



# CAPACITANCE VALUE ANALYSIS OF COMPOSITES OF ACTIVATED CASHEW SHELLS CHARCOAL AND IRON SAND

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## ABSTRACT

This study aims to determine the use of iron sand extract and cashew nut shell activated charcoal in the capacitor manufacturing process and determine the effect of grain size on the capacitor capacitance with electrodes from a composite of iron sand extraction and activated charcoal from cashew nutshells. The sample preparation of cashew nutshell activated charcoal was carried out by carbonation and activation methods at a temperature of 700 °C and continued by extracting iron sand. The results of the iron sand extract were then crushed using a mortar, followed by varying the mass fraction of iron sand starting at 40%, 60%, and 80% for each particle size (60 mesh, 100 mesh, and 200 mesh). Then composite the iron sand extract and activated charcoal mixed for 4 hours, and added 0.7 mL of LiNO<sub>3</sub> 1M solution. The analysis showed that the highest specific capacitance was found in the 200 mesh grain size, namely 0.0695 F/g.

Keywords: capacitance; capacitor; iron sand; cashew nutshell.

## INTRODUCTION

Various terms are used to solve the problem of energy storage for electricity begins with the discovery of the battery for the first time. The electrochemical energy storage device is used on a limited basis due to its small capacity and costs in its manufacture expensive<sup>[1,2]</sup>. Another settlement of the same problem is with the discovery of a capacitor. As energy storage devices, capacitors have been widely used in the fields of electronics and transportation, such as digital computer telecommunication systems<sup>[3]</sup>. Some of the advantages of capacitors compared to conventional batteries are a longer lifetime, simple principles and models, short charging times, safety, and high power density, 10 -100 times greater<sup>[2,4]</sup>.

From the technical side, capacitors have a relatively large number of cycles (> 100,000 cycles)<sup>[5]</sup>, high energy density, great energy saving ability, simple principle, and easy construction. Meanwhile, in terms of user-friendliness, capacitors increase safety because there are no corrosive materials and less toxic materials. To determine the capacitance of capacitor carbon made of various kinds of carbon materials, including a composite for extraction of iron sand and activated charcoal from cashew nut shells, they are not toxic well as easy to obtain

and do not contain chemicals. Ease to acquire iron ore and cashew nut shell supported from the abundance of iron sand and the cashew nutshell in Indonesia from Sabang to Merauke.

Iron sand is an iron ore that is used as raw material for the steel industry. It is also used in the cement industry and the titanium oxide industry<sup>[6]</sup>. One of the areas that contain lots of iron sand is Laompo Rural District Subdistrict Batauga Buton. From results of research conducted by Haslinda<sup>[7]</sup>. Iron sand found in the Laompo area, Batauga District, South Buton Regency, contains elements such as Silicon Dioxide ( $\text{SiO}_2$ ) 33,756%, Magnesium Oxide ( $\text{MgO}$ ) 6,617%, Ferric Trioxide ( $\text{Fe}_2\text{O}_3$ ) 12,613%, Iron ( $\text{Fe}$ ) 8,829%, Calcium Oxide ( $\text{CaO}$ ) 4,058%, and Aluminum Oxide ( $\text{Al}_2\text{O}_3$ ) 8,096%. The potential of iron sand is related to the properties and characteristics of the magnetic minerals contained in iron sand.

Cashew nutshell activated charcoal is a cashew plant that produces fruit and seeds. Cashew nuts have skin, which is a potential agricultural waste and is not used by the community<sup>[8]</sup>. Cashew nut production in Indonesia in 2011 was 148,144 tons. If 1 kg of cashews produces 0.3 kg of peanut shells, then the amount of skin (shell) cashew nuts produced in 2011 was 44443.2 tons<sup>[9]</sup>. It is proved by many cashew nut shell waste that is abundant<sup>[10]</sup>. One study supports that the activated charcoal and  $\text{TiO}_2$  composites were made by Aslan<sup>[11]</sup>. Results of research<sup>[11]</sup> this study identified that the capacitance value in the mass variation fraction of  $\text{TiO}_2$  was 0.7 grams for each mesh size; the resulting capacitance values were 0.0207 F/g and 0.0853 F/g and 0.102 F/g, respectively. Furthermore, in several studies it was written that activated charcoal from activated cashew nut waste has great potential in the field of energy storage with a high energy density of  $11.2 \text{ Wh Kg}^{-1}$ , as well as excellent long-term cycle retention with 97.1%. The resulting capacitance value is greater along with the shrinking of the activated charcoal grain size<sup>[12]</sup>. Various problems were faced, namely how to use iron sand extract and cashew nut shell activated charcoal in making capacitors? How is the effect of grain size on the capacitor capacitance with electrodes from a composite of iron sand extract and activated charcoal from cashew nut shells? Seeing this, it is necessary to have a study to determine the optimization of iron sand extract and cashew nut shell activated charcoal in the process of making capacitors.

Based on this description, the researchers are interested in conducting a study on utilizing a composite of iron sand extract and cashew nut shell activated charcoal in the manufacture of capacitors. This study aims to determine the effect of grain size on the capacitor's capacitance with electrodes from a composite of iron sand extraction and activated charcoal from cashew nutshells. The study is expected to provide contributions and references in terms of using natural materials as one of the basic materials for the manufacture of capacitors.

## METHODS

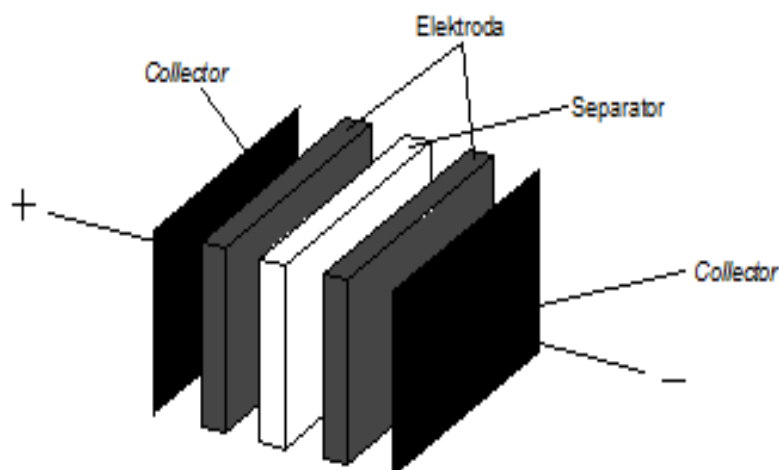
Sampling site (cashew shells) in Labuan Village and iron sand collection in Laeya Village, North Wakorumba District, North Buton Regency, and Southeast Sulawesi.

Activation of cashew nutshell charcoal (samples) will be carried out at the Laboratory of Forensic Biology, Faculty of Mathematics and Natural Sciences, Halu Oleo University. Measurement of the capacitor capacitance of iron sand extract and activated charcoal from cashew nut shells (samples) will be carried out at the Laboratory of the Department of Physics Education, Faculty of Teacher Training and Education, Halu Oleo University.

The tools and materials used in this study were as follows: Cashew shell, sieve, plastic samples, label paper, electric furnaces, connecting cables, PCB chips, iron sand, pyrolysis retorts, alcohol,  $\text{LiNO}_3$  solution, mica sheets, resistors, potentiometers, oscilloscopes, Copper wire, glue gun, and copper plate.

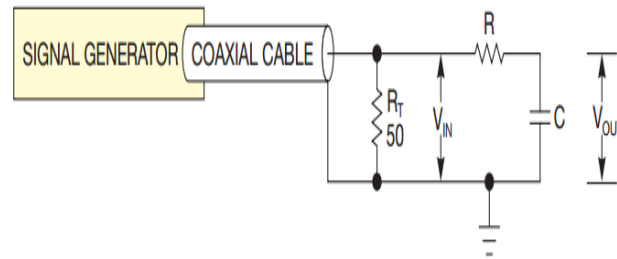
The sample was first washed with distilled water and then dried in the sun so that the sample was dry and could be easily extracted. The dried samples were separated from other materials to obtain iron sand. The extraction is carried out using a permanent magnet wrapped in paper. The sand that is attached to the magnet is separated into a beaker which is first given alcohol. Furthermore, scouring samples was done by using a mortar. The extracted sample was mashed using a mortar. After the iron sand is fine enough, the sample is filtered. This filtering is done by using a sieve of 60 mesh, 100 mesh, and 200 mesh. The prototype capacitor manufacturing stage consists of (1) the preparation of a 1.0 M  $\text{LiNO}_3$  electrolyte solution used for fishing in the capacitor's initial use. Lithium-ion ( $\text{Li}^+$ ) is obtained by dissolving lithium nitrate ( $\text{LiNO}_3$ ) salt in distilled water as a solvent to produce  $\text{Li}^+$  and  $\text{NO}_3^-$  ions with a degree of ionization and is a strong electrolyte; (2) Making a capacitor container with a length of  $\pm 2$  cm, a width of  $\pm 1.2$  cm, and a height of  $\pm 1.5$  cm. The two sides of the capacitor are perforated as a path to insert the copper wire and are connected to a copper plate with a size of 1.3 mm x 0.8 mm, which is used as the capacitor's leg. Then insert a copper plate on both sides of the container as a collector on the capacitor. Then insert 1.3 mm x 0.8 mm mica in the middle of the capacitor container as a capacitor separator, which in the middle has been sawed to the bottom of the container and glued using hot glue; (3) Each composite sample of iron sand extract and cashew nut shell activated charcoal, each measuring 60 mesh, 100 mesh, 200 mesh for each sample tested, weighed 0.8 grams, then mixed with 14 drops of  $\text{LiNO}_3$  electrolyte solution (0, 7 mL). Furthermore, the mixed sample is put into the capacitor container and then tested. Furthermore, the capacitor capacitance measurements were carried out for each sample. This research was conducted by varying the particle size from 60 mesh, 100 mesh, and 200 mesh with variations in the mass fraction of iron sand starting at 40%, 60%, and 80%.

For capacitance are measurements on the capacitor with a container measuring length ( $P$ )  $\pm 2$  cm, width ( $L$ )  $\pm 1.2$  cm, and height ( $T$ )  $\pm 1.5$  cm. The collector used is a copper plate with a cross-sectional area ( $A$ ) of  $1.04 \text{ cm}^2$  with a mica paper separator having a cross-sectional area  $1.04 \text{ cm}^2$ . The capacitor design of the composite activated charcoal and iron sand of cashew nut shells can be seen in Figure 1.



**Figure 1.** Capacitor electrode circuit developed

Measurement of capacitance using an RC circuit utilizes a signal generator as a frequency (4.545 KHz) source connected to the potentiometer B50K and an oscilloscope for reading the input voltage wave  $V_{in}$  (Ch.1) and the output voltage  $V_{out}$  (Ch. 2) the RC circuit. By adjusting the signal generator's frequency value to get the rated voltage on the capacitor ( $V_{out}) = \frac{1}{2} V_{in}$ , 1 k $\Omega$  resistor is connected in series with the test capacitor.



**Figure 2.** Capacitor RC Circuit

The data analysis technique is used analytical analysis (analysis without errors) to calculate the capacitor's capacitance from a composite of iron sand extract and activated charcoal from cashew nutshells. The research data obtained for capacitance measurement used equation (1).

$$C = \frac{\sqrt{3}}{2\pi fR} \quad (1)$$

Where:  $C$  = capacitance;  $f$  = frequency;  $R$  = resistance

## RESULTS AND DISCUSSION

The measurement results of the super capacity composite of iron sand and cashew nut shell activated charcoal, with variations in the size of grains of iron sand and activated charcoal 60 mesh, 100 mesh, and 200 mesh. The results of the specific capacitance measurement (F/g) of the composite capacitor of iron sand and activated charcoal can be seen in Table 1.

**Table 1.** Specific Capacitance Parameters (F/g) of Capacitors

No	Sample Grain Size	Mass fraction of iron sand (%)	C (F)	CSP(F/g)
1.	60 mesh	40	0,0196	0,049
		60	0,0138	0,03
		80	0,0092	0,02
2.	100 mesh	40	0,0275	0,0687
		60	0,0093	0,02
		80	0,0047	0,0117
3.	200 mesh	40	0,0092	0,023
		60	0,0278	0,06
		80	0,0046	0,0115

The analysis results show (Table 1) that the highest capacitance value is obtained in the mass fraction of iron sand 60% with a particle size of 200 mesh with a capacitance value of 0.0695 F / g. It confirms that the particle size affects the resulting capacitance value. It is supported by research Aslan<sup>[11]</sup> that particle size affects the capacitance value.

The capacitance value produced by compositing iron sand extract and iron sand activated charcoal is quite high. The specific capacitance value produced from the composite extract of iron sand, activated charcoal, and cashew seed shells can be seen from the specific capacitance value, which can increase due to the large surface area produced by activated carbon. The 200 mesh particle size has a high enough capacitance value (Figure 2) due to a larger surface area and a high particle density level. It is between the activated charcoal of the cashew nutshell and the resulting particle, and the iron sand extract is very tight. In contrast, Liu et al.<sup>[13]</sup> mentioned that the large power density in the capacitor is due to the large surface area of a material. Whereas Adila et al.<sup>[14]</sup>; Ahmad et al.<sup>[15]</sup> reported that the size of 200 mesh affects the capacitance of an electrode.

In line with the study conducted by Kurniawan et al. [16] using pepper shell waste, the highest capacitance value was obtained at a grain size of 200 mesh. The grain size of 200 mesh has a much larger adsorption surface area and a much larger pore size. The pore size affects the capacitor electrode's specific capacitance value, representing the capacitor electrode's ability to be synthesized<sup>[17]</sup>. Itoi et al.<sup>[18]</sup> explained that the use of activated carbon from natural materials (organic) could be used to maximize capacitance. Porous carbon materials are the best materials for achieving high capacitance because they combine high electrical conductivity, chemical and physical stability with surface pore structures. Thus allowing the electrode prepared with properties that are optimized to maximize the capacitance<sup>[19–21]</sup>.

However, something is interesting that at the size of 60 mesh and 100 mesh, as the grain size increases, the resulting capacitance value decreases. This decrease is characterized by a decrease in the resulting capacitance value, although the decrease is not significant (Figure 3).

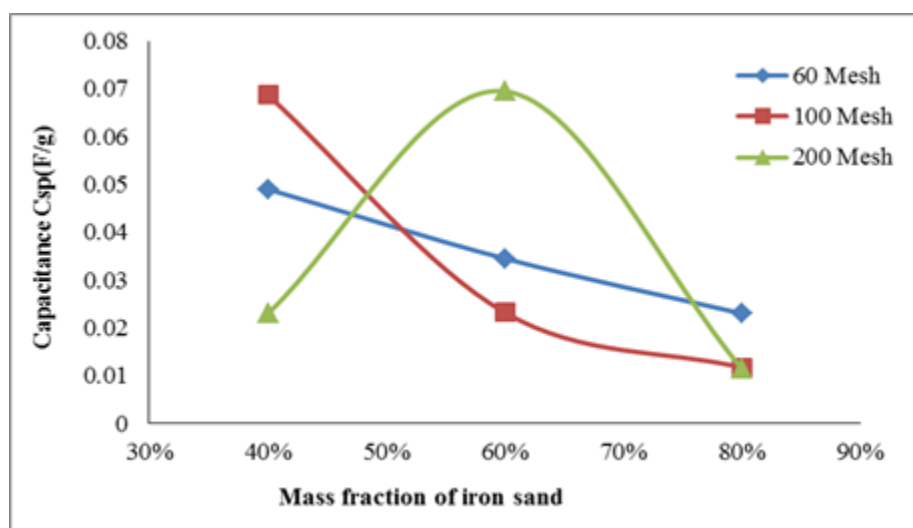


Figure 3. Capacitor circuit developed

Based on Figure 3, it can be seen that the change in the capacitance value at each grain size (mesh). The decrease in the capacitance value is most likely influenced by the mass fraction given. At the mesh size of 60 & 100 mesh, the mass fraction used is 40% sand, 60% activated charcoal and 60% iron sand, and 40% activated charcoal. It shows that in that section, activated charcoal is more dominant than iron sand. When is exposed to a certain temperature, some parts, such as hydrocarbons, resulting in a reduced surface area. Pineiro-Prado et al.<sup>[22]</sup> suggested that the available surface area is related to the wettability of the electrode porosity, which arises as a result of the combination, on the one hand, of the polarity and size of the solvent molecules and the ions that make up the electrolyte, and on the other hand, the pore size and the surface chemistry of the electrodes. The electrode pores must show the same size as the electrolyte ion to avoid sieving effects and increase the surface capacitance.

However, from the preliminary study results, there are still several challenges in developing the capacitor system, which needs to be considered as energy density. In addition, electrode materials with high conductivity, pore size, temperature stability & high surface area are the most important parts in developing super cases<sup>[23]</sup>.

## CONCLUSION

Based on the investigation results, it was found that: (1) One of the uses of iron sand extract and cashew nut shell activated charcoal is that it can be used as a base for making capacitors; (2). The amount of capacitance capacitor composite extract iron ore and cashew nut shell

activated carbon increases with decreasing grain sizes of activated charcoal; (3) Variations in mass and grain size affect the capacitance value with the highest capacitance value being 60% mass fraction with a size of 200 mesh (0.0695 F/g). The implication of this study is the discovery of composite materials as an alternative base material in the preparation of capacitance electrodes. The study is an initial development that will be tested with various advanced methods.

## ACKNOWLEDGMENTS

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