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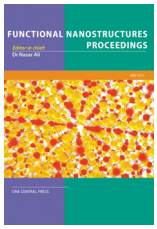

Effect of H_2O Activation on the Electrochemical Performance of Pitch-based Activated Carbon Fibers for EDLC

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ABSTRACT

The present study developed electrode materials for supercapacitors by pitch-based ACFs with H_2O. For the activation reaction, after setting the temperature at 900 °C, four types of activated carbons were produced, over an activation time of 0-40 minutes and with an interval of 10 minutes as the unit. The surface and structural characteristics of ACFs were observed by scanning electron microscopy (SEM) and X-ray diffraction (XRD), respectively. Pore characteristics were investigated by N_2/77K adsorption isotherms. Specific surface area of the ACFs were increased up to 3230 m^2/g and the ACFs were found to be mainly composed of mesoporous structures.

I. INTRODUCTION

Environment and energy are becoming important issues worldwide, and activated carbons are being developed as core materials for supercapacitors, secondary batteries, and fuel cells. Especially, supercapacitors are attracting attention due to their high power density and semi-permanent life cycle [1].

The activated carbon can be classified into Granular activated carbon (GAC) [2] and activated carbon fiber (ACF) [3]. GAC is produced using precursors such as coconut, coal, polymers and the like. High adsorption capacity and application form of activated carbon are greatly influenced by pore structure, surface area, pore volume, pore distribution, density and physical properties such as surface chemistry. In addition, activated carbons with different adsorption characteristics are produced according to various manufacturing parameters such as the kind of raw material, temperature and activation method adopted.

Granular activated carbon (GAC) has been widely used as a core material of environment and energy in various fields. However, GAC is inconvenient to handle as granular or powder, and the adsorption tower filled with the GAC has a large disadvantage of large size and high pressure loss, which is inefficient and difficult to regenerate. In addition, since the activated carbon takes a long time to reach the micropores, the adsorption rate is slow and the distribution of the pore size is wide, so that the adsorption separation of the trace materials and the selective adsorption of the multicomponent mixture are limited. Therefore, there is a demand for a new adsorbent which is excellent in adