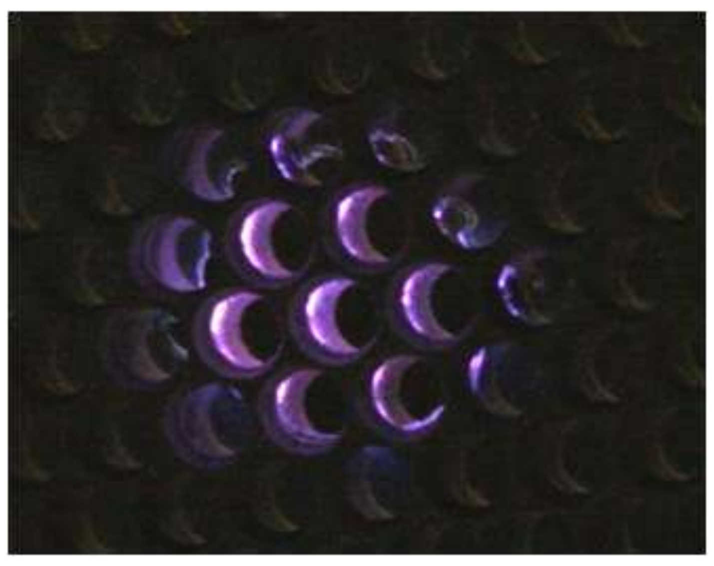

Fig. 2 Emission of microplasma(Vd=1.0kV).

Experimental Setup

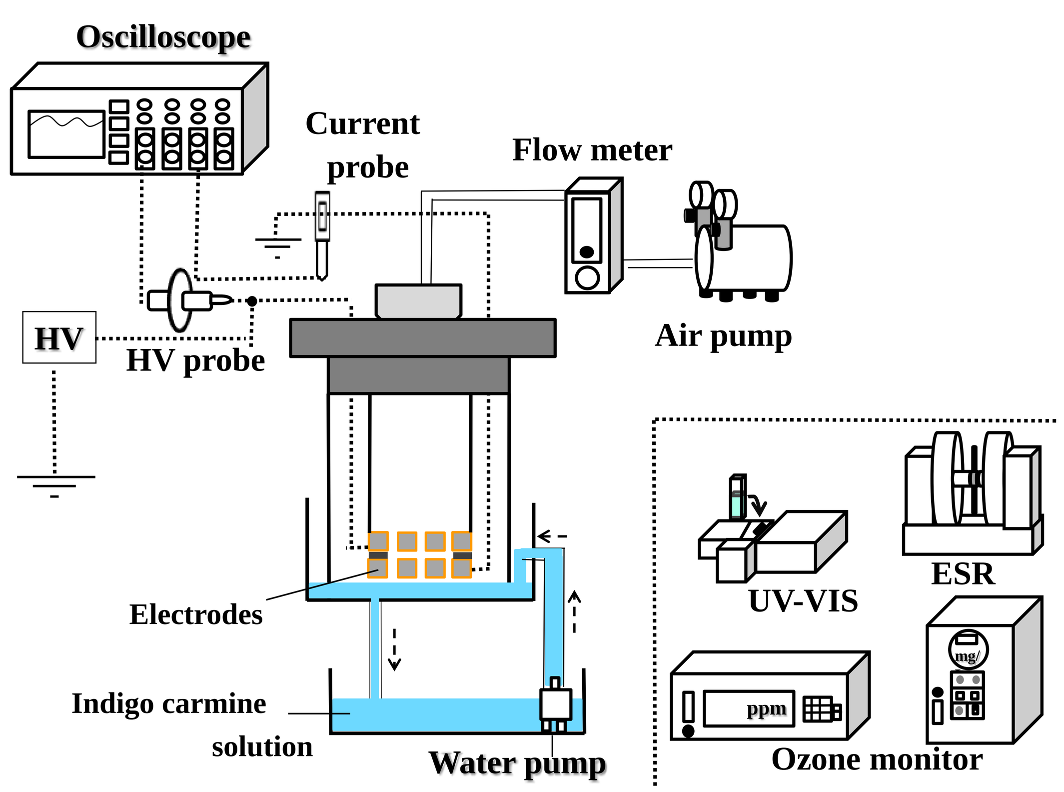

Fig. 3 An experimental setup for water treatment.

