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# The Characteristics of Five Ceramics and Two Granites as Solid Dielectrics for An Ozone Generator

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***Abstract*— The utilization of ozone is commonly applied in various fields, for instance, it is used as a disinfectant for water treatment, disinfecting, sterilizing medical devices and preserving foodstuffs. Ozone is a nearly colorless gas with a characteristic odor that can be detected by humans up to 0.01 ppm. It can be produced by the dielectric barrier discharge method, which is generally used as a method of generating ozone supplied by high voltage or also called high voltage plasma generators. High voltage plasma occurs in the dielectric barrier discharge air gap, as a result of the air failed in maintaining its insulator properties. The power supply used in this study is a parallel resonant pushpull inverter using a flyback transformer. Furthermore, this study did not use an additional magnetic loudspeaker and used ceramic dielectrics instead. 5 types of ceramics and 2 different types of granite and combined the range of air gap were used during examination and research. The research indicates that the best plasma was found in ceramics 3, 5, granite 1 and 2 with an air gap of 2 mm. The current discharge in ceramic 1 with an air gap of 2 mm was higher than the others. The highest voltage discharge was on granite 2 with an air gap of 2 mm. Ceramics 3, 5, granite 1 and 2 with an air gap of 2 mm had better ozone concentrations than ceramics 1, 2 and 4.**

***Keywords*— *dielectric barrier discharge, ozone, plasma, high voltage generator, ceramics, granite***

## I. Introduction

The use of ozone has been widely applied in various fields, such as in Europe, ozone has been used as a disinfectant to treat drinking water in the late 19th century, as well as America and even Japan. Lots of sectors - the use of ozone, including disinfecting, washing and whitening fabrics, aquaculture, sterilization of medical equipment, food preservation and so on [1].

Ozone is a nearly colorless gas with a very characteristic odor that can be detected by the human sense of smell up to a concentration of 0.01 ppm (parts per million). In the open space the maximum ozone concentration is around 0.10 ppm and the highest is 1.00 ppm and can still be considered harmless as long as it is not inhaled into the respiratory tract for more than 10 minutes [2].

At this time, dielectric barrier discharge (DBD) is known as an effective method for ozone generation. Ozone generation with this method is also referred to as high voltage plasma technology. This technology includes high voltage generating equipment, electrodes, and dielectrics (Fri Murdiya, 2017). DBD is a type of nonthermal plasma which generally consists of two electrodes separated by a gap of a few millimeters and covered with a dielectric layer. Where the electrodes are connected with AC (alternating current) high voltage. Dielectric functions as a current limiter, prevents spark formation and evenly distributes discharges throughout the electrode area [3].

The dielectric barrier used as an insulating layer material is such as glass, quartz, ceramics, and a polymer layer. The type of material, thickness and surface structure of the dielectric material can affect plasma discharge. DBD is generally used as technology of ozone generation that supplied by high voltage or also called high voltage plasma generators. High voltage plasma generators are widely used in areas such as the medical, chemical and physical in the world. This technology consists of high voltage generators, electrodes and dielectric parts. How it works is by supplying the dielectric barrier discharge with a high voltage which at a certain value will produce plasma visible to the eye. This plasma occurs because of the failure of a material to maintain its insulating properties [4-6].

Efforts that can be made to increase ozone production can be achieved in two ways, first by optimizing discharge equipment and second by combining discharge equipment with catalysts, photocatalysts, or by adding additional fields such as ultrasound and magnetic fields [7].

Based on previous research related to ozone generation with dielectric barrier discharge, this research will develop research on dielectric barrier discharge without the use of magnetic fields (without the addition of magnetic loudspeakers) and its dielectrics using several brands of floor tiles (ceramics) and granites. So, in order to get the desired results in the form of ozone concentration, plasma form, discharge current and discharge voltage must be tested on several different ceramics with different distances so that different results are obtained each test.

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Ceramic permittivity value is calculated by calculating the value of ceramic dielectric capacitance, air capacitance, air permittivity. The relative permittivity value is related to the capacitance value. The equation for finding the capacitance and relative permittivity values can be calculated using the following equation 1 dan 2.

$$\varepsilon_{rk}.\varepsilon_0 = \frac{C.d}{A} \qquad (1)$$

$$\varepsilon_{rk} = \frac{C.d}{A.\varepsilon 0} \qquad (2)$$

So if the equation 1 and 2 are substituted, then the relative permittivity value of the ceramic dielectric can be calculated using the following equation 3.

$$\frac{Ck}{Cu} = \frac{\varepsilon rk}{\varepsilon ru} \qquad (3)$$

Ck is the measured dielectric ceramic capacitance value, Cu is the measured air capacitance value, $\varepsilon_{rk}$ is the relative permittivity of ceramics and $\varepsilon_{r0}$ is the relative permittivity of air. The fixed air permittivity value is 1.

## II. Research Methodology

The method used in this research is testing at the Electrical Engineering Laboratory of the University of Riau by collecting data on test and research results. This research was conducted to determine the form of plasma, discharge current, discharge voltage, and ozone concentration produced by using 5 types of floor tiles and 2 types of granite with different brands as dielectric and the air gap (2 mm) between the anode electrode and solid dielectric on an ozone generator to get the desired measurement results. The power supply used in this study is a parallel resonant push pull inverter circuit that is controlled by IC CD4047 and it was supplied by smps (switch mode power supply) with an output voltage of 12 VDC that it is presented in Fig. 1.

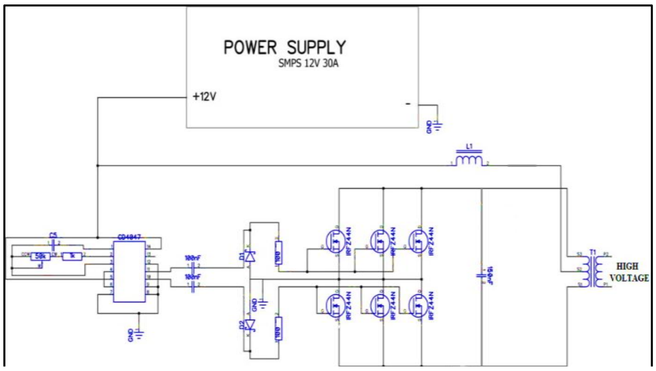
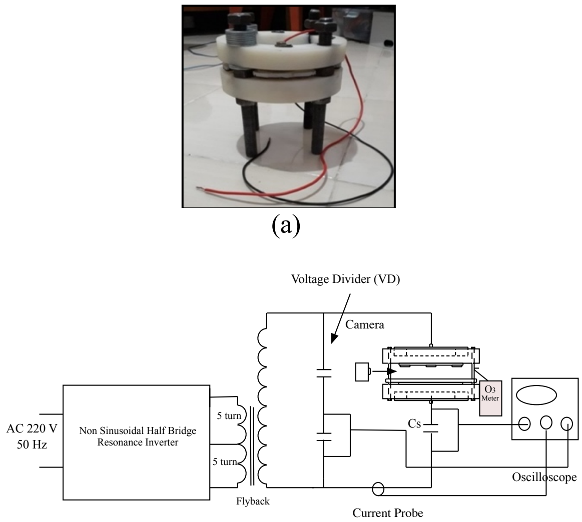



Fig. 1. The schematic diagram of high voltage power supply

In this ozone generator, there was iron plate with dimension 10x10 cm square as anode and cathode electrodes, these plates were attached to the teflon framework. There was a solid dielectric between anode electrode and air gap and cathode electrode. Air dielectric was also known as air gap. The gap used in this test was 2 mm. Whereas the data retrieval variable was by varying or exchanging all solid dielectrics until completion of the test. The DBD construction and circuit test are presented in figure 2.




