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THE MEASURENMENT OF ELECTRICITY AND DIELECTRIC CHARACTERISTIC OF ONION (*ALLIUM CEPA*)

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Abstract

This experiment aimed to measurenment of the electricity and dielectric characteristic of onion (*Allium cepa*). In this study, the onion have been done through the variation of frequency and temperature. The frequency was setup in 30 different values from 100 Hz -1 MHz with the temperature are from 26 ^{0}C up to 40 ^{0}C with each increase of 2 ^{0}C. The measurement was performed on AC current in 1 kHz and input voltage is one volt. The ions through to the membrane was measured as a conductance value by using LCRmeter that connected with two pieces of AgCl electrodes on both side of the membrane. Beside that, the conductance (G) was measured by the variation temperature of the solution. The results based on the electric characteristics variation of the frequency shows that the electricity of the onion membrane from the conductance itself is tend to increase and the capacitance is decrease due to increasing of the frequency. However, the conductance and the capacitance of the soaked onion membrane is increase doe to increase of the temperature than the original onion membrane. In adddition, the increasing of conductance to temperature was plotted on ln G to $1/T$ curve. The slope or gradient of the curve is used to determine the change of the self-energy of the membrane and its pore radius. Self-energy of ion which obtained from non-washed and washed and soaked (with distilled water) membrane is respectively 7,66967 x 10^{-21} J or 0,04787 eV dan 1,2156 x 10^{-19} J or 0,7869 eV (1 joule = 6,2415 x 10^{18} eV) and the average of pore membrane radius is 2,00 x 10^{-9} meter (2,00 nm) and 1,26 10^{-10} meter (0,126 nm). Based on the results the onion membrane could be a good membrane for established the electrisity anf the dielectricity.

Keyword: *Electrical conductivity, Dielectric constant, Onions*

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1. Introduction

Membrane is a thin skin or a thin sheet of material that serves to separate the material based on the size and shape of the molecule. The membrane also hold the components of the material that has a larger size than the pores of the membrane and skip the parts on its smaller size. The membrane has a thickness is about 100µm to several millimeters (Pabby *et* al., 2009). The membrane is also can be a separator that separates the two phases as a transport restraint the selectivity of various chemical compounds. The mixture might be homogeneous or heterogeneous, symmetric or asymmetric structure, solid or liquid, have a positive or negative charge, and also polar or neutral.

Previous studies have found that the plant tissue can changes the permeability in membranes of biological materials by pulsed electrical fields. Membrane has wide applications such as sea water desalination with *reverse osmosis* membranes, recycling of waste water by using a membrane ultrafiltration and microfiltration . In previous studies on the cell membrane is the use of membrane biology conducted by Seda Ersus and Diane Barett on the integrity of onion membrane that are getting treatment of electrical field pulses . On onion , they found that the impact of the electric field pulse on the membrane tissue onions can caused by an increased of ion and its may affect to the changes of membrane permeability (Ersus *et al*.,2010).

The performance of a membrane is determined by the surface structure of the membrane sublayer. The electrical properties of the membrane can be seen by measuring the inductance, capacitance, impedance and the coefficient loss (Nuwaiir *et al*., 2009). The Membrane characteristics is determined the effectiveness of the membrane in a process of separation and purification. It is very important to improve the efficiency of a system that uses membrane as one of its components. Therefore, we need an adequate membrane characterization methods (Mamat *et al*.,2000).

In this study aims to determine the characterization of the onion membrane that will be done by testing on electrical and dielectric properties such as conductance, capacitance, and the membrane porosity of onions.

2. Materials and Methods

2.1. Membrane preparations

The onion membrane is the inner and outer *fleshyscaleleaf* layer (layer that separates between midrib / leaf meat with midrib others). The membrane were taken carefully to prevent the leakage and the damaged. The size of the membrane is taken approximately 2.5 cm x 2.5 cm. After that the membranes soaked in a solution of distilled water for 12 hours, and the other membran was not soaked as an initial.

