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Reactor Study of Double Dielectric Barrier Discharge (DDBD) Plasma for Ozonation Olive Oil

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ABSTRACT

Ozone gas is a gas consisting of three oxygen molecules and is a disinfecting agent. Olive oil is oozed using ozone gas generated by a Double Dielectric Barrier Discharge (DDBD) plasma reactor. DDBD reactors are generated with a voltage of 3.75 kV at a frequency of 50 Hz and a Duty Cycle (DC) of 30% at various oxygen gas flow rates 0.1, 0.3 and 0.6 L / minute. The parameters measured were dissolved ozone concentrations and dissolved ozone doses in olive oil. The results showed that the dissolved ozone concentration in olive oil was inversely proportional to the oxygen gas flow rate, while the dissolved ozone dose was directly proportional to the oxygen gas flow rate. At the flow rate of 0.1, 0.3 and 0.6 L / min of the concentration of dissolved ozone were 2398.8, 1672.4 and 1077.9 ppm, and the dissolved ozone doses were 1101.3, 2293.9 and 2964.8 mg O3/g of oil respectively.

Keywords: *Gas Ozone, DDBD Reactor, Olive Oil Ozonation, Dissolved Ozone Concentration and Dosage.*

INTRODUCTION

Ozone (O_3) is a gas that naturally exists on the Earth's atmosphere, has a strong odor, strong oxidizer and as a disinfecting agent [1, 2]. Ozone molecules are very reactive and have a very short life span. Ozone will return to oxygen in 20-30 minutes [3]. Therefore, ozone technology is an environmentally friendly technology. Ozone can be produced in several ways, namely electrical discharge, ultraviolet arc [4] and electrochemistry [5]. There is a development of electrical discharge, namely the Double Dielectric Barrier Discharge (DDBD). The DDBD reactor can simultaneously produce two uniform plasma zones on the two sides of the dielectric plate, thus achieving an enlarged plasma area and high energy efficiency [6,7]. In addition, DDBD also produces higher ozone concentrations [8], and avoids rust because the air does not experience direct contact with the two electrodes.

Ozonated olive oil is formed by bubbles of ozone gas in oil with a portion of 65-85% oleic acid

[9,10]. Ozonated oil leads to the formation of trioxolane, lipid peroxide and aldehyde in ozonatedolive oil that is cytotoxic to microorganisms, thus used for wound healing [11]. Calculation of the value of concentration and dosage of dissolved ozone in olive oil is the first step in determining its influence on parameters contained in oil such as peroxide numbers, acid numbers and viscosity thus these parameters affect the healing of certain wounds in humans.

The dissolved ozone concentration in oil is the difference between the ozone concentration in the oil before it is oozed and after ozonation. Similarly, the dissolved ozone dose is the difference between ozone doses before and after ozonation.

MATERIAL AND METHOD

Set-up Experiment

The reactor that will be used is the Double Dielectric Barrier Discharge (DDBD) reactor. The Figure 1 below shows schematic cross-section of the DDBD reactor