Table.1 Experimental parameters.

Power supply	AC
Carrier gas	Air
Flow rate [L/min.]	10
Target	Indigo carmine
Concentration [mg/L]	10
Treatment volume [ml]	200

A neon transformer was used as the AC high voltage power supply. The carrier gases were supplied in case of the air from an air pump and in case of N_2, Ar and O_2 from gas cylinders. It flowed above the reactor and passed through the holes of electrodes. Indigo carmine was used as the target to be decomposed. The treated sample was analyzed by UV-VIS, ozone monitor and ESR(Electron Spin Resonance).

Electrode Feature

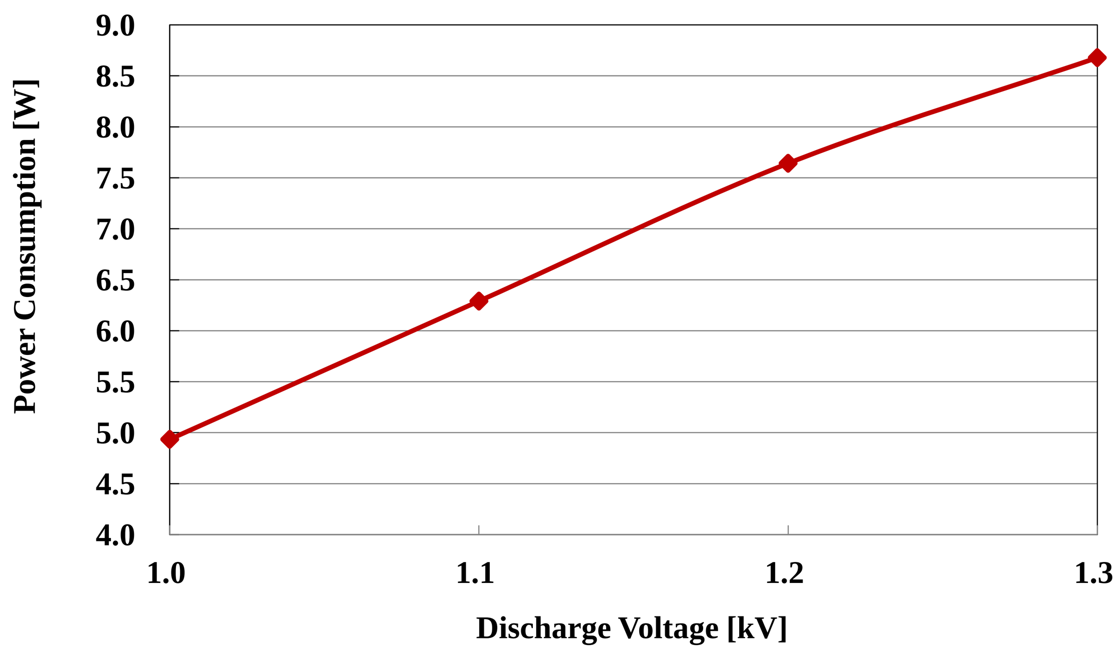

Fig. 4 Power consumption of microplasma electrode using AC power supply.

Microplasma electrodes power consumption is less than 10 W as shown in Fig. 4. Thus microplasma is ecological technology.

Results

(1)Observation of indigo carmine solution absorbance

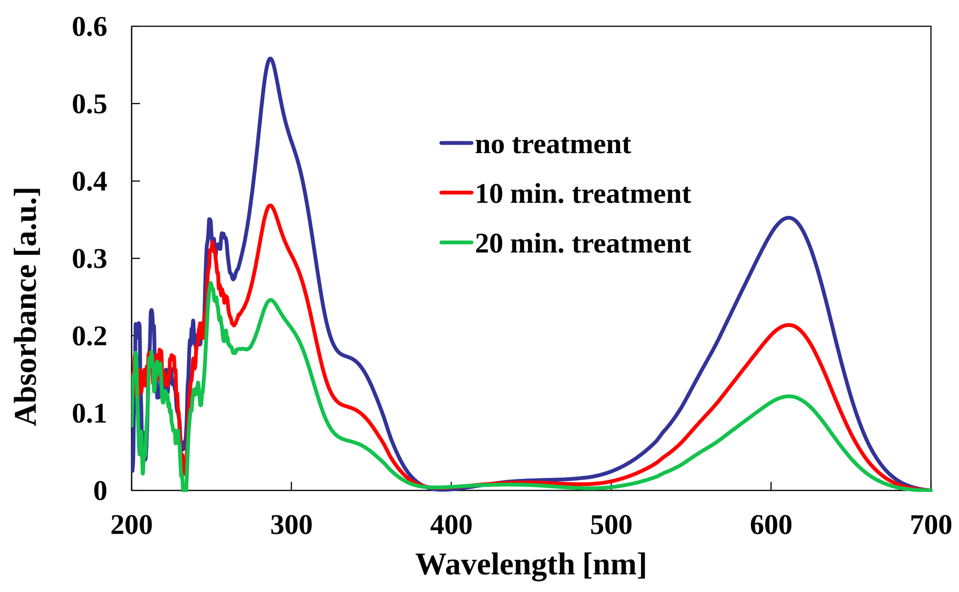

Fig. 4 Absorbance of the indigo carmine solution before and after microplasma treatment (Vd=1.0 kV).

The decrease of 610 nm and 300 nm peaks suggested that organic compounds contained in indigo carmine solution was decomposed during microplasma treatment.

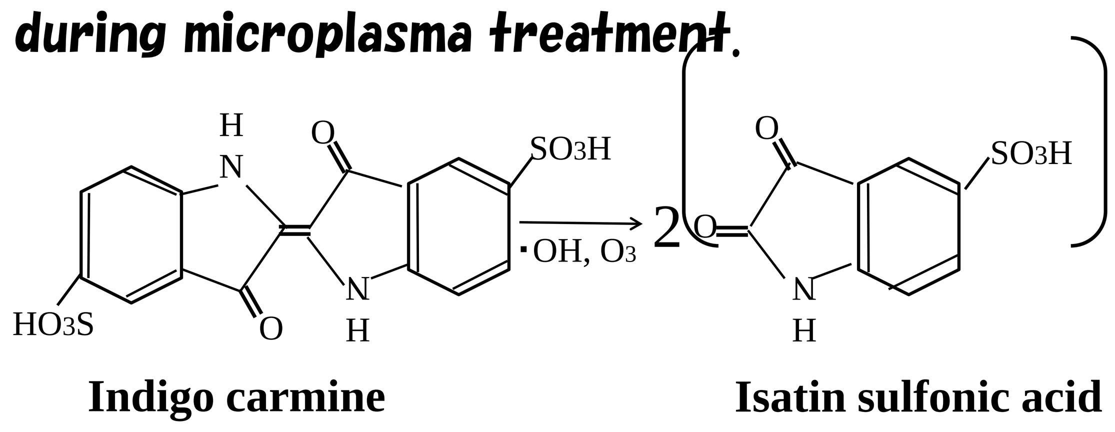

Fig. 5 Chemical reaction of indigo carmine promoted by microplasma treatment.

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 as a by-product of plasma treatment process be isatin sulfonic acid.

(2) Decomposition rate for various carrier gases

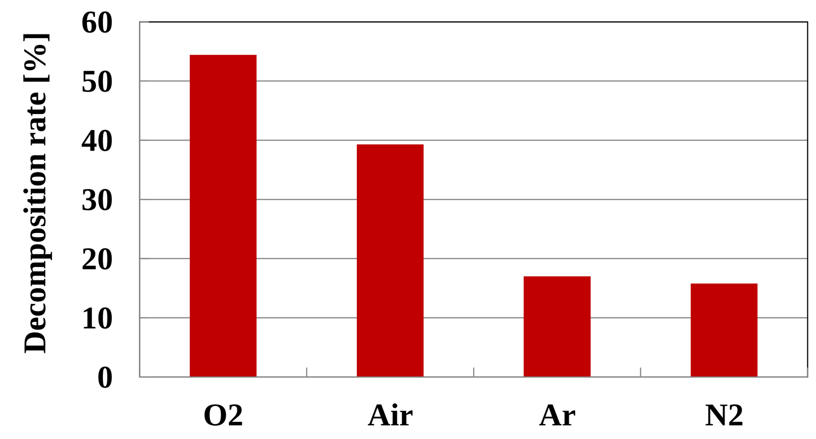

Fig. 6 The decomposition rate of indigo carmine for various carrier gases (Vd=1.0kV).