2.2. Measurements of Conductance, Capacitance and Porosity

Pieces of parallel plate was made of pcb board with a size of 2.5 cm x 2.2 cm. The test *chamber* with a hole area is about 0.9 cm^2. The *chamber* type was used a horizontal type. The conductance and capacitance was measured using LCRmeter Hioki300 models with a range of 5 MHz. The conductance was measured on a medium chamber, with KCl electrolyte solution flowing across the membrane. Part of the active layer membrane exposed to the KCl solution with a molarity higher at 1 mM and the other side with a solution of 0.1 mM KCl, where the flow of ions to flow from high to low molarity.

The amount of the ions flow through the membrane was measured as its conductance by using LCRmeter connected with 2 pieces AgCl electrodes on both sides of the membrane. The measurements were taken at a frequency of 1 kHz AC with an input voltage is about 1V. The conductance (G) was measured by the variations of temperature in a solution (T) 26-40 ^{0}C. To heat the KCl solution, the *chamber* was placed on a *waterbath* glass filled a pure water, which is heated using electric heaters. The measurement processes of the conductance has shown in Figure 1. The increasing of the conductance against the temperature was plotted in the ln G curve against 1 / T. However, the slope or the gradient of the curve is used to determine the changes of energy self-membranes and the radius of the membrane pore.

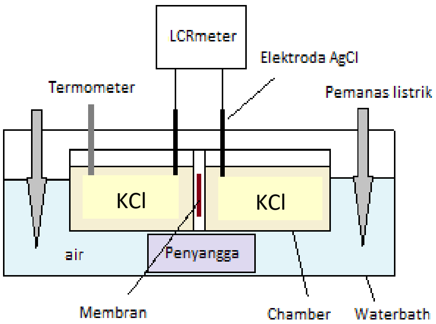

Figure 1 Measurement of membrane conductance

Changes of energy-self (ΔU) membrane is determined by the following equation:

Where B is the gradient of a graph of the conductance (ln K) against the temperature ($1 / T$), and k is the Boltzmann constant value (1.38662 x 10^{-23} J / K). The radius size of the membrane pore obtained using the following equation

$$b = \frac{z^2 q^2 \alpha}{4\,\pi\,\varepsilon_0 \varepsilon_m \Delta U} \qquad 2$$

with:

b = Radius of the membrane pores (m)
z = Ion valency (untuk KCl = 1)
q = Ion charge (1.6 x 10^{-19} C)
α = Geometric and dielectic constant (approach 0.2)
ε_o = Vacuum permittivity / diffusion constant (8.85 x 10^{-12} F/m)
ε_m = Dielectric constant of the membrane (Cahyani *et al.*, 2012).

3. Result and Discussion

3.1. Effect of Frequency on the Conductance and Capacitance

Membrane conductance values of onions which were unsoaked and soaked in distilled water for 12 hours will *increase* as the *frequency increases*, as shown in Figure 2 and Figure 3. The increases of the frequency make the movement of cargo and ions in the membrane will increase, this process will boost the mobility of the membrane so that conductivity will increase.

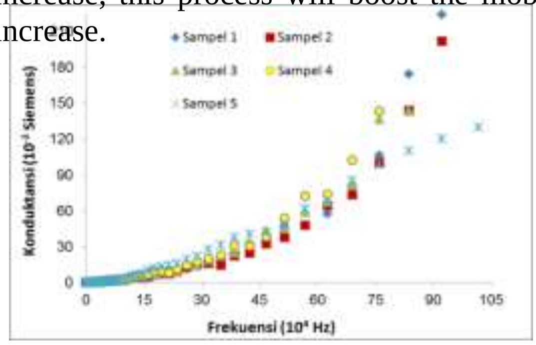

Figure 2. The relationship between the frequency and the conductance of the original onion.