(b)

Fig.2. a. DBD construction and b. circuit test of ozone generator

Current and voltage measurement tools were carried out by connecting them to a digital oscilloscope and also connected to a laptop. An current probe was CC65 Hantek and a high voltage probe with a ratio of 1: 1000. The plasma photograps was recorded by using a mobile camera that had the AspectraMini application for Android smartphone. And it can see the spread of plasma in the gap in the ozone generator and the value of the intensity of the plasma light produced in the test. For the measurement of ozone concentration was carried out by using an ozone meter or HT-E-O3.

## III. Result and Discussions

### A. Plasma Pictures

Experiments had been carried out to obtain the plasma form on 5 types of ceramics and 2 types of granite (K 1, K 2, K 3, K 4, K 5, G 1 and G 2) using the AspectraMini application.

| K | Gap of 2 mm |
|---|---|
| K 1 |  |
| K 2 |  |
| K 3 |  |
| K 4 |  |
| K 5 |  |
| G 1 |  |
| G 2 |  |

Fig.3. Plasma pistures for all solid dielectrics

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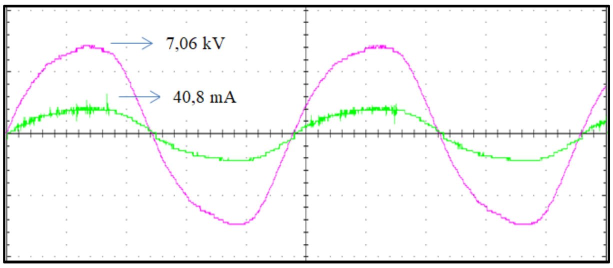
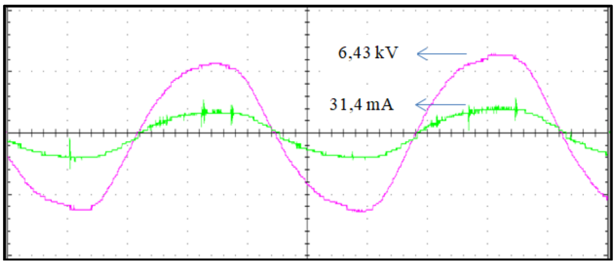
Testing were done by combining the distance (gap) between the two electrodes. The gap used for this test was 2 mm. The results of testing the plasma form are in the following fig.3. K3 and K4 and G1 were seen that the plasma distribution was tight along the surface of solid dielectric. While plasma in other ceramics and granite shows that the plasma distribution is not tight.

### *B. Voltage and Discharge Current*

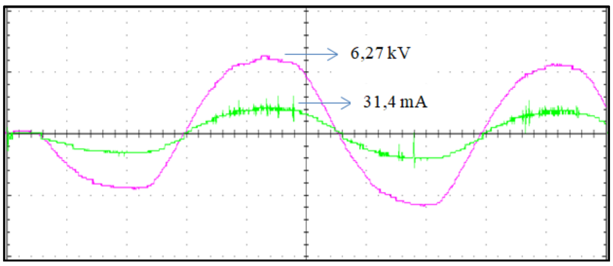
Current and voltage testing was carried out on 5 types of ceramics and 2 types of granite, the voltage was measured using a high-voltage probe and the current using a current probe. For example, for obtaining the amount of current and voltage was done at a gap distance of 2 mm for each ceramic and granite. The characteristics of voltage-current is presented in Fig.4. For all ceramics and G1, the currents had a lot of pulse in positive cycle. It is also indicated that there are many micro discharges in the gap. Whereas, in G2, the current pulse occurred in negative cycle. After testing to get the current and voltage values, the highest current value is 40.8 mA in K1 and the highest voltage value is 8 kV in G2.



