OH Radical Intensity of Dielectric Barrier Discharge (DBD) Plasma Measured by Optical Emission Spectroscopy (OES)

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Abstract. This study aims to identify the intensity of the OH radical emission spectrum of dielectric barrier discharge (DBD) plasma. The OH radical emission spectrum was measured using Optical Emission Spectroscopy (OES) Ocean Optic Maya Pro 2000. Characterization of current as voltage function is done by providing a high-voltage AC source to the DBD reactor with variations of 1-10 kV. The results of the characterization show that the current increase with voltage. The OES measurement of DBD plasma was carried out at a voltage of 10 kV. As a result, the OH radical emission in DBD plasma was observed at a wavelength of 313.54 nm. The smallest intensity was 4678.5 counts obtained at 2.4 s. While the greatest intensity was 13644.67 counts obtained at 44.6 s.

1. Introduction
Plasma technology which involves several electrical discharge processes that have specific chemical and physical characteristics became a challenging method in waste treatment [1]. The process of electric discharge will produce active species that can eliminate pollutants in waste [2]. These active species such as hydroxyl radicals (OH) and hydrogen peroxide (H₂O₂) play an important role in the decomposing compounds of waste. The decomposition of compounds in the waste can occur due to reactions between active species and compounds inside the waste [3]. Therefore, the amount of active species is one factor that determined degradation efficiency besides pH temperature, gas input, and conductivity of the waste [4-8]. The OES is a method used to identify and determine plasma parameters such as electron temperature and ion density, free radicals, and electrons in incandescent discharge by the line comparison. Also, it can provide information in the form of the emission spectrum from an excitation process and the production of OH radicals, electrons, and ions, or other active species [9]. Hui et al. reported the optimization of excited OH radical in the DC plasma corona discharge using a reactor configured by needles-plate electrodes [10]. The OH radical emission spectrum was measured using OES Acton Spectra 2500 at atmospheric pressure in moist air. In the reactor, there are nine needles located vertically perpendicular to the plate. When corona discharge occurs, light signals emitted from the reactor are collected through quartz
optical fibers and displayed on a computer screen. The results of OES measurements show that the OH radical emission spectrum appears at a wavelength of 309 nm for the needles to plate distance is 20 mm and air humidity between 40-60% [10]. In this study, we will identify the intensity of OH radicals of DBD plasma since the production of active species depends on the reactor configuration.

2. Method
The OH radical emission spectrum was measured using the Ocean Optic Maya Pro 2000 spectrometer. The DBD reactor uses mesh as an outer electrode and stainless steel as an inner electrode and pyrex glass as a dielectric barrier. A high-voltage AC source at a range of 1-10 kV was supplied to the DBD reactor to obtain the I-V characteristic of plasma. While the OES measurement was carried out at a voltage of 10 kV.

![Figure 1. Set up of OES Measurements in DBD plasma reactor](image)

3. Results and Discussion
Figure 2 shows the current-voltage characteristic of plasma DBD for 1–10 kV of voltage. The current increased with increasing the applied voltage until the electrical breakdown limit condition at 10.5 kV. It means also the electric field that causes the process of ionization, excitation, re-excitation, and recombination of air gas will increase.

![Figure 2. Current-voltage characteristic](image)

When the air starts to ionize, it will emerge free electrons that move in the ionization channel. These free electrons will be accelerated by an electric field and collide atoms or
other gas molecules so that a chain ionization and electron multiplication occurred. More ionization means that a greater amount of active species will be produced. Therefore in the next, the voltage of 10 kV was chosen for plasma emission spectrum measurement.

![Graph of DBD Plasma Emission Spectrum](image)

**Figure 3.** Graph of DBD Plasma Emission Spectrum

Figure 3 shows the plasma DBD emission spectrum from OES measurements at 10 kV. The emission spectrum peaks are in the range of UV wavelengths of 300 - 400 nm. The OH radicals are in the range of 306.068 - 315.874 nm. Then, the species of N₂ in the range of 330.796 - 337.317 nm has the highest intensity since it is the most available constituent of air. While species of N₂⁺ is in the range of 350.344 – 357.779 nm of wavelength [11]. It can be seen that OH radicals as an oxidant can be produced at DBD plasma. Then, the consistency of OH radical measurement was depicted in figure 4.

![Intensity vs Time Graph](image)

**Figure 4.** The intensity of OH radicals at OES interval time measurement of 0-100 s

Figure 4 shows the measurement of the OH radical emission spectrum taken at 313.54 nm of wavelength. The smallest intensity at 2.4 s was 4678.5 counts. Meanwhile, the greatest intensity at 44.6 s was 13644.67 counts. It can be seen from the curve that the OH radical intensity of the DBD plasma was no significant deviation. It means the production of OH radical as active species was stable.
4. Conclusions

Based on the result, plasma was generated in the DBD reactor using air as a gas source. Higher voltage results in high ionization and active species production. Moreover, the OH radicals were obtained in the range of 306,068 - 315,874 nm of wavelength with stable intensity.

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