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# Determination of Ion Mobility in EHD Flow Zone of Plasma Generator

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**Abstract.** Determination has been carried out for ion mobility in EHD flow zone generated using a pin-concentric multiple ring electrodes and a pin-single ring electrode used as a comparator. The pin needle was made from stainless steel with a tip diameter of 0.18 mm. The concentris multiple ring electrode in form three/two concentric ring electrodes which made of metal material connected to each other. Each ring of three concentric ring electrode has a diameter of 24 mm, 16 mm and 8 mm. And each ring of two concentric ring electrode has a diameter of 24 mm and 16 mm. Single ring electrode has a diameter24 mm. The all ring has same of width and thickness were 2 mm and 3 mm. EHD was generated by using a DC high voltage of 10 kV. Pin functional as an active electrode of corona discharge while the all ring electrodes acted as ions collector and passive electrodes. The experimental results show that the ion current is proportional to $V^2$ according to calculations by Chouelo for hyperbolic-field approach. Ion mobility obtained from the quadratic polynomial fitting of experimental data were current and voltage as well as Choelo formulation. The results showed that the mobility of ions in the EHD flow zones utilizing pin-consentric multiple ring electrode larger than utilizing pin-single ring electrode. Pin-three Consentic ring electrode has the largest of ion mobility

**Keyword:** EHD flow zone, Pin-three/two concentric ring electrodes, Ion mobility

## INTRODUCTION

An electrohydrodynamic (EHD) flow due to a positive corona discharge have been carried out primarily for the pin-ring electrode configurations [1-3]. The EHD flow is also known as corona, electric, or ionic wind [4]. Applications of ion mobility in EHD flow zone in the technology as an integrated chip cooling technique for Laptops with EHD Pump [5-7]. Another application of EHD flow is for mikrofan [8] and as the dryer for the biscuit industry [9,10]. Devices that use ionic wind flow or EHD flow by corona discharge has many advantages such, the EHD flow requires no moving parts and provides flexibility in the form of channels and free from mechanical vibration and acoustic noise.

EHD flow due to positive corona discharge can be formed by providing positive polarity on pin electrode and negative polarity on the electrode ring/multi consentric ring. Moving electrons from the three/two concentric ring electrodes to the pin electrodes will be able to ionize the atoms or molecules of air between the electrodes. Ionization occurs around the pin electrodes, due to the influence of the electric field. Ions of ionization results will flow or move toward the three/twoconsentric ring electrode through the flow (drift region). The flow of these ions will cause the ion current is called saturation current unipolar [11].

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In this study, we have investigated ion mobility in EHD flow zone produced by the electric corona discharge in the pin-concentric multiple ring configuration, utilizing a pin electrode as a corona discharge electrode. By monitoring the corona discharge current-voltage characteristics and the ion mobility in EHD flow zone, we `offering an interpretation that electric field intensity of the concentric multiple rings is much higher than the single ring with a comparable size.

## EXPERIMENTAL SETUP

The initial step of determining the mobility of ions in the zone due to EHD flow is positive corona discharge ion current measurement (*I*) as a function of voltage variation (*V*) installed on the distance between the electrodes (d) remain. Furthermore, measurement data is made graphed. Graphics ion current as a function of voltage variation on the distance between the electrodes remains. This graph is called the graph characteristics of corona discharge generator. And ion mobility obtained from the calculation of the coefficients of curves.

In this study, used generators corona discharge with electrode configuration pin-three/twoconsentric ring electrode and pin-single ring electrode for comparison of results. Pin electrodes used had a diameter of 0.18 mm and a length of 50 mm. While the diameter of the electrode three concentric rings of magnitude, from the smallest ring for the biggest ring, each 24m,16mm and 8mm. And the diameter of the electrode two concentric rings of magnitude 24m and 16mm. Single ring electrode is used as control of the measurement results have diameter 24 mm. The all ring has width and thickness is the same was 2 mm and 3 mm.

