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EDLC Type Supercapacitor Electrode Based on Banana Peels Activated Carbon

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ABSTRACT

The objective of this research is to observe the influence of surface area and porosity of banana peels activated carbon on the specific capacitance value as EDLC (*Electrochemical Double Layer Capacitor*) type supercapacitor electrode. Banana peels have been carbonated at temperature of 600ºC and activated using KOH with concentrations of 5%, 15%, 25% and 35% at temperature of 700ºC. The activated carbon banana peels mixed with PVAc (Polyvinyl acetat), added with aquades and compressed on pressure of 80 kN. The specific capacitance has been carried out using galvano static method with KOH 30% as electrolyte solution. Pore size of membrane activated carbon was observed using Scanning Electron Microscopy (SEM) and Brunnuaer-Emmet-Teller (BET) method for surface area of activated carbon. The result shows that the optimum value at activation using KOH 25% with large surface area 540,454 m^2/g, porosity 17,89 μm and specific capacitances of 72,93 F/g. The increase of large surface area and porosity activated carbon has affected to specific capacitance value, so activated carbon of banana peels potentials as electrode material supercapacitor EDLC type.

Keyword: activated carbon; porosity; specific capacitance; and supercapacitor electrode.

INTRODUCTION

In this modern era, the demand of highly efficient technology based on the recycling and reuse materials has been increased. One of the instance is the utilization of banana peels as a main component of an advanced electronic device. Banana peel contains 47,45% carbon, 5,68% hydrogen, 0,37% nitrogen, 19,01% oxygen and 15% moisture [1]. This is based on innovation by changing the function of banana peels that is considered as waste into activated carbon that can be used as electrode material EDLC type supercapacitor.

Supercapacitor is an alternative energy storage device that has high energy density with the ability to store the large energy that designed to be more sustainable and friendly environmental. Supercapacitor has high power density, virtually unlimited life cycles, long shell life, fast charge, high efficiently, wide temperature operation range, safety and more life time than batteries [2-3]. Supercapacitor has been used extensively in many field, such as medical electronics, electrical utilities and transportation.

Currently, the electrode material of supercapacitor using porous carbon as natural ingredients with carbonization [4]. Activated carbon potentially used as an electrode material EDLC type supercapacitor because it has large surface area, high porosity and density, inexpensive, easy to process, stable electrochemical property and perfect cycle property [5-9]. The carbon structure, the porosity, and the surface area are the key to increase a specific capacitance

value and the important properties for an ideal electrode material [10]. The surface area and porosity of activated carbon can be controlled with physical and chemical parameters such as annealing temperature and variety of activator.

In this research, we study on activated carbon made from banana (*Musa paradisiaca L.*) peels because it also contains organic compounds such as hemicellulose, lignin, and cellulose, which means it constitutes highly percentage of carbon chains [11]. Manufacture of banana peels activated carbon were processed by carbonization and activation using KOH because it can provide a large surface area and porosity of activated carbon [9]. To obtain an activated carbon with large surface area and porosity, we will make variety concentration of KOH.

Activated carbon are used as electrode EDLC type supercapacitor. EDLC (*Electrochemical Double Layer Capacitor*) consists of two electrodes, a separator and an electrolyte solution. The specific capacitance is characterize using galvanostatic method. The specific capacitance value of EDLC type supercapacitor depends on the surface area, electrolyte solution and the pore-size distribution of activated carbon [12, 6, 13]. So, The Influence of surface area and porosity on specific capacitance of activated carbon banana peels will be studied and it will be the best activated carbon that can be used as material electrode for EDLC type supercapacitor.

EXPERIMENTAL

Materials Electrode EDLC type Supercapacitor

The materials had used in this research are banana (*Musa paradisiaca L.*) peels, KOH, 5 M HCL, 0,5 gram PVAc and aquades. Banana peels has been activated at temperature of 600ºC for two hours and sifted by a sieve of 400 mesh. The activated carbon was activated by KOH (5%, 15%, 25% and 35% concentrations) with activation temperature of 700ºC. Variety concentration of KOH were aimed to know the difference of surface area and porosity of activated carbon. Activated carbon was immersed into a solution of 5 M HCL until the solution became yellow and colorless. It was cleaned by aquades and heated at temperature of 120ºC. Activated carbon, PVAc 0,5 gram and aquades 10 mL were mixed to press with pressure 80 kN. The resulting mixture are ready to characterize by *Scanning Electron Microscopy* (SEM) and *Quantachrome Autosorb Automated Gas Sorption Analyzer* using *Brunnuaer-Emmet-Teller* (BET) method.

Specific Capacitance Assay of EDLC type Supercapacitor Electrode

To measure the electrochemical performance of activated carbon, two pellet of activated carbon were affixed to Cu as current collector with polypropylene as a separator. Before Cu was used, it has been activated with KOH 7% and heated at temperature of 120ºC for one hour. The component of supercapacitor was immersed in KOH 35% solution and the specific capacitance was observed by using galvanostatic method. Specific capacitance of activated carbon was calculated by *E(t)* slope [14, 9]:

$$C = \frac{2It}{m\Delta E} \quad (1)$$

Where I is the discharge current, t is the discharge time, m is the mass of carbon on an electrode, and ΔE is the voltage drop in discharge.

