Analysis of an Effect Broadcasting the Capacity Value in Super Capacitors Graphene

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ANALYSIS OF AN EFFECT BROADCASTING THE CAPACITY VALUE IN SUPER CAPACITORS GRAPHENE

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ABSTRACT

This paper described an effect of the collector cross-sectional area on the capacitance value of four graphene super capacitors using a digital multimeter In the first experiment on a super graphene square capacitor with a cross-sectional area of 25 cm2 produced a capacitance of 0.842 µF. The need for large amounts of energy can be stored and sent, reducing energy consumption and changing sustainable energy sources is needed. Especially super capacitors, referred to as double-layer electric capacitors (EDLCs) or ultra capacitors, meet the standards for high-powered applications. Use of super capacitors is very rare because of the high cost of manufacture. Thus it is evident that the collector cross-sectional area of a super capacitor affects the value of capacitance. The greater the cross-sectional area of a super capacitor, the greater the capacitance value

KEYWORDS: Graphene, Activated Carbon, Polyurethane, Phosphoric Acid (H3PO4), Super Capacitors & Cross-Sectional Area

Original Article

I. INTRODUCTION

Need of energy in the amount that is new. Energy must be able to be stored and sent at any time. Super capacitors can be made using activated carbon and polymer electrolytes made from Phosphoric Acid (H3PO4) so that they can be used to find the capacitance value of a super-capacitor (Pasaribu et al., 2015).

Graphene became a reality and led to Geim and Novoselov being awarded the Nobel Prize in 2010. This preparation method still makes the highest quality crystals, but is only useful for labscale experiments and prototyping because it is not possible to improve the process (Pasaribu et al., 2020).

In 2014, graphene was successfully synthesized and obtained graphene which has the best electrical conductivity (0.00021S / cm) with an ultrasonication time of 120 minutes and a hydrothermal holding time of 12 hours (solly Aryza, 2017).

Results obtained are the highest capacitance properties obtained at ultrasonification 90 minutes and 160oC hydrothermal temperature that is equal to 491.36 F / gr. This study discusses the effect of collector cross-sectional area on the capacitance value of graphene super capacitors (Malwiya & Rai, 2015).

II. LITERATURE REVIEW

2.1 Relevant Literature Review

The graphene arrangement of carbon atoms in a hexagonal framework resembles a honeycomb that forms a sheet as

thin as one atom (O et al., 2016).

Much research has been done both to model various properties of graphene and to make and use it.

A method used to synthesize graphite oxide in this study is the modification of the Hummer Method. This method uses various chemical reactions to oxidize graphite to graphite oxide. This oxidizer will oxidize graphite to produce graphite oxide.

2.2 Graphene

Graphene is rubber-like and resistant to liquid and gas (Motor et al., 2006). Because of its neat structure graphene can be used as a super-detailed filter, because large atoms do not pass between them

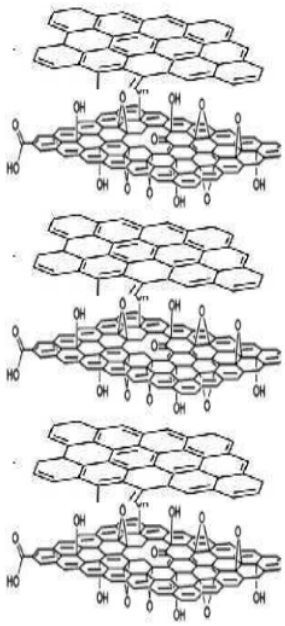


Figure 1: Pore Structure Grapheme Oxide.

Amorphous activated carbon with a surface area of about 300 to 2000 m2 / g. This very large surface area because it has a pore structure, these pores that cause activated carbon has the ability to absorb. The absorption capacity of activated carbon is very large, which is 25-1000% to the weight of activated carbon (Irsyad, 2016).

