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Utilization of young coconut fiber activated carbon with pre-carbonization variations as a supercapacitor electrode

Winda Nofriyanti, Awitdrus*
Department of Physics, Universitas Riau, Pekanbaru 28293, Indonesia

*Corresponding author: awitdrus@lecturer.unri.ac.id

ABSTRACT

A supercapacitor is an electrochemical device that integrates power supply and charge storage capabilities. The primary constituents of a supercapacitor consist of electrodes, separator, electrolyte, and current collector. This work focuses on the production of carbon electrodes using coconut fibre biomass waste. The carbonisation process is carried out at three different temperatures: 200ºC, 225ºC, and 250ºC. The resulting samples are labelled as SC-200, SC-225, and SC-250, respectively. The production of Carbon electrodes involves multiple procedures, including pre-carbonization, chemical activation using a $ZnCl_2$ activator at a concentration of 0.5 M, followed by carbonisation using N_2 gas at a temperature of 600ºC, and physical activation using CO_2 gas at a temperature of 750ºC. The mass reduces by 23.01%, 27%, and 36.51% following pre-carbonization. The sample with the greatest density value is SC-225, which has a mass loss percentage of 41.66%. The results of cyclic voltammetry indicate that the SC-225 supercapacitor cell has the maximum capacitance value of 199.82 F/g. To summarise, the SC-225 temperature can function as an activated carbon electrode that enhances the performance of the supercapacitor electrode.

Keywords: Electrode carbon, pre-carbonization, supercapacitor, young cocofiber

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INTRODUCTION

The increase in energy consumption along with the progress of economic development poses a serious threat to humans and the environment, encouraging us to innovate regarding energy [1-3]. Rapid technological developments in fields such as electronics, digital telecommunications, and transportation have caused an increase in energy consumption [4,5]. The currently available energy sources are not commensurate with the energy needs that must be met, making people think critically about alternative energy. Alternative energy is becoming important as a relatively cheap, renewable, and abundantly available source to help meet energy needs [6-8].

The energy requirement that is currently most widely used is electrical energy. Electrical energy is an important factor in supporting development. The demand for electrical energy continues to increase so a breakthrough energy storage device is needed [4,9]. Some of the energy storage devices used today are batteries and capacitors. However, several researchers have found energy storage devices with higher capacitance. This storage medium is called a supercapacitor. Supercapacitors or in other words double-layer electrochemical capacitors are used as energy storage devices which have advantages including a long life cycle, fast charge-discharge, high power density, safe when used, and good temperature characteristics [10-12]. Supercapacitor electrodes include the materials used, namely nanotubes, carbon graphene, and activated carbon [13-15].

The biomass currently used to make supercapacitor carbon electrodes is coconut fiber. Indonesia is the largest coconut producer. Coconut plantations in Indonesia cover 3.5 million hectares, and 17.7 million tonnes of coconuts are produced annually. The products produced are copra and crude oil for various applications, but coconut production produces quite a lot of agricultural waste, one of which is young coconut fiber. It is known that coconut production contributes around 35% of the 6.2 million tons of coconut fiber produced as waste in Indonesia every year [16-18]. This study focuses on the role of the influence of pre-carbonization temperature on mass loss, density properties, and specific capacitance of the resulting supercapacitor cells.

RESEARCH METHODS

This research method explains the procedure for making supercapacitor cells. Young coconut fiber was obtained from Pangkalan Kerinci, Pelalawan Regency. Cut the coconut fibers into several pieces and then separate the fibers with a cork. Coconut fiber is dried in the sun for 2 days until the mass obtained remains constant. 30 grams of coconut fiber was weighed and placed in a pre-carbonized tube, then the bottom was covered with aluminum foil to make it airtight. After that, the tube was put into an electric oven. Refining the samples was carried out using a mortal and pestle, however, to produce a smoother sample a ball milling process was required for ± 20 hours.

The fine samples were then sifted using a 53 µm sieve. Chemical activation uses the activating agent $ZnCl_2$ 0.5 M. Then, pellets are printed using a hydraulic press. Carbonization was carried out using N_2 gas at a temperature of 600ºC and physical activation using CO_2 gas. Next, the sample was soaked in a beaker containing distilled water, then dried, and then polished to reduce the thickness and diameter of the carbon pellets. Several components for making supercapacitor cells are a separator, electrolyte, current collector, and carbon electrodes from young coconut fiber. Electrochemical characterization of activated carbon electrodes was carried out by making a supercapacitor cell and calculating it using cyclic voltammetry.