RESULTS AND DISCUSSION

Physical Parameter of Banana Peels Activated Carbon

The characterization results of banana peels activated carbon using *Scanning Electron Microscopy* (SEM) with a magnification 4000X reveals that surface roughness is a function of KOH concentration. At KOH concentration of 5 – 25%, it is observe that surface roughness is proportional to KOH concentrations. The surface roughness itself impacts the activated carbon's porosity. The quantitative relations between KOH concentration and porosity is as follows: activated carbon with KOH 5%, 15%, and 25% has largest porosity 6,86 µm, 8,21 µm, and 17,89 µm while at 35% has largest porosity of 12 µm.

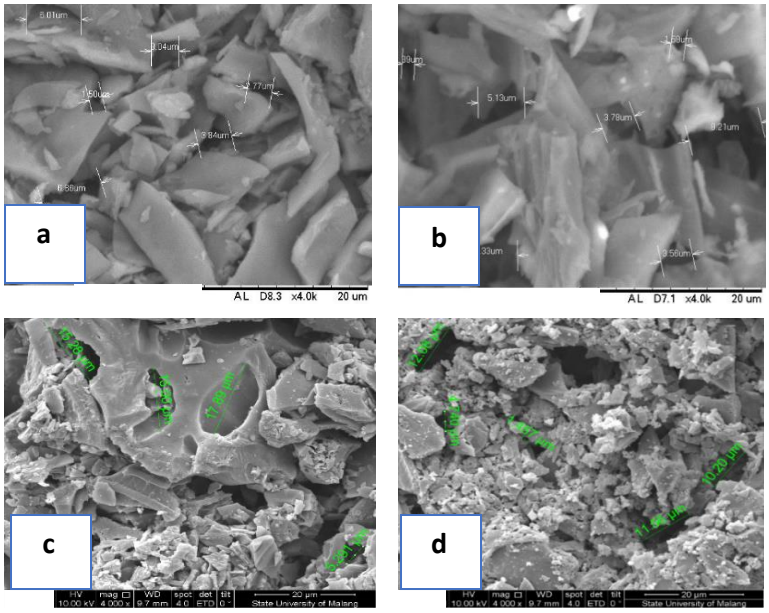


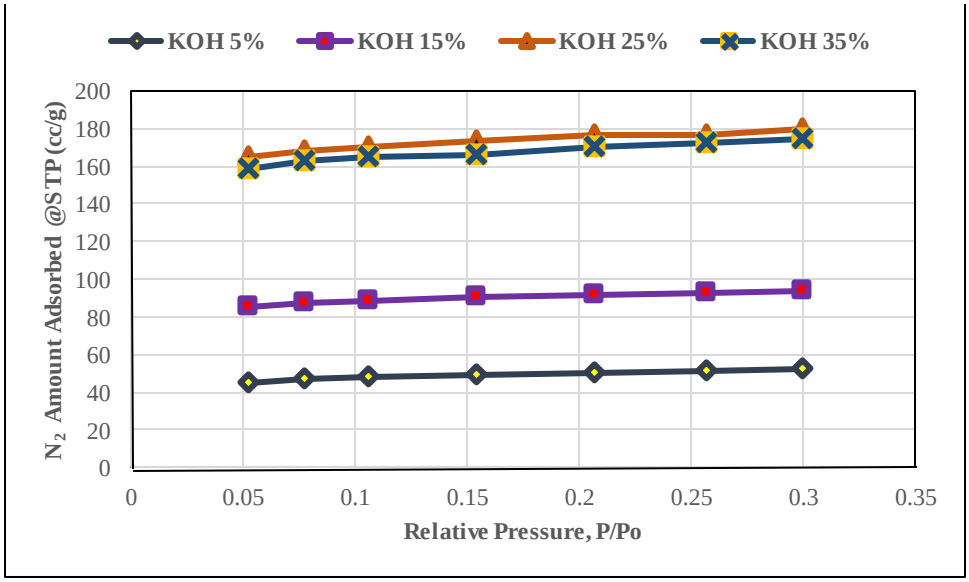
Figure 1. *(color online)* The morphology of surface activated carbon; a) KOH 5%; b) KOH 15%; c) KOH 25%; and d) KOH 35%

The results of surface area calculation using BET method showed that the greater porosity (pore size) of activated carbon then the greater surface area of activated carbon as shown in Table 1. In this research, we used Nitrogen gas as adsorbat.

Table 1. The*Brunnuaer-Emmet-Teller*method results of banana peels activated carbon.