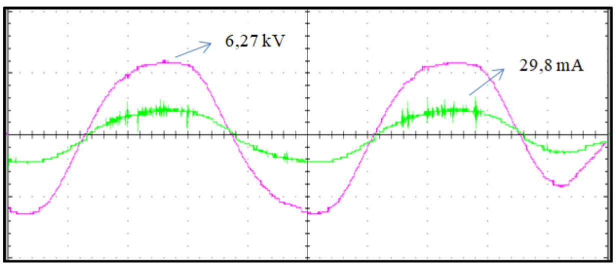

K1



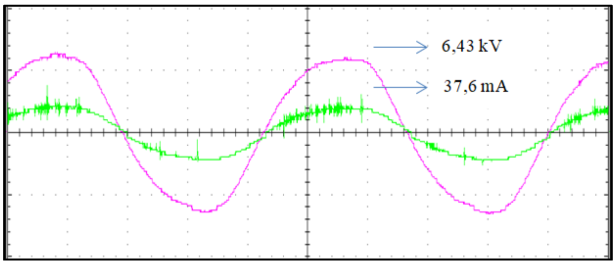

K2



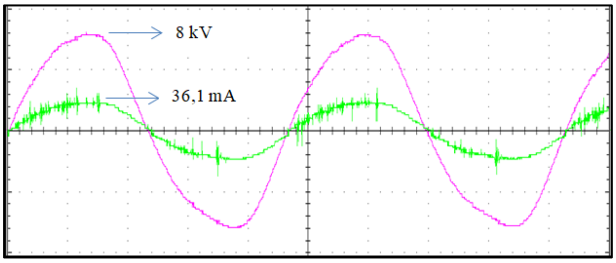

**K3**



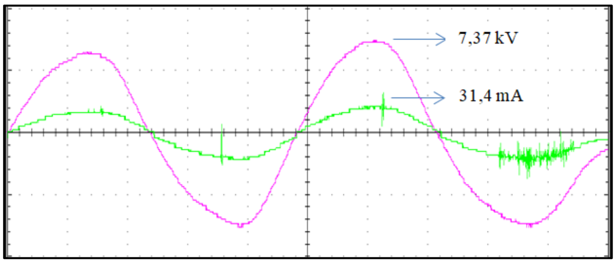

K4




K5




G1




G2

Fig.4. Voltage and discahrge current for all solid dielectrics

### *C. Ozone Production*

Measurement of ozone concentration was carried out using HT-E-O3. The unit of measure in measuring this ozone concentration is ppm (parts per million). This measuring instrument is able to measure the concentration of ozone produced up to 225 ppm. The air compressor was placed in the air gap, so the amount of oxygen sprayed is more and faster. This wind compressor was placed in the lid of the tap and must be equal or in line with the gap or distance on the ozone generator.

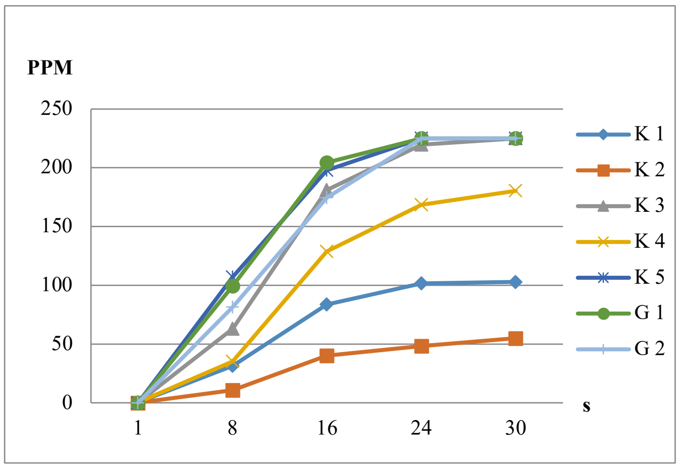



Fig.5. Ozone production for all solid dielectric combinations

It is shown that K3, K5, G1 and G2 can produce ozone gas until maksimum value after 30 seconds discharge. K1, K2, K4 was slowly increase for producing ozone.

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## IV. CONLUSIONS

The best plasma shape are K3, K5, G1 and G2 when the gap (distance) is 2 mm. Voltage and current discharge also indicated that those solid dielectric have many current pulses. Those are also produce the ozone gas until 200 ppm after 30 s discharge.


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