Experiment setup in this study include the EHD flow zone of plasma generator with a pin- concentric multiple ring electrode, high voltage power, set voltage and current measurement tools. The air flows from top to bottom, as shown in Figure 1.

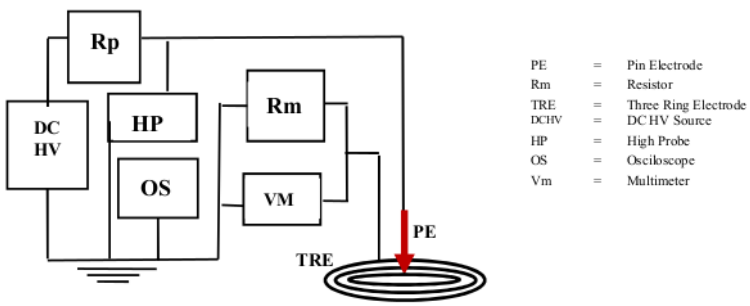


**FIGURE1**. Experiment set-up

The EHD flow generated by installing a high voltage DC 10 KV on the electrodes of the corona discharge system with a positive polarity of the pin electrodes and a negative polarity of the ring. To measure the high voltage used a high-voltage probe 1000: 1, which is connected to the CRO and to measured the ion current used multimeter.

## RESULTS AND DISCUSSION

### *I-V* characteristics

Graphs ion current*(I)* as afunction of voltage is attached *(V)* of the measured data with the distance between the electrodes remains a characteristic of EHD flow generator here in after referred to as *I-V* characteristics. *I-V* characteristics with fixed geometry factors shown in Figure. 2.

Figure 2. compares I-V characteristics of the EHD flow generator using configuration electrode pin-three/two concentric rings with pin-rings on the distance between the electrodes fixed. The spacing of electrodes successive: 6 mm and 14 mm. In graph I-V characteristics using pin-three/two consentric rings electrodes marked TR6/DR6 and TR14/SR14. While I-V characteristics using the electroda pin-rings marked SR6 and SR14.The I-V characteristics on the distance between the electrodes fixed, the greater the applied voltage then increased ion

current. This happens, either for electrode configuration pin-three/two concentric rings or the single ring. This is because the relationship between voltage and current is a parabolic function [1]. The saturation current value proportional to the square of the value of V (Is ∞ V2) .

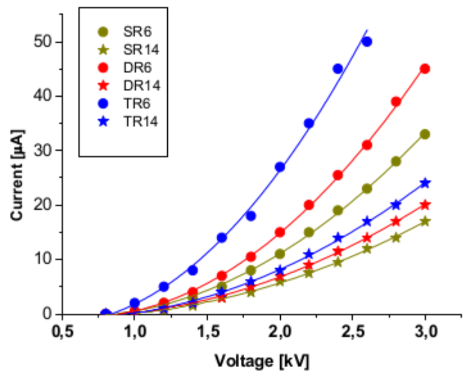


**FIGURE 2**. *I-V* characteristics

Figure.2. shown the distance between the electrodes (d) fixed, successive d=6mm and 14 mm at the same value of voltage $V$ = 3.5 kV The ion current of the EHD flow generator uses electrode configuration pin-three/two concentric ring. Ion current of pin-three/two cincentric rings higher then the pin-ring electrode. The pin-three consentric electrode has the largest of ion current. This is plasma generator that uses electroda configuration pin-three/two concentric ring having flux of electric field greater than using pin-ring electrode.

Figure.2 shown that the onset voltage at the all distance fixed is 1.0 kV. At all the distances between the electrodes, with increasing the applied voltage to the generator then the greater the ion current that are detected and accompanied by corona discharge, then at the end break down voltage. Value of ion current during breakdown voltage, using electroda configuration pin-three/two concentric ring is lower than using a pin-ring electrode. The difference in the magnitude of the ion current is due to at the breakdown voltage, the corona discharge with electrode configuration pin-three/two concentric rings required more energy than the pin-ring electrode.

## Ion mobility

In experiments, the ion current *(I)* can be measured for the applied voltage (V) of the corona discharge utilizing electrode all configuration to the distance between the point and the field of d certain. If calculated the corona threshold voltage $V_0$ then relationship of the ion current to the applied voltage shown by equation Choelo (1971):

$$I = \frac{2\mu\varepsilon_0}{d}(V - V_0)^2 \quad (1)$$

With $I$ is the ion current, $V_0$ is the voltage corona, μ is the mobility of unipolar ions, $\varepsilon_0$ the permittivity of vacuum and d is the distance between the electrodes. The flow of ions in the positive corona is positively charged ions. Using experimental data the relationship between current and voltage, and using the formulation Choelo charge carrier mobility and the rate can be determined, namely:

$$I = K(V - V_0)^2 \quad (2)$$

With,

$$K = \frac{2\mu\varepsilon_0}{d} \tag{3}$$

$K$ is a constant with units of ($C/V^2.s$). From the graph characteristics of ion current–voltage appleid of plasma generator using pin-three/two consentric ring electrodes configured (TR/DR) and pin-rings(SR) obtained K values as shown in Table1.

**Table 1.** Value of constan *K*

| *d (mm)* | *K [C/V^2.s]* | | |
|---|---|---|---|
| | ***SR*** | ***DR*** | ***TR*** |
| *6* | 3,569 | 7,983 | 11,458 |
| *10* | 3,569 | 4,909 | 5,769 |
| *14* | 2,622 | 3,175 | 4,002 |
| *18* | 1,529 | 2,662 | 2,662 |

From equation (3) obtained the value of ion mobility (μ) with units of $m^2/(Vs)$ as follows

$$\mu = \frac{kd}{2\varepsilon_0} \tag{4}$$

The graph of ion mobility in EHD flow zone for configuration electrode pin-three/two concentric rings (TR/DR) and pin-rings (SR) on the distance between electrodes (*d*) is 6 mm, 10 mm, 14 mm and 18 mm as shown in Figure 3.

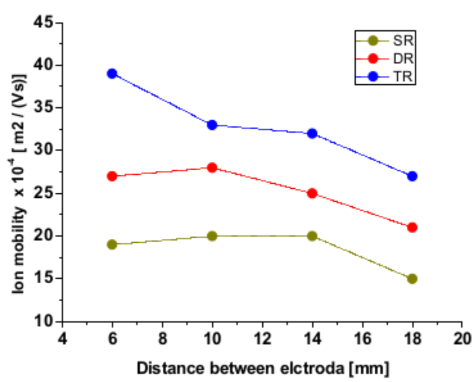


**FIGURE 3**. The graph of the ion mobility

Figure 3. shows the distance between the electrodes (d) fixed, successive d=6mm,10 mm, 14mm and 18 mm the ion mobility in EHD flow zone of plasma generator. Ion mobility utilizing Pin-three/two cincentric rings higher then the pin-ring electrode. The pin-three consentric electrode has the largest of ion current. This is plasma generator that uses electroda configuration pin-triple/double concentric ring having flux of electric field greater than using pin-ring electrode. The maximum ion mobility in the zone of EHD flow using the electrode configuration a pin-three/two consentric rings (TR/DR) and a pin-single ring electrode (SR) at distance between elctrode is 6 mm, 10 mm and 14 mm respectively. Shown that the greater number of rings in concentric multiple ring elctrode, the maximum ion mobility is achieved in a shorter distance than a single ring electrode. This means that best

performance of plasma generator utilizing pin-concentric multiple ring elctrodeis as EHD flow generator or as ion wind generator at a minimum distance.

## CONCLUSIONS

The *I-V* characteristics of plasma generator on the spacing between the electrodes fixed, ion current or ion mobility of Pin-three/two cincentric rings higher then the pin-ring electrode. The pin-three consentric electrode has the largest of ion current/ion mobility. The best performance of plasma generator utilizing pin-concentric multiple ring elctrodeis as EHD flow generator or as ion wind generator at a minimum distance.

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