4 Concentration of KOH (%)	5 Porosity (µm)	6 Surface Area (m^2/g)	7 Volume @STP (cc/g)
8 5	9 6,86	10 157,55	11 53
12 15	13 8,21	14 279,23	15 93
16 25	17 17,89	18 540,454	19 179,3
20 35	21 12,08	22 526,223	23 174,4

Based on Table 1, it is inferred that the larger surface area of banana peels activated carbon, is proportional to the amount of Nitrogen gas adsorbed, since more active sites formed on activated carbon capable to bind Nitrogen gas. The graph of adsorption of Nitrogen gas after characterized using Brennuer-Emmet-Teller method as shown in Figure 2.



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25 **Figure 1.** *(color online)* Isothermsof banana peels activated carbon

Isotherm curve on Figure 2 shows that Nitrogen gas adsorption on banana peels activated carbon is classified as type I adsorption according to IUPAC classification which is occurred on micropore materials (< 2 nm). Based on Figure 2, it can be noted that banana peels activated carbon adsorbs Nitrogen gas at the maximum when the relative pressure is 0,3 P/Po and the maximum absorption volumes of 53 cc/g (KOH 5%), 93 cc/g (KOH 15%), 179,3 cc/g (KOH 25%), and 174,4 cc/g (KOH 35%) are obtained. From this experimental results, it can be conclude that the greater porosity of activated carbon than the greater surface area and the adsorption power possessed by activated carbon. The large surface area and porosity of activated carbon affects the specifics capacitance value of EDLC type supercapacitor.

The Specifics Capacitance Value of the Banana Peels Activated Carbon

In this research, banana peels activated carbon is convert into electrode of EDLC type supercapacitor and acts as a site of an electrochemical reaction. When charging process begin, occurs ions exchange from the two electrodes passing through a separator. The surface area and porosity formed affects the accessibility of ions onto surface of electrode in the process, and the charges are then stored in the electrode, which in returns generates electric field and measurable value of capacitance[23]. The specific capacitance of EDLC type supercapacitor is affected by electrolyte solution, surface area, and porosity of activated carbon. Ion accessibility in activated carbon with less porosity is more difficult compared to the case in activated carbon with larger value of porosity.

The value of specific capacitance obtained by KOH-activated carbon are 14,5 F/g (KOH 5%), 31,89 F/g (KOH 15%), 72,89 F/g (KOH 25%), and 42,03 F/g (KOH 35%). The graphical relationship between the specific capacitance, porosity, and KOH concentration is presented by following Figure 3.

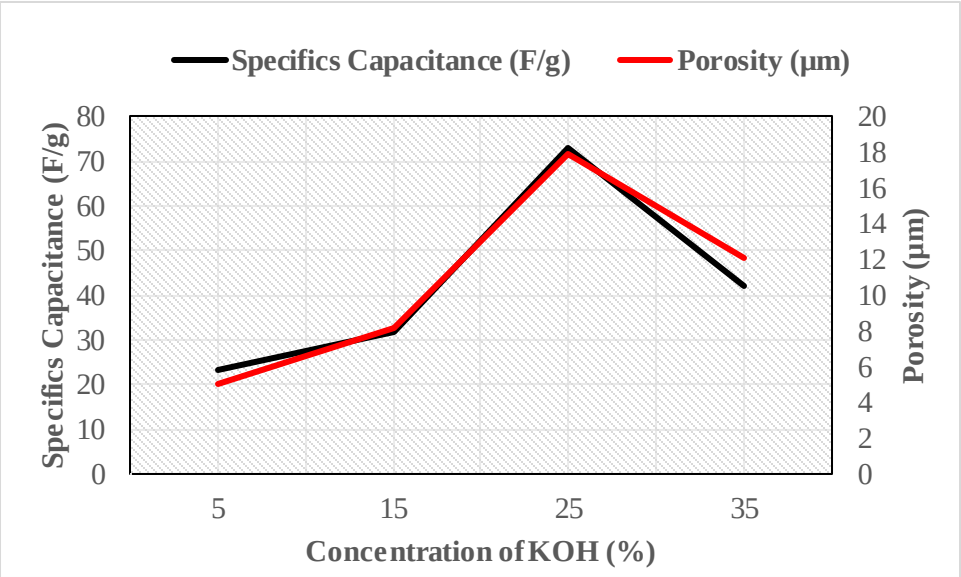

Figure 3. *(color online)* The relationship of specific capacitance and porosity of activated banana peels.

These resultalso in good agreement with SEM (Figure 1) and BET method analysis (Table 1). High porosity and surface area of banana peels activated carbon makes as higher a specific capacitance value. Therefore, preparing activated carbon pore structure, porosity and high surface area is important in preparing the electrode material EDLC type supercapacitor.

CONCLUSION

The effect of surface area and porosity of banana peels activated carbon on the specific capacitance value as EDLC type supercapacitor electrode have been observed. The results shows that the optimum value of porosity (17,89 µm) occurs at activation with KOH 25% with surface area of 540,454 m^2/g and gives specific capcitance 72,93 F/g. It is therefore concluded that banana peels activated carbon is highly potential to be an electrodematerial of EDLC-type supercapacitor.

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