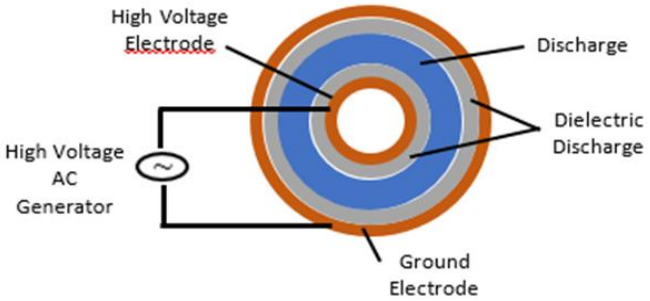

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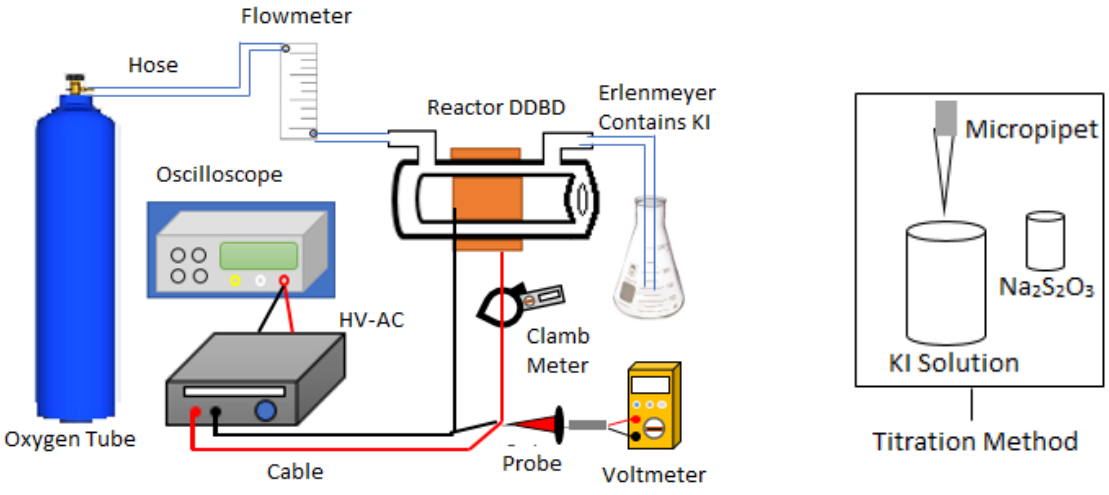
Figure 1.Schematic cross-section of the DDBD reactor

The reactor is connected to an AC voltage source of 3.75 kV. Inner electrodes with a length of 12.56 cm (coated with pyrex tubes forming a cylinder) and outer electrodes with a length of 25.12 cm (coated with the pyrex tube forming a cylinder). Both are made of copper plate with a width of 12.5 cm. The diameter of the inner and outer pyrex tubes are 2 cm and 4 cm respectively, the distance between the pyrex tubes is 0.5 cm. The length of pyrex tube on the outer electrode and the electrode in DDBD is 16.5 cm. The two electrodes are connected to a High Voltage Alternating Current (HV-AC) source that has been coupled with the ammeters and probes. The HV probe was connected to a voltmeter in order to know the value of the voltage used as seen in the Figure 2 (a) below.



a **b**

Figure 2. Research equipment scheme (a) DDBD reactor tool scheme (b) titration method

The High Voltage AC is connected to the oscilloscope to regulate and measure the value of the frequency and duty cycle that will be applied to the High Voltage AC. At the end of the two sides of the reactor, two small pipes that function as input and output gas are present. The gas put into the DDBD reactor is oxygen with a flow rate of 0.1, 0.3 and 0.6 L / minute. Then the result gas from the reactor is ozone gas dissolved into Kalium Iodide (KI) solution to calculate the value of ozone concentration and ozone dose by titration method using a solution of Sodium Thiosulfate ($Na_2S_2O_3$). Titration method can be seen in figure 2 (b). The Equation 1 below is used to measure ozone concentration.

$$C_{O_3} = \frac{M_r\, V\, N}{2\, v\, t} x1000 \quad (1)$$

Where C_{O_3} is ozone concentration (mg/L) or (ppm), M_r molarity of $Na_2S_2O_3$, V is volume of the $Na_2S_2O_3$ solution (mL), N is normality of $Na_2S_2O_3$ (mol/L), t is time (min), v is oxygen flow rate of (L/min). Ozone capacity calculation uses the Equation 2 below.

$$Cap = C\ x\ v \quad (2)$$

Cap is ozone capacity (mg/minute), C is ozone concentration (mg/L), and v is oxygen flow rate (L/minute). Whereas ozone dose measurement uses the Equation 3 below.

$$D = Cap\ x\ t \quad (3)$$

D is ozone dose (mg), Cap ozon capacity (mg/minute), and t is time (minute). The time used for the DDBD reactor study in calculating the concentration and initial dose of ozone gas is 2 minutes.

Ozonated Olive Oil

After calculating the concentration and dosage results of the DDBD reactor at the flowrate of 0.1, 0.3 and 0.6 L / min, then this value is calculated as the initial concentration of ozone gas, then used for treatment of olive oil. The time given for treatment is 14 hours. Olive oil ozonation process can be seen in the Figure 3 below.

