An Experimental Investigation of the Concentration of KCl in Liquid Electrode of Atmospheric Pressure DBD

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Abstract— In this paper, the high voltage power supply for dielectric barrier discharge (DBD) have been design and constructed by using a function generator, power amplifier and twin car's ignition coil. Three different types of electrode configurations namely, cylindrical-cylindrical, cylindrical-plate and parallel-parallel were used in the experiment. The air discharge gap between the dielectric layers was fixed at 3 mm. The main objective of this study is to study the effect of the concentration of potassium chloride (KCl) in liquid electrode of the DBD at atmospheric pressure on the uniform discharge and number of electrode on the discharge voltage. Finally, we investigate the usage of DBD system with cylindrical-cylindrical electrode for waste water treatment.

1. INTRODUCTION

The atmospheric pressure plasma is non-equilibrium plasma produced by the dielectric barrier. The non-equilibrium atmospheric pressure plasma has been used in many areas, such as surface treatment, surface modification, waste water treatment, air flow control, agriculture and medical field. The dielectric barrier discharge (DBD) is one of a method of an atmospheric pressure generation. Basically, the DBD device consists of a pair of electrodes covered with dielectric material and a high voltage alternating current or high voltage pulse power supply. The DBD plasma can be easily obtained in atmospheric pressure by using simple equipment and an arbitrary geometry electrode. An experimental device for DBD generally consists of two electrodes separated by thin dielectric layer. An AC voltage is applied to the electrodes at a frequency of several hundred hertz to few hundred kilo hertz. A breakdown occurs in the gap between the two electrodes at a sufficiently high voltage enough to ionize the media around. The purpose of the dielectric barrier is to limit the electron current between the electrodes. The DBD devices can be made in many configurations, three different types of electrode configurations namely, cylindrical-cylindrical, cylindrical-plate and parallel plate were used in the experiment. In this work, the simple high voltage pulse power supply for DBD system and liquid electrode DBD atmospheric pressure have constructed. The air discharge gap between the dielectric layers was fixed at 2 mm.

2. MATERIALS AND METHODS

Figure 1 shows the block diagram of simple high voltage power supply. The sine wave from function generator fed to input of power amplifier and produced high voltage output by using 2 car's ignition coil, which is used to power the DBD plasma system.

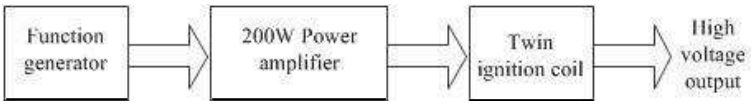


Figure 1: Block diagram of pulse high voltage power supply.

The schematic diagram of liquid cylindrical-cylindrical electrode is shown in Figure 2. It consists of two test tubes and there are some liquid of potassium chloride in two test tubes. To generate the volumetric DBD plasma, we have developed 4×4 cylindrical electrodes as shown in Figure 3. The parallel electrode system made from glass plate with thickness 2 mm. The dimension of parallel electrode is $25 \times 130 \times 130$ mm ($W \times L \times H$). The air discharge gap between the dielectric layers for

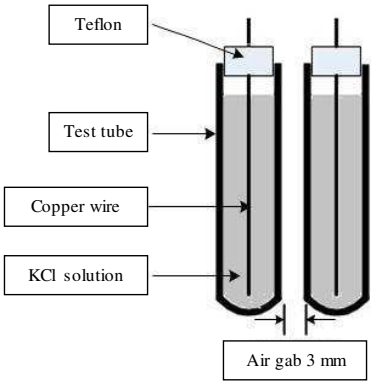
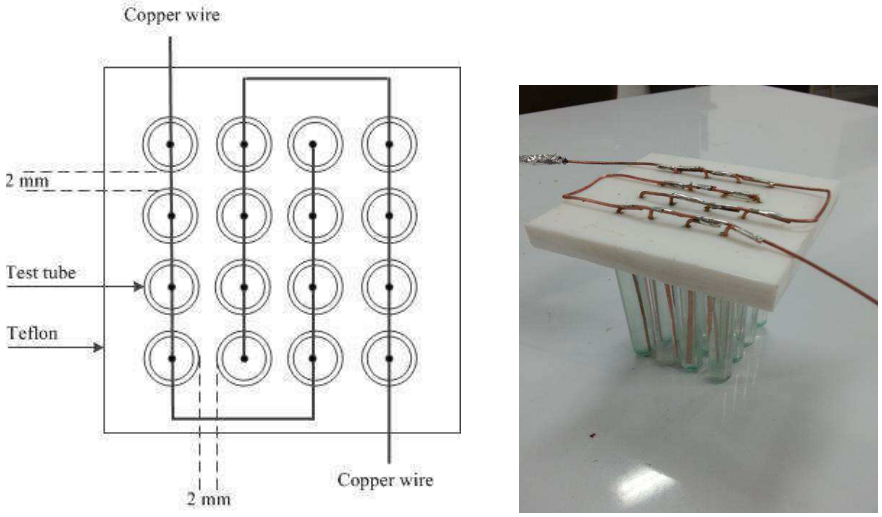


Figure 2: Schematic diagram of liquid cylindrical-cylindrical electrode.