The decomposition rate was calculated by the absorbance value. In the case of air and oxygen were higher due to the active species of oxygen origin.

(3)The change of the pH value

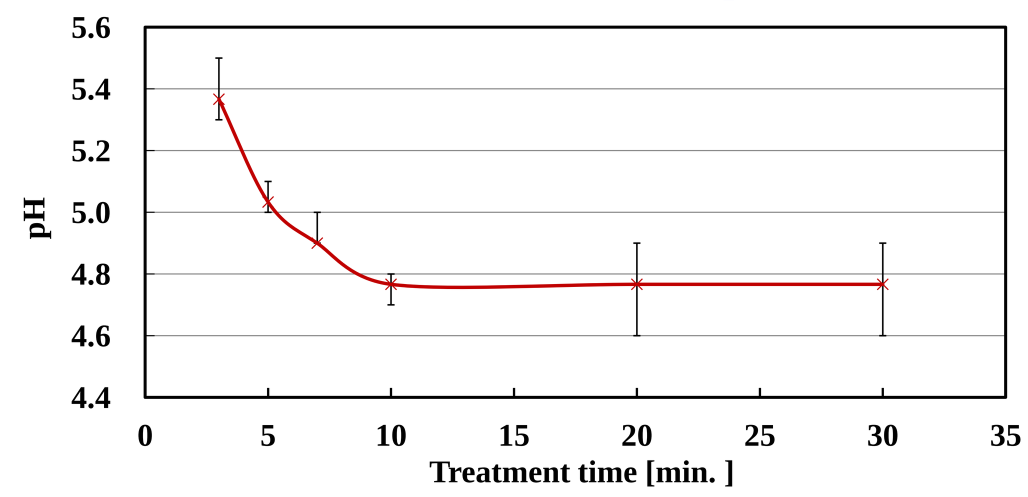

Fig. 7 pH value changed by the microplasma treatment.

The pH value was changed to the acid property. It saturated at about 4.8.

(4)ESR analysis

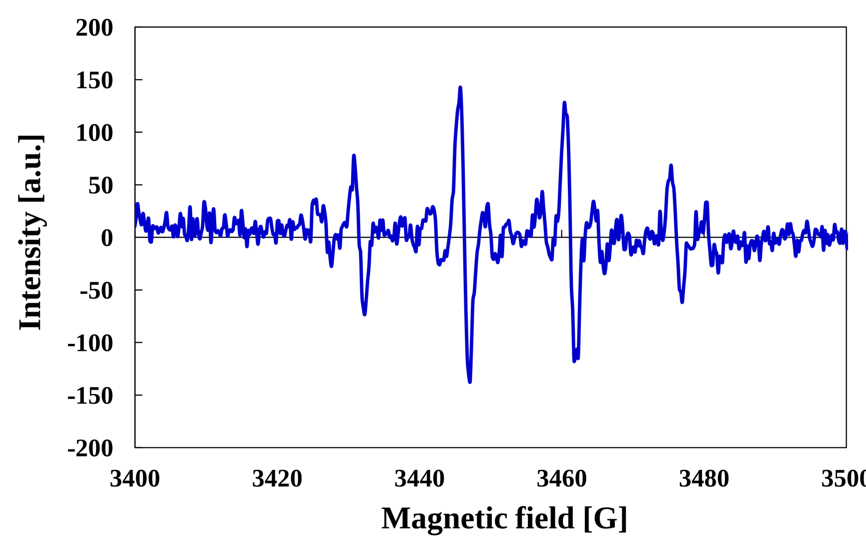

Fig. 9 OH signal detected by an ESR measurement.

Spin trap agent 5,5-dimethyl-1-pyrroline N-oxide was used to perform ESR analysis. Generated OH radical by microplasma were observed at 3450, 3460, 3430, 3480 gauss.

Conclusions

Microplasma could be used as an ecological and economical technology. Water treatment using microplasma was carried out.

1. Indigo carmine was decomposed after microplasma treatment and decomposition rate was reacted to 70% with the treatment time.
2. OH radical was one of the causes of indigo carmine decomposition. It was dissolved in the water as confirmed by using ESR analysis.
3. Active species of oxygen origin were the most effective for decomposition process.

Reference

[1] Y. Shen, L. Lei, X. Zhang, M. Zhou and Y. Zhang, Energy Conversion and Management 49 pp. 2254-2263(2008).