Study of Wastewater Purification by Atmospheric 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 such as decomposition of organic compound and sterilization of bacteria. Conventional technologies require 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 and Mechanism

Microplasma electrodes are perforated metallic plates covered with a dielectric layer and faced together with a spacer of 100 μm as shown in Fig. 1. 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.[1]

![Fig. 1: Mechanism of water treatment by microplasma.](Image)

Fig. 2. The emission during discharge(Vd=1 kV).

Microplasma is a typical dielectric barrier discharge. The image of microplasma discharge is shown in Fig. 2.

Experimental Setup

Table 1 Experimental parameters.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power supply</td>
<td>AC</td>
</tr>
<tr>
<td>Carrier gas</td>
<td>Air</td>
</tr>
<tr>
<td>Flow rate [L/min.]</td>
<td>10</td>
</tr>
<tr>
<td>Target</td>
<td>Indigo carmine</td>
</tr>
<tr>
<td>Concentration [mg/L]</td>
<td>10</td>
</tr>
<tr>
<td>Treatment volume [ml]</td>
<td>200</td>
</tr>
</tbody>
</table>

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 N₂, Ar and O₂ from gas cylinders. It flows above the reactor and pass 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).

Results

(1) Observation of indigo carmine absorbance

![Fig. 4: The analysis of absorbance using spectrum photometer(Vd=1.0 kV).](Image)

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

![Fig. 5: Chemical reaction of indigo carmine by microplasma treatment.](Image)

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

(2) Decomposition rate for various carrier gases

![Fig. 6: The decomposition rate of indigo carmine for various carrier gas(Vd=1.00kV).](Image)

Fig. 6 shows the decomposition rate was calculated by the absorbance value, Air and oxygen were higher due to the active species of oxygen origin.

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 increased with the treatment time and discharge voltage.
2. OH radical was one of the causes of indigo carmine decomposition. It was dissolved in the water as confirmed by using ESR.
3. 0.5 – 2.2% of the ozone generated in gas phase was dissolved in water.

Reference