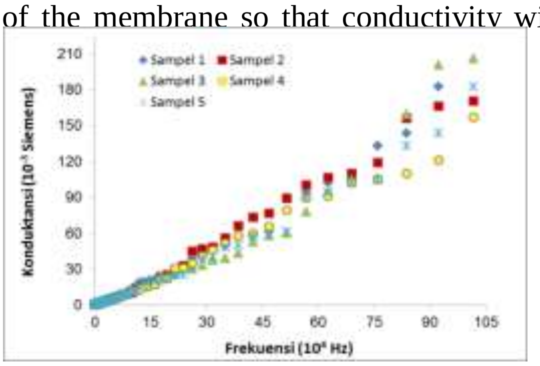

Figure 3. The relationship between the frequency and the conductance of the soaked onions.

Figure 4 shows that the conductance of the washed and soaked membrane for 12 hours in a solution of distilled water is higher than the original membrane.

It is assume that when the onion membranes are washed and soaked with a solution of distilled water, the epidermis which has a supple and pliant nature experience a reduction in flexural properties and clayed.

The membrane cell can be modeled with an electric circuit consisting of a combination of capacitors and resistors (Young *et al*., 2003)

$$\tilde{Z}_1 = \frac{1}{G_1 + \tilde{I}\omega C_1} \qquad \tilde{Z}_2 = \frac{1}{G_2 + \tilde{I}\omega C_2} \qquad \tilde{Z}_M = \frac{1}{G_m + \tilde{I}\omega C_m}$$

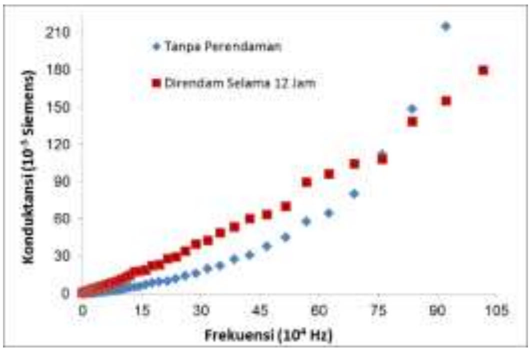

Figure 4. The conductance of the soaked and the original onion.

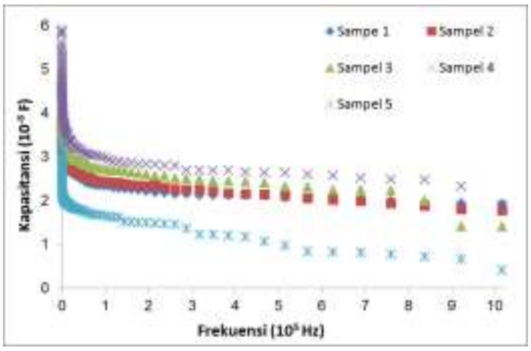

Figure 5. The relationship between the frequency and the capacitance of the soaked and the original onion.

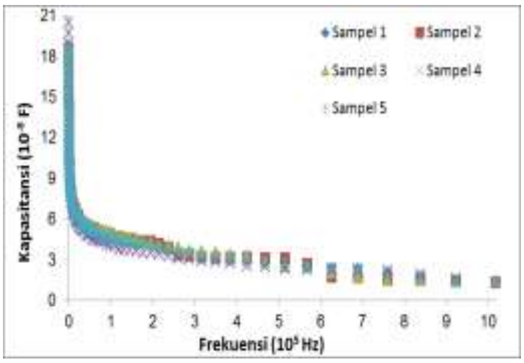

Figure 6. The relationship between the frequency and the capacitance of soaked onion.

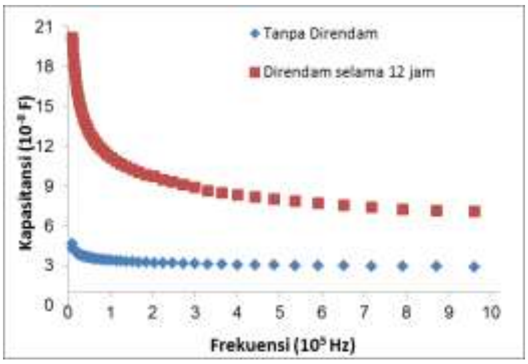

Figure 7. The capacitance of the soaked onion and the original one.

