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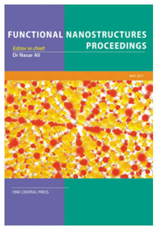

Electrochemical Behaviors LDPE-based Activated Carbon by Steam Activation

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ABSTRACT

In this study, activated carbons (ACs) were prepared for supercapacitor electrode applications by using cross-linked LDPE under various activation conditions. The cross-linked LDPE was prepared by using sulfuric acid cross-liked method. From the results, it was found that specific surface area and pore volumes were enhanced with increasing activation time. It was also observed that various pore size distribution were found to be depended on the functions of activation time. The ACs were applied as an electrode for EDLCs and analyzed in relation to the activation conditions.

I. INTRODUCTION

Due to the depletion of fossil fuels and the serious environmental pollution, interest in energy storage is increasing. Among many energy storage systems, supercapacitors are very attractive due to their high power density, fast charge / discharge rates, low cost, and semi-permanent lifetime. However, supercapacitors have a low energy density as a disadvantage and many studies are under way to improve them [1].
The electrode of the supercapacitor is made of a porous material. Among the porous materials, activated carbon has high specific surface area and high electric conductivity, and is generally used as an electrode material of supercapacitor.

Activated carbon is produced using various activation methods for carbon precursors. Activation is largely divided into physical and chemical activation. Physical activation is achieved by carbonizing the carbon precursor in a nitrogen atmosphere and then oxidizing at high temperature in an activated gas (CO_2, H_2O) atmosphere. Chemical activation is produced by mixing the carbon precursor with an activator (KOH, NaOH, ZnCl) followed by heat treatment at a high temperature in a nitrogen atmosphere. Generally, chemical activation has advantages such as lower temperature, higher yield and higher specific surface area than physical activation, but it requires additional process (washing) and high processing cost is a disadvantage [2-4].

Activated carbon is generally produced using carbon precursors such as coal, pitch, wood, coconut shell, coke, and polymers. Most carbon precursors have many ash. However, ash reduces the energy density of supercapacitors and reduces the lifetime of the supercapacitor. Polymers are very attractive materials for use as carbon precursors. The polymer can control the structure for the carbonization yield, and the content of ash. The ash negatively affects the cycle life of the supercapacitor. The polyolefin had the advantages of low ash, low cost and uniform structure, but it was difficult to use it as a carbon precursor because it was a thermoplastic resin.

In this study, we tried to fabricate polyolefin as supercapacitor electrode material by physical activation. The cross-linking method of polyolefin was studied and the cross-linked polyolefin was physically activated to produce activated carbon with high pore characteristics.

II. EXPERIMENT

The carbon precursor was prepared using LDPE. According to Kim et.al., LDPE was able to improve the yield of carbonization by crosslinking using sulfuric acid. In this study, LDPE was crosslinked with sulfuric acid at 180 °C for 30 minutes and then washed several times until the pH reached 7. The crosslinked LDPE was carbonized at a temperature of 900 °C in a nitrogen atmosphere. The carbonized LDPE was heated to 900 °C in a N_2 atmosphere and then activated for 20 to 40 minutes in a steam atmosphere. After activation, it was cooled again in a N_2 atmosphere. The morphology of the prepared LDEP based activated carbon was observed using SEM and XRD. The pore characteristics of LDPE based activated carbon were analyzed by isothermal adsorption curve at N_2/77K.

LDPE based activated carbon was pulverized to 10μm size using a ball mill, and super capacitor electrodes were fabricated. The binder of the electrode was carboxymethylcellulose (CMC) and styrene-butadiene rubber (SBR), and the conductive agent was Super-P. The ratio of the electrode active material: binder: conductive agent was 8: 1: 1. The prepared electrode was prepared by using electrolytic solution (1M $TEABF_4$/PC) to produce a coin-cell supercapacitor with two electrodes. The electrochemical characteristics of supercapacitor were analyzed by galvanostatic charge/discharge curve, cyclic voltammetry (CV) curve, and impedance curve.

III. RESULT AND DISCUSSION

Figure 1 shows the specific surface area of LDPE based activated carbon. The carbonized LDPE has a specific surface area of 3 m^2/g, showing almost no pores. As the activation time of steam increased, the specific surface area of LDPE based activated carbon increased to 1600 m^2/g. It is well known that amorphous is oxidized preferentially over crystalline during the activation process [5]. Since the amorphous materials are oxidized from 0 to 20 minutes in which the specific surface area is greatly increased, it is considered that the specific surface area is greatly increased because pores are formed mainly in the micropores. After 20 minutes, the micropores were collapsed and the mesopores were formed.

