Cold atmospheric pressure plasma diagnostics using an UV-absorption spectroscopy

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Abstract

Cold atmospheric pressure plasma consists of OH, O, O_3, NO, and NO_2 radicals is currently well known in biomedical applications. This is due to its ability on killing microbes and stimulating on production of new cells. For such applications, the density measurement of any radical in the plasma is needed. In this work, the density of hydroxyl (OH) radical in dielectric grow discharge plasma on glass surface has been investigated and measured by ultraviolet (UV) absorption spectroscopy. The plasma was produced by Medi-Plasma system with frequency 50 Hz and intensity level 5. When the Ar gas flow rate is 8 l/min, radial distribution of OH radical density reach a maximum concentration of OH radical of $9.5x10^{14}$ cm^{-3} at the center of plasma area. In the range of Ar gas flow rate from 4 l/min to 12 l/min, the maximum value of OH density is $2.0x10^{15}$ cm^{-3}. .

Introduction

Recently, the non-thermal atmospheric pressure plasma have proven in novel-biomedical applications due to its capability on killing microbes and stimulating on production of new cells. For such applications, development of techniques to measure density of radicals in the cold atmospheric pressure plasma become important. This plasma consisting of O, O_3, NO, NO_2 and OH radicals. The hydroxyl (OH) radical play important role as oxidation in the application area. In this work, we develop a method to use an UV-absorption spectroscopy around 308 nm for measuring the density of the OH radicals on glass surfaces. The surface was applied by dielectric grow discharge plasma from Medi-Plasma head with 50 Hz of frequency and intensity level 5. Moreover, we investigate the radial density distribution of the radical and the influent of Ar gas flow rate on OH radical.

Materials and Methods

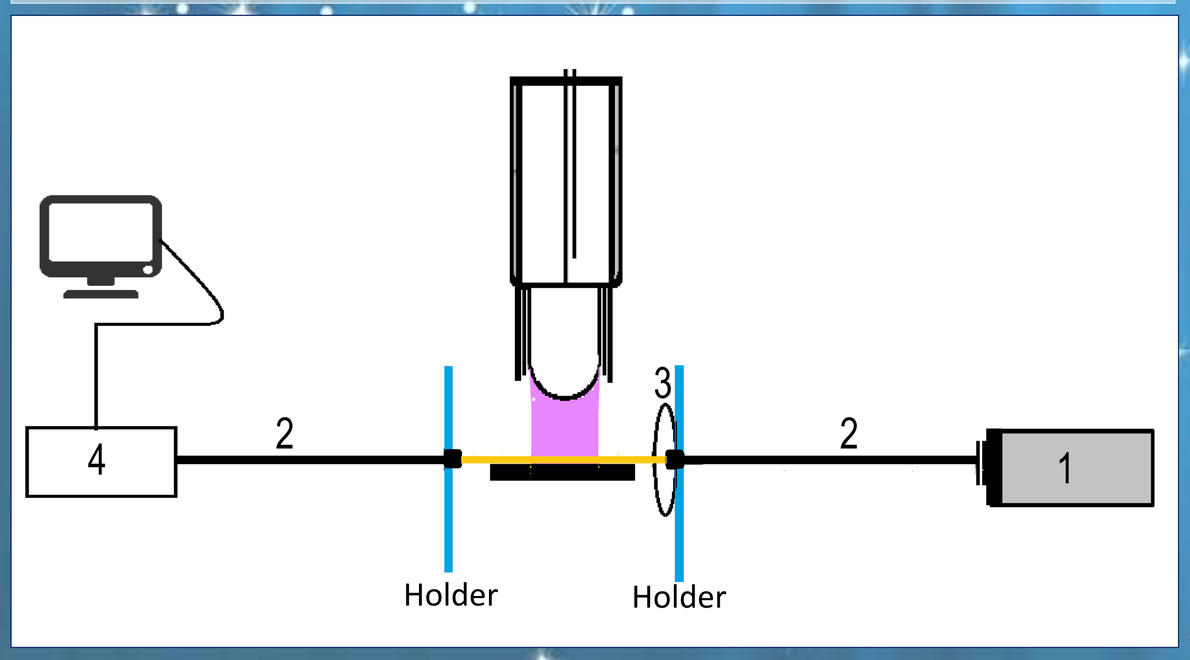

Figure1. shows the schematic measurement setup to determine hydroxyl radical concentration by using ultraviolet (UV) absorption spectroscopy. This apparatus governs (1)Deuterium UV light source (AIS D-1000) (2)fiber optic (3)collimating lens(COL-UV/VIS) (4)fiber optic spectrometer(AvaSpec-2048).

The density or concentration of ground state hydroxyl OH radicals, [OH],could be obtained by ultraviolet absorption spectroscopy by using the Lambert-Beer's law

$$[OH] = \frac{1}{\sigma \cdot l} \ln\left(\frac{I^{s}}{I^{t+p} - I^{p}}\right)$$

where σ is the cross sectional area about is $1.03x10^{-16}$ cm^2 for absorbing species of hydroxyl radical OH , and l is the cold atmospheric pressure plasma spatial depth. Whereas I^{t+p} is the total light intensity (the sum of the transmitted light and plasma light) measured with lamp and plasma on, I^{s} is the light intensity of the source with the plasma off and I^{p} is the light intensity of the plasma with the source off.