2.3 Activated Carbon (Activated Carbon)

Activated charcoal is a carbon that has a good absorption ability to anions, cations, and molecules in the form of organic and inorganic compounds, both in the form of solutions and gases. Rubber fruit shell is a solid waste that has the potential for a variety of uses, including the raw material for making activated carbon. The properties of activated charcoal are as follows:

A. Chemical Properties

Carbon nanopores are activated carbon that has pores on the nanometer scale. The large pore distribution in the nanopore,

the very large surface area, and the large capacitance causes this material to be chosen as the electrode material in the supercapacitor (Warsono & Ruksamin, 2014).

B. Physical Properties

Activated carbon is used as an adsorbent because it has a selective, porous adsorption power so that the surface area of a large mass unity and has a strong binding power to substances that want to be separated physically or chemically (Kee et al., 2013).

C. Structure

Activated carbon is an amorphous carbon with a surface area of about 300 to 2000 m2 / g. This very large surface area because it has a pore structure, these pores that cause activated carbon has the ability to absorb. The absorption capacity of activated carbon is very large, which is 25-1000% to the weight of activated carbon.

D. Absorption

There are several factors that influence absorption of activated charcoal, that is, the nature of activated charcoal, the nature of the components it absorbs, the nature of the solution and the contact system.

2.4 Polyurethane

Polyurethane is a mixture or isolation result between rubber and plastic so as to obtain a dissolving material that has the advantage of being very friction resistant, thirst resistant, resistant to some mild chemicals, stable in cold and hot temperatures.

Polyurethane (PUR and PU) is a polymer consisting of organic units joined with carbamate (urethane). While most polyurethane is a thermosetting polymer that does not melt when heated, thermoplastic polyurethanes are also available.

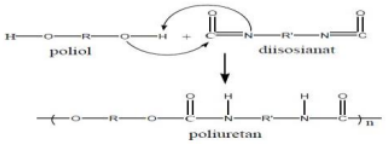


Figure 2: Urethane Bonds and Polyurethane Formation Reactions.

Non-isocyanate-based polyurethanes (NIPU) were recently developed as a new class of polyurethane polymers to reduce health and environmental problems. The coefficient of heat propagation produced by polyuretahane is only around 0.017 (Nugroho & Facta, 2014). That is a sign that after being plastered with polyurethane, the heat capacity that is passed on to a building is very small. Because fluorinated polyurethane contains a high percentage of fluorine-carbon bonds, which is the strongest bond among all chemical bonds (Irsyad, 2016).

2.5. Super Capacitors

Super capacitor m electrochemical capacitors which have a high energy density compared to conventional capacitors. Energy storage based on a double layer is accumulated by the ion charge that occurs between the electrodes / electrolytes with some differences.

Electrostatic dual-layer capacitors use carbon electrodes or their derivatives with electrostatic double-layer capacitance which is much higher than electrochemical pseudocapacitance.

Electro-chemical pseudocapacitors using metal oxides or conducting polymer electrodes with high electro-chemical pseudocapacitance with additional metal capacitance

Hybrid capacitors, such as lithium-ion capacitors, use electrodes with different characteristics: one shows most electrostatic capacitance and most other electrochemical capacitance.

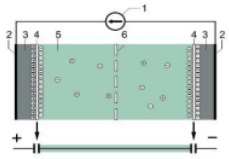


Figure 3: Typical Construction of Super Capacitors.

Typical Supercapacitor constructs are:

- Resources
- Collector
- Polarized electrodes
- Helmoholtz double layers
- Electrolytes that have positive and negative ions
- Separator

Electro-chemical capacitors (super capacitors) consist of two electrodes separated by permeable ion membranes, and electrolytes that connect the two electrodes electrically. Total capacitance C total is given by the formula:

$$C_{total} = \frac{C_1.C_2}{C_1 + C_2} \quad (2.1)$$

For asymmetric capacitors, total capacitance can be taken as an electrode with smaller capacitance (if C1 >> C2, then total C ≈ C2) is formed separating the ions in the electrolyte and also in the distribution of the mirror charge with the opposite popolarity as figure 2.4

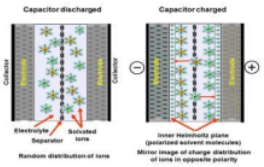


Figure 4: Structure and Function of Capacitors Double Layer.

The standard formula for conventional plate capacitors discovered by Michael Faraday can be used to calculate super capacitor capacitance:

$$C = \varepsilon \frac{A}{d} \quad (2.2)$$

C = Capacitance

ε = dielectric permitivity (F / m)

A = Las Penampang (m2)

d = Distance between the two plates (m)

One of the electrodes used in supercapacitor devices is carbon electrodes. Capacitance is defined as comparison between the charge stored in the capacitor (Q) and the electric potential (V) given:

$$C = \frac{Q}{V} \quad (2.3)$$

$$Q = C \times V \quad (2.4)$$

C = Capacitance (F)

Q = Electric charge (Coulomb)

V = Voltage (Volt)

For conventional capacitors directly proportional to the area on each surface and inversely proportional to the distance between charges:

$$C = \varepsilon_o \varepsilon_r \frac{A}{d} \quad (2.5)$$

C = Capacitance

ε_o = Permitivity of vacuum (8,854x10-12 F / m)

ε_r = dielectric constant of the material

To measure density can be calculated as the amount per unit mass or per unit volume. The energy E stored in a capacitor is directly proportional to the capacitance:

$$E = \frac{1}{2} C (V)^2 \quad (2.6)$$

E = Electrical energy (Joules)

C = Capacitance (F)

V = mains voltage (Volt)

To determine the power of the capacitor, we must consider that the capacitor is generally represented as a series circuit with an external resistance R, as shown in figure 2.5.

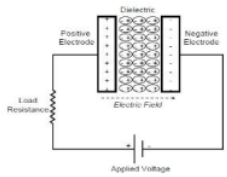


Figure 5: Conventional Capacitors.

Voltage during not charging is determined by this resistance. When measured at the impedance adjustment (R = ESR), the maximum power for a capacitor is given by:

$$P_{maksimum} = \frac{V^2}{4 \times ERS} \quad (2.7)$$

Therefore, according to equations 2 and 3 this will cause an increase in capacitance and energy in super capacitors.

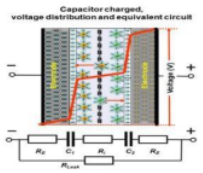


Figure 6: Ilustration of Super Capacitor Distribution.

III. ANALYZED AND RESULT

The Materials used for the design of graphene super capacitors:

- 8 Aluminum Plates with a thickness of 1mm as a collector media.
- Graphene powder as an electrode.
- Polyurethane resin as an adhesive between aluminum plates and graphene.
- Activated Carbon (activated carbon) is used to support the absorption of electrical energy as an electrode.
- Phosphoric Acid as an electrolyte16. Tissue is used as a separator to separate positive and negative electrodes.
- The cable is used as a negative and positive collector leg.
- Plastic wrap as supercapacitor cover.
- Duct tape as a second cover layer and as a super capacitor adhesive.
- Gun nails as connecting cables and aluminum plates.

3.1. Stages of Material Design Manufacturing Procedure

Place the ice bath on the hot plate magnetic stirrer, and put the jar into the ice batch, then add 50 ml of sulfuric acid into the jar, after one hour add 1.5gr graphite powder stirrer for one hour, after one hour add 4.5gr of pottasium permanganate slowly, because there will be a chemical reaction, the temperature of the plate must be maintained below 20 0C and stirer for 3 hours, remove the ice bath after 20 minutes stirrer, after 3 hours stirrer added 55 ml of distilled water into the a drop

to avoid excessive chemical reactions resulting in heat, so we have to set the plate temperature of 50 0C to start the oxidation process.

Then stirrer to change color to brown which shows the formation of graphene oxide. Add another 100 ml of distillation solution to oxidize graphite if any are left behind. In the final step, add 5 ml of hydrogen peroxide to remove excessive amounts of potassium permanganate to stop the reaction.

3.2 Equipment Testing

The test carried out in this chapter is testing the capacitance values of some graphene super capacitors which have different cross-sectional areas using a digital multimeter. 4 Graphene Super Capacitors that will be the test sample are as follows:

- Graphene Super Capacitor egi in terms of shape.
- Graphene shape Super Capacitors Circle.
- Super Capacitor Graphene Isosceles Triangle shape.
- Graphene shape Super Capacitors Hexagonal.

Graphene super capacitors that are made have a gap between pieces of 1 mm. By using a digital multimeter that has a tolerance of ± 5%, the capacitance values of the data are obtained as follows:

Table 3.1: Capacitance Values Obtained using a Multimeter

No.	Shape Super Capacitor *Graphene*	Capacitance (μF)
1	Square	0.842
2	Circle	0.146
3	Triangle	0.195
4	Hexagonal	0.408

Testing is done to find out what the value of capacitance in graphene super capacitors square which has a size of 5x5 cm. By using equation (8) the cross-sectional area values on graphene square super capacitors are obtained:

- Area = s x s
- Area = 5 cm x 5 cm
- = 25 cm2

Then the capacitance value is tested using equation (5), where the value of ε_r for similar separator which is a polymer material is assumed to be 10,000 through previous research [35]. So we get the results:

$$C = \varepsilon_o \varepsilon_r \frac{A}{d}$$

$$C = 8{,}885\ x\ 10^{-12} Fm^{-1}.1000.\frac{25\ cm^2}{1\ mm}$$

$$C = 8{,}885\ x\ 10^{-12} Fm^{-1}.1000.\frac{25\ x\ 10^{-4} m^2}{1\ x\ 10^{-3} m}$$

$$C = 8{,}885\ x\ 10^{-12} Fm^{-1}.2{,}5\ m$$

$$C = 0{,}221\ x\ 10^{-6}F$$

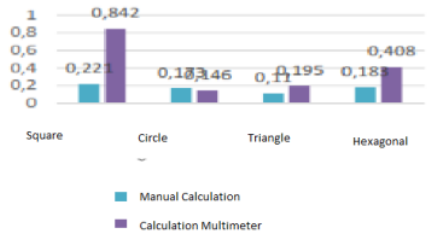
3.3. Comparison of Calculation Results Capacitance and Multimeter Results

After the capacitance value data is obtained from manual calculations and measurements using a digital multimeter, the data is then entered into a table along with the cross-sectional area data of each graphene super capacitor that has been measured. The comparison table that has been made is included as follows

Table 3.2: Comparison of Capacitance Value in Manual Calculation with Multitester Measuremen

No.	Shape Super Capacitor Graphene	Cross Section	Capacitance (μF)	
			Manual Calculation	Calculation Multimeter
1	Square	25	0,221	0,842
2	Circle	19,625	0,173	0,146
3	Triangle	12,5	0,110	0,195
4	Hexagonal	20,784	0,183	0,408

The comparison of the Capacitance Value of the Manual Calculation with the Multimeter Measurement is then visualized into a comparison chart to make it easier to see the difference in data, which is attached as follows:



Figures 7: Comparison of Calculation Capacitance values with Multitester Measurements.

From the graph above we can see that graphene super capacitors with the best capacitance are of the square type. Square graphene super capacitors with a cross-sectional area of 25 cm2 have a capacitance of 0.842 μF. Thus it has been proven that the collector cross-sectional area of graphene super capacitors influences the capacitance value.

As a reference, previous studies using aluminum plates measuring 4x7 cm or a cross-sectional area of 28 cm2 were obtained by rectangular graphene super capacitors with capacitance values of 230 μF using LCR meters.

IV. CONCLUSIONS

Based on research that has been planned and designed several conclusions can be obtained:

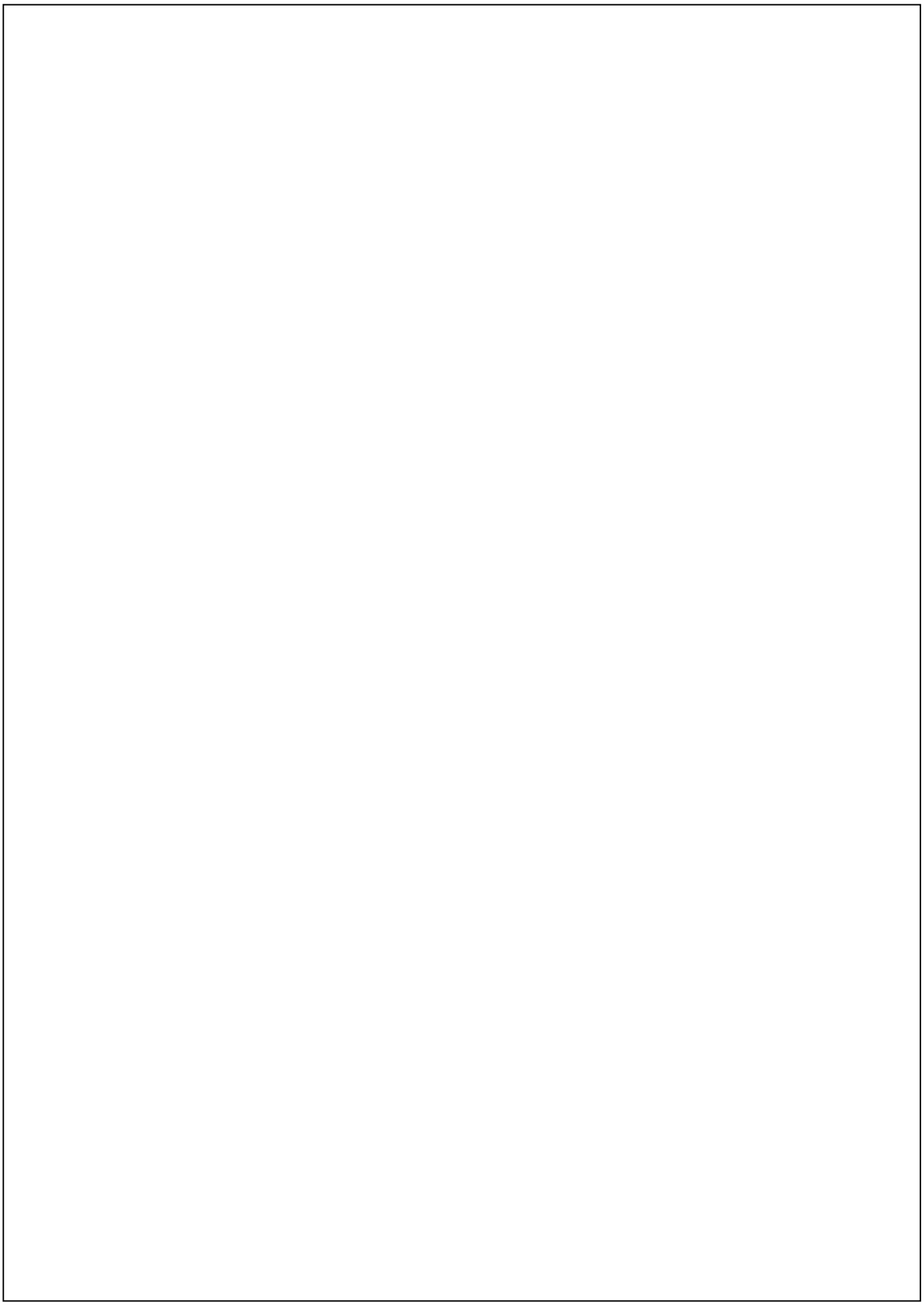
- Graphene super capacitors in the research are designed in several stages. Synthesis of graphene as an electrode obtained by mixing H2SO4, H3PO4, KMnO4, Graphite Powder, which will be dried for 12 hours at 110^{o}C.
- Making electrodes by mixing activated carbon on the surface of graphene synthesis fluid. Using H3PO4 as an electrolyte by applying it to the surface of the electrode by mixing activated carbon on the surface of graphene synthesis fluid. Use H3PO4 as a separator. Then wrap the prototype sper graphene capacitors using a vacuum palette
- The type of graphene super capacitor which has the best capacitance is a square shape super capacitor measuring

5x5 cm with a cross-sectional area of 25 cm2 producing a capacitance of 0.842 μF.

- The cross-sectional area of a super capacitor influences the capacitance value. The greater the cross-sectional area of a super capacitor, the greater the capacitance value.

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