(a) Top view (b)

Figure 3: (a) Schematic arrangement, (b) photo of 4×4 cylindrical electrodes.

all type electrodes were fixed at 2 mm. The concentration of potassium chloride solution is varying by 5, 10, 15, 20, 25 and 30 percent. The discharge current and voltage across the gab are measured by digital oscilloscope. The image of the discharge was captured by a digital camera.

2.1. Ozone Reactor with Cylindrical Electrode Configuration

The ozone generator for waste water treatment is designed by using two cylindrical electrodes as shown in Figure 4. The plasma chamber is shape cylinder, which made from acrylic material. Based on the process of testing an ozone generator is in the process color fading of waste water, taken 3 cycle process, where each cycle has an average duration process 20 minutes.

3. RESULTS

(a) High voltage power supply

We have successfully developed the high voltage power supply and applied it to produce atmospheric pressure plasma system. The output voltage from this power supply depends on frequency and can be up to ~ 19.9 kV.

(b) Atmospheric pressure plasma

To obtain a homogeneous discharge, the voltage and frequency were carefully adjust. Uniform discharge was observed throughout the inter-electrode space only at particular values of voltage and frequency. These values were measured for the three type of electrode as shown in Table 1.

In Figure 5 there were three different discharge processes with three different voltages of

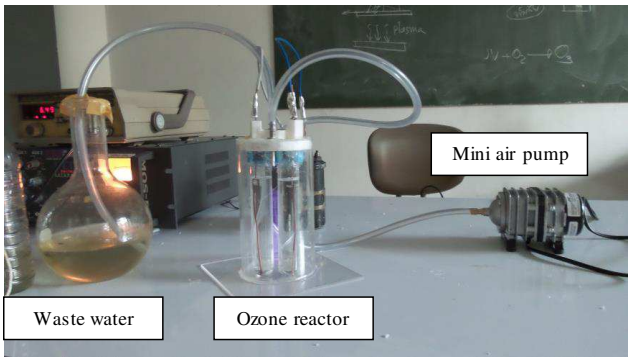


Figure 4: Schematic diagram and photo of ozone generator for waste water treatment.

Table 1: Voltage and frequency of uniform discharge in different of the concentration of KCl.

Concentration of KCl	Voltage (kV)	Frequency (kHz)
5%	19.88	5.43
10%	16.57	4.94
15%	16.90	4.91
20%	16.57	4.91
25%	16.57	4.91

all type electrode, uniformly and intensity of violet blue light gradually increase with apply voltage and frequency. In Figures 5(a) and (b), the discharge was not uniform.

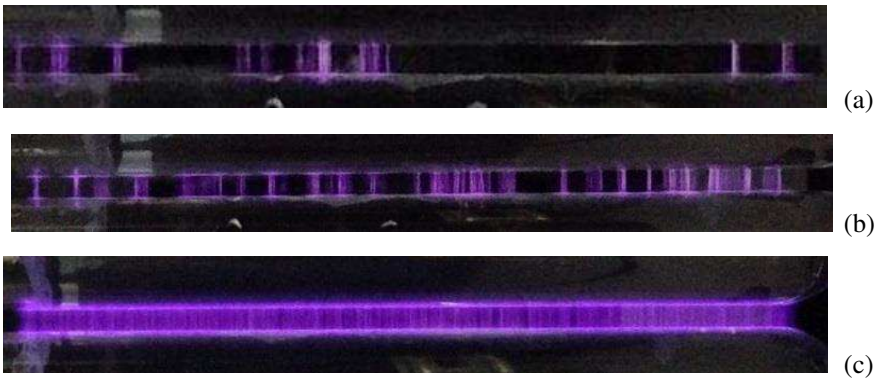


Figure 5: Image of three different discharge at (a) 13.58 kV, 1.9 kHz (b) 14.25 kV, 2 kHz and (c) 16.57 kV, 4.9 kHz.

Figure 6: Waste water after treatment.

(c) Waste water treatment

The test result of waste water after the treatment using ozone generator is physical changes on the waste water, which is obtained the fading color in the waste water that is more clearly compared with the color of initial waste water.

4. CONCLUSION

We have successfully developed the high voltage power supply for plasma DBD. The atmospheric pressure plasma by using liquid electrode was developed and produced by applying 1.9–4.94 kHz, 13.58–16.57 kV. Uniform discharge was observed throughout length of inter-electrode space when the voltage across the electrode was about 16.57 kV and frequency 4.91 kHz. The discharge does not depend on the concentration of potassium chloride and the large volumetric plasma could be increased by more electrodes. For ozone generator with two liquid electrodes has been applied to industrial waste water treatment.

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