Results

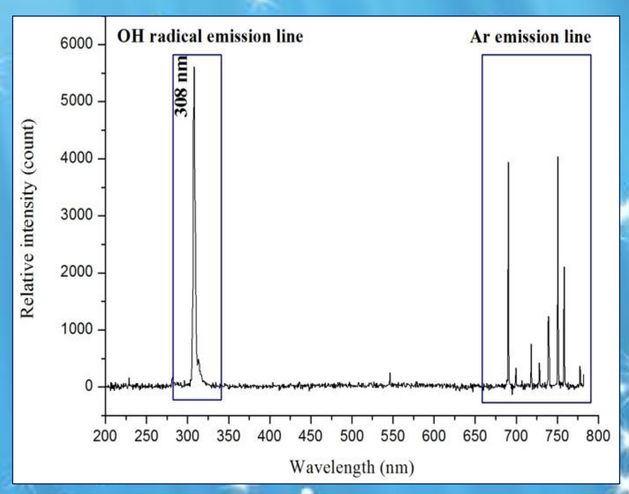

Figure 2. Optical emission spectrum of plasma from Medi-Plasma head

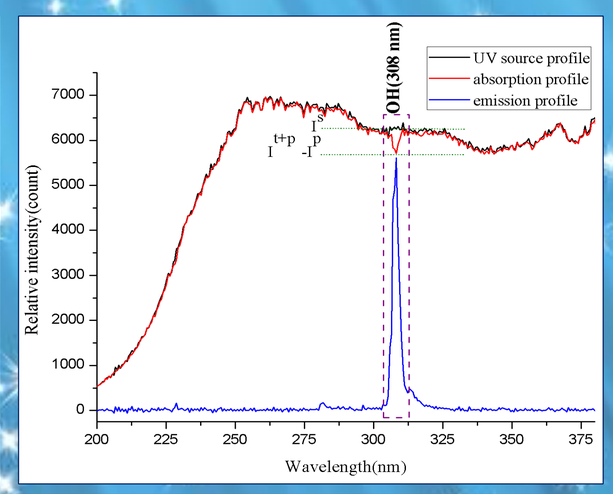

Figure 3.UV absorption profile of hydroxyl (OH) radical.

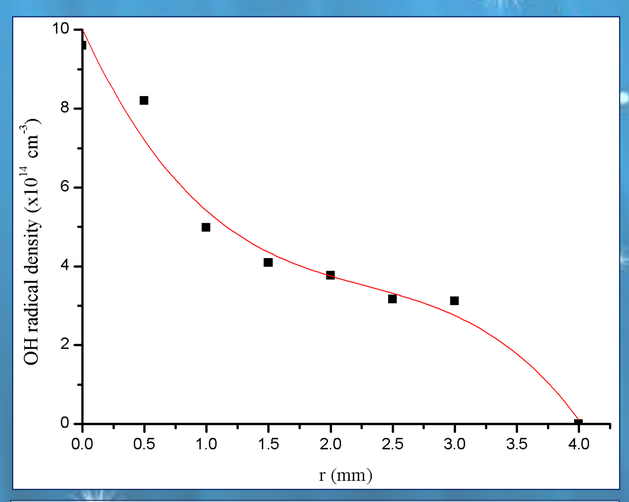

Figure 4.OH radical density radial distribution on glass surface with 8 l/min of Ar gas flow rate.

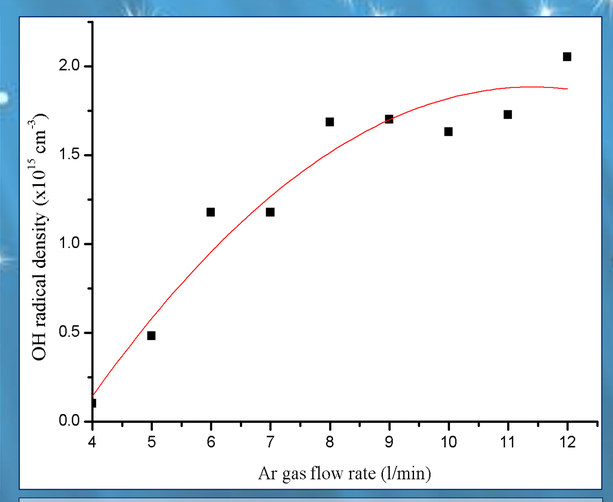

Figure 5. OH radical concentration on glass surface versus Ar gas flow rate from 4 l/min **to** 12 l/min.

Conclusions

We investigated hydroxyl (OH) radical in dielectric glow discharge plasma by using ultraviolet (UV) absorption spectroscopy. The plasma was generated by Medi-Plasma head with 50 Hz of frequency and intensity level 5 and the end of inner electrode located by 1 mm upward from the glass surface and the surface was on ground plate. It is seen the maximum OH radical density on glass surface is $9.5x10^{14}$ cm^{-3} at the origin of radial axis with Ar flow rate 8 l/min. As the Ar gas flow rate dependence of OH density ,we found that the maximum OH radical concentration is $2.0x10^{15}$ cm^{-3}. In this experiment, we also revealed that the hydroxyl OH radical on glass surface depend on humidity in ambient air.

Acknowledgments

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