Diagnostics of a plasma jet using optical emission spectroscopy

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1. Introduction

   1.1 Background
   - Dielectric barrier discharge (DBD)
     - DBD is well known as a stably generated discharge at atmospheric pressure.
     - This does not require a vacuum system, allowing simple structure of discharge equipment.

     **DBD has attracted attention and used for gas reforming and sterilization**[1].

     However, the discharge area of DBD is limited between electrodes.

   1.2 Plasma jet, a kind of DBD has attracted as a novel plasma source.

   - Plasma generated by applying AC voltage to a glass tube with a rare gas flowing in the tube.
   - Generated gas is pushed out of the tube by the rare gas.

   - The plasma reaches to solid and liquid easily; therefore, the plasma jet is used for sterilization, stimulation of germination, etc.

   - To control the plasma jet properly, and studying the plasma characteristics is important.

2. Experimental apparatus and conditions

   - Discharge reactor
     - Glass tube: A T-shaped glass tube of 3 mm in inner diameter and 90 mm length.
     - High voltage electrode: A copper tube of 2 mm in inner diameter and 3 mm in outer diameter is inserted into an inlet of the T-shaped glass tube.
     - Earth electrode: An aluminium sheet is bound round the outside of the T-shaped glass tube.
     - The gap length between copper tube and aluminium electrode is 10 mm.

   - Applied voltage
     - AC voltage 12 kVp at a frequency of 17 kHz.

   - Gas conditions
     - Argon gas, the purity of which is 99.99% is fed into the glass tube through the copper tube at constant flow rate of 10 L/min.

   - Measurement of optical emission spectra
     - Optical emission intensity of the plasma jet is measured using monochromator (JASCO, CT-25CS, 0.16 mm resolution).
     - The monochromator is placed normal to the direction of the gas flow to measure the spatial distribution of the emission intensity.
     - The distance between the plasma jet and the entrance slit of the monochromator is fixed at 10 mm.

3. Derivation method of rotational temperature

   - The shape of rotational spectra is partially affected by temperature.

   - It is possible to deduce gas temperature by the shape of rotational spectra.

   - In this work, the shape of measured spectra of OH is compared with theoretical spectra considering temperature, calculated by LIFBASE[3] with different gas temperature. The rotational temperatures of plasma jet are deduced by the correspondence between measured and theoretical spectra.

4. Results and discussion

   4.1 Gas temperature of plasma jet

   - The band head of OH is 309 nm, and rotational spectra lie at 303.8 - 308.8 and 309.5 - 311.5 nm.
   - The emission spectra of OH are due to H₂O contained in Ar or in air in the vicinity of the plasma jet.
   - The theoretical rotational spectra at 380 K agree well with the measured rotational spectra, therefore, the gas temperature of the plasma jet is determined to be 380 K.

5. Conclusions

   In this work, the emission spectra of OH are measured and the gas temperatures of the plasma jet are deduced.

   - The emission spectra of OH from H₂O contained in Ar or in air in the vicinity of the plasma jet are measured.
   - The maximum gas temperature is 380 K at 1.0 mm away from the exit of the plasma jet reactor.
   - The gas temperature tends to fall above 1.0 mm away from the exit of the reactor.