The specific capacity of LDPE based activated carbon was observed in proportion to the pore characteristics. The specific capacitance of activated carbon increased significantly up to 20 F/g until 20 minutes when the specific surface area was greatly developed, but only slight change was observed thereafter. It is considered that the pores formed through the activation are formed with the pores optimized for the storage of the electrolyte ions.

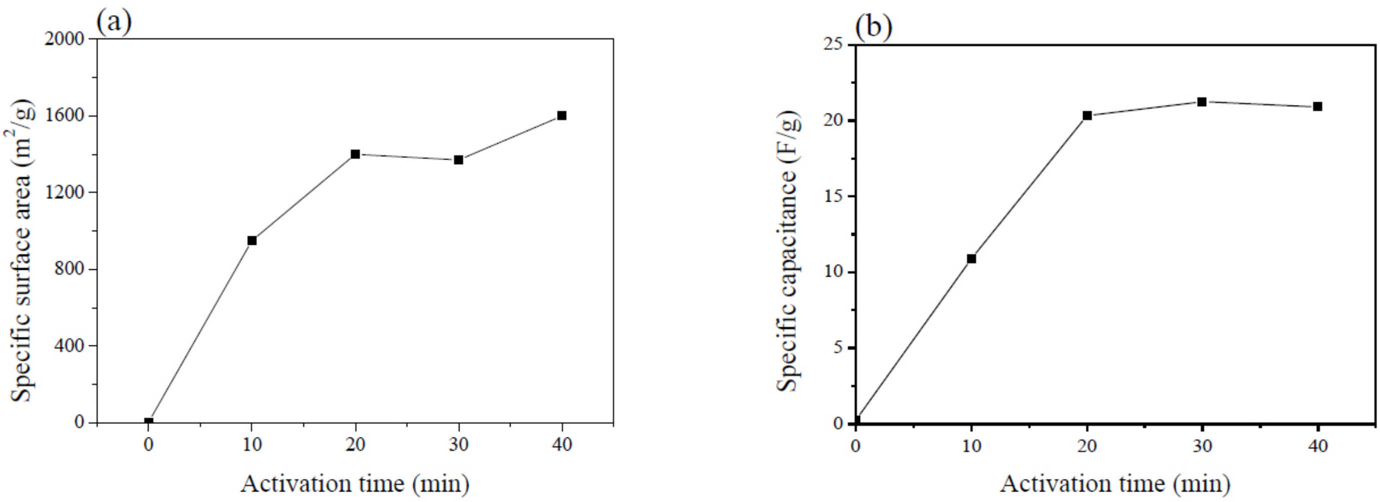

Figure 1 (a) Specific surface area of LDPE based activated carbon with various steam activation conditions and (b) specific capacitance of LDPE based activated carbon with various steam activation conditions.

IV. SUMMARY

In this paper, activated carbon was prepared by LDPE using steam activation method. LDPE was crosslinked by sulfuric acid and could be used as a carbon precursor. As a result of steam activation, LDPE based activated carbon showed a specific surface area of 1600 m^2/g and a specific capacitance of 20 F/g. Due to the low ash characteristics of LDPE, a stable cost was observed with increasing cycle.

V. REFERENCES

[1] P. Sharma, T. S. Bhatti, A review on electrochemical double-layer capacitors, Energ. Convers. Manage. 51 (2010) 2901-2912.

[2] H. M. Lee, H. R. K, K. H An, H. G Kim, B. J. Kim, Comparative studies of porous carbon nanofibers by various activation methods, Carbon lett. 14 (2013) 180-185.

[3] R. L. Tseng, Physical and chemical properties and adsorption type of activated carbon prepared from plum kernels by NaOH activation, J. Hazard. Mater. 147 (2007) 1020-1027.

[4] F. Caturla, M. Molina-Sabio, F. Rodríguez-Reinoso, Preparation of activated carbon by chemical activation with $ZnCl_2$, Carbon 229 (1991) 999-1007.

[5] J. Baek, H. M. Lee, J. S. Roh, H. S. Lee, H. S. Kang, B. J. Kim, Studies on preparation and applications of polymeric precursor-based activated hard carbons: I. Activation mechanism and microstructure analyses, Micropor. Mesopor. Mat. 219 (2016) 258-264.