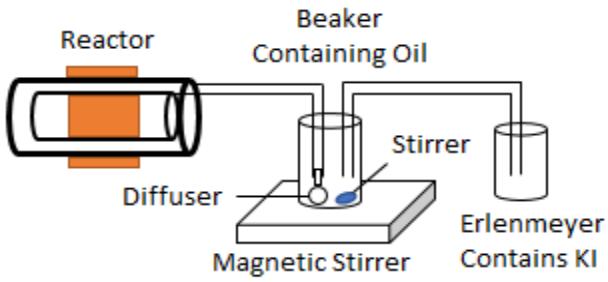


Figure 3. Scheme of olive oil treatment

Ozone gas from the DDBD reactor is poured into olive oil. Ozone gas bubbles are formed by a diffuser located at the end of the hose. Ozone stirring in oil uses a magnetic stirrer. Treatment is carried out within 14 hours. Ozone gas that is not dissolved in oil is captured by KI solution.

RESULT AND DISCUSSION

During the oil ozonation process, the ozone gas which is insoluble in oil will come out through the hose and is captured by the KI solution, the process looks like in figure 3. This result is calculated as the ozone concentration which is wasted or insoluble in oil. The difference between the initial concentration of ozone and wasted ozone concentration is called the concentration of ozone dissolved in oil. As with dissolved ozone doses, the difference between the initial ozone dose and the wasted ozone dose captured by the KI solution is referred to as the ozone dissolved in oil. The results of the dissolved ozone concentration and dissolved ozone dose were calculated by the Equations 4 and 5 below respectively.

$$C_t = C_1 - C_2 \quad (4)$$

$$D_t = D_1 - D_2 \quad (5)$$

C_t and D_t are ozone concentration and dissolved ozone doses in oil, C_1 and D_1 are initial ozone concentrations and crew ozone doses before ozonation, C_2 and D_2 are ozone concentrations and

doses of ozone that are wasted or not dissolved in oil. The unit of dissolved ozone in oil is expressed in mg O_3 / g of oil. The mass of oil used is 91.44 g. The results of the study are shown by the Figure 4 below.

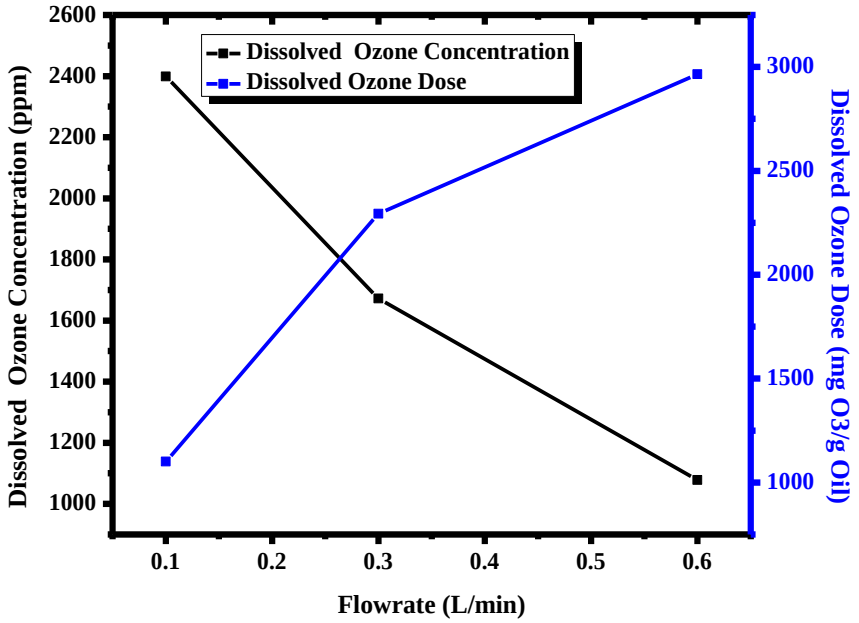


Figure 4. Concentration and Dissolved Ozone Doses as Flowrate Functions

From Figure 4 above it can be seen that at the flow rate of 0.1, 0.3 and 0.6 L / min of the concentration of dissolved ozone were 2398.8, 1672.4 and 1077.9 ppm, and the dissolved ozone doses were 1101.3, 2293,9, and 2964.8 mg O_3 / g of oil respectively.

CONCLUSION

Dissolved ozone concentration is inversely proportional to the oxygen gas flow rate given while the dissolved ozone dose is directly proportional to the oxygen gas flow rate given.

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