The series combined between Z_1 and Z_2 and the Z_m formulation, it will produce the membrane capacitance.

$$C_m = \frac{G_2^2 C_1 + G_1^2 C_2 + \omega^2 C_1 C_2 (C_1 + C_2)}{(G_1 + G_2)^2 + \omega^2 (C_1 + C_2)^2} \qquad 3$$

where the $\omega = 2\pi f$ is the angular of the frequency so that the capacitance depends on the frequency.

Frequency have affected on the material itself (in this case is the membrane onion), i.e There are more waves are transmitted each second by the increasing of the frequency. The mechanisms in parallel has been occured when the direction of the electic current has been turned around before the capacitor is fully charged. So it was rapidly discharging cargo of the capacitor electrode plate.

The onion membrane are stored between the two plates which have a capability to adjust the condition of the electrode plate. Furthermore, the charge of the density on the surface of the material caused by the shift of the molecular charges around the electrode surface due to external electric fields that cause polarity. The decreasing of the charge density in the onion membrane characterized by a decrease in capacitance, are shown in Figure 4 and Figure 5. This make the total of electric field of the material becomes large. The electric field of this material is inversely proportional to the dielectric constant, thereby the onions impaired dielectric constant than the density of free charge in the chip of the electrode.

3.2 Effect of Temperature on Conductance Value

Figure 8 shows that the data generated plot tend to be in a straight line with a negative slope for the original membrane and membrane which is soaked in a solution of distilled water for 12 hours in a row at -553.12 and -8766.3 respectively. The slope values proportional to the value of the energy barrier. This indicates that the value of the conductance has dependence on temperature with energy change ΔU themselves to the membrane without soaked and washed and soaked in a solution of distilled water in a row of 553.12 J / K and 8766.3 J / K.

The rise of the temperature increase the kinetic energy, which can be concluded that the faster movement of ions will increase the membrane conductance values and it is ultimately will affect the characteristics of the membrane it self. By using equation (1), a slope of the curve is used to determine the energy self-ion obtained for unsoaked and unwashed membranes and soaked membranes in a solution of distilled water in a row of 7.66967 x 10^{-21} J or 0.04787 eV and 1.2156 x 10^{-19} J or 0.7869 eV (1 joule = 6.2415 x 1018 eV) respectively.

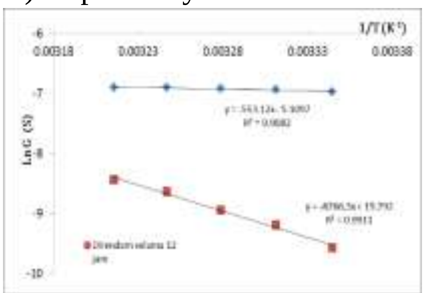

Table 2 The range of the pressures, pore, and the molecular weight of the various types of membranes . [Mulder (1996), Porter (1990)]

Membrane type	Pressure (atm)	Pores (µm)	Molecular weight (g/mol)
Mikrofiltrasi	0,5 – 2	0,1 - 10	500000
Ultrafiltrasi	1,0 – 3	0,001 – 0,1	5000

Osmosis Balik	8,0 – 12,0	0,0001 – 0,001	50

Figure 8. The relationship between temperature and the conductance of the soaked and original onion.

4. Conclusion

The temperature variation test show that the higher the value of the temperature the higher the membrane conductance value. Conductance value is plotted against the temperature rise in the curve ln G against 1 / T. The slope or gradient of the curve is used to determine changes in energy self-membranes and membrane pore radius. The amount of energy self-ion obtained for unsoaked and unwashed membranes and soaked membranes in a solution of distilled water in a row of 7.66967 x 10^{-21} J or 0,04787 eV and 1,2156 x 10^{-19} J or 0.7869 eV (1 joule = 6.2415 x 1018 eV) and the average membrane pore radius obtained of 2.00 x10^{-9} meters (2.00 nm) and 1.26 x 10^{-10} meters (0.126 nm). Refers to the classification of IUPAC, the membrane onions in this study is a group of microporous membranes

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