RESULTS AND DISCUSSION

Density Analysis

Figure 1 is the result of carbon pellet density data before and after pyrolysis. In carbonization, stronger carbon atomic bonds are formed which changes the young coconut fiber sample into pure carbon and increases the carbon content [19]. The decrease in density is also caused by physical activation, where CO2 reacts with carbon to form a new pore structure due to erosion of the walls between the pores. Shows that all samples experience a decrease in density as the pre-carbonization temperature increases. Samples with higher pre-carbonization temperature variations cause erosion of the carbon walls, reducing the surface area and pore structure formed before pyrolysis. The effect of higher temperatures can also destroy existing pores so that they accumulate and cover the previous surface area.

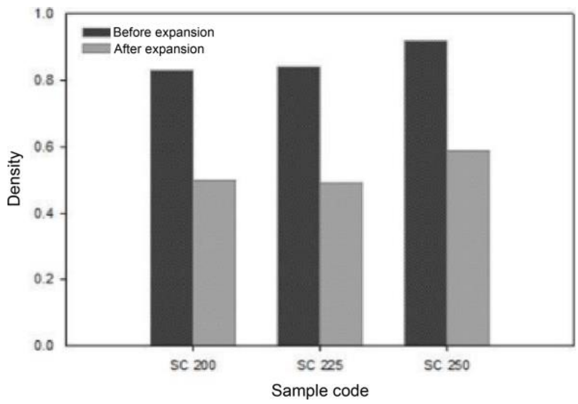

Figure 1. Percentage density graph of carbon electrodes.

Figure 1 shows the largest shrinkage percentage of the electrode in the SC-225 sample and the lowest density shrinkage in the SC-250 sample. During the carbonization process, the density decreases due to elements other than carbon disappearing. SC-225 experiences more shrinkage because the bonds between the elements oxygen, hydrogen, and carbon are weakened. Pre-carbonization is the first step that needs to be considered because the optimum temperature provides better density.

Cyclic Voltammetric Analysis

A voltammogram curve is formed as in Figure 2 with a scanning rate of 2 mV/s for each pre-carbonization variation. In the voltammogram curve, you can also see the charging current (Ic) and discharging current (Id) values. The current density value, namely the charge current (Ic) is the current that occurs when the charge comes from the electrolyte which breaks down into ions when the voltage is increased and the discharge current (Id) is the current when the voltage is lowered. Cyclic voltammetry curves have a rectangular closed area and some curves show a slight increase in current or have a hump in the curve with a certain voltage range [20]. The SC-225 curve has a larger curve area and width than SC-200 and SC-250, which indicates that the pre-carbonization temperature has a great influence on the specific capacitance results obtained. The optimal temperature, the thin thickness of the separator, and the carbon electrode mass are closely related to obtain the specific capacitance value. The specific capacitance of the SC-225 is an optimal temperature which has a specific capacitance value of 156.48 F/g.

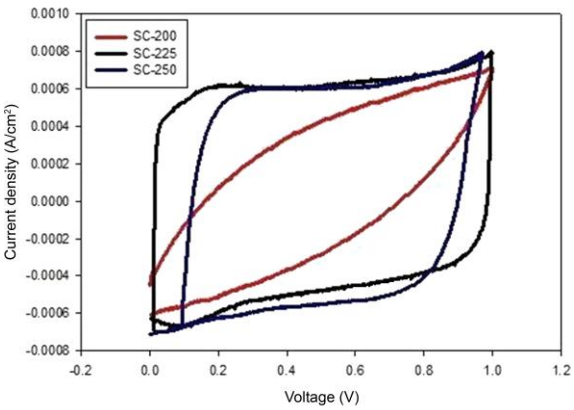

Figure 2. Cyclic voltammetry voltammogram curve of 1 mV/s.

CONCLUSION

P The research that has been carried out can conclude that young coconut fiber biomass can be used as a supercapacitor cell electrode. The SC-225 sample had the largest percentage of density shrinkage at 41.66% and the specific capacitance value was 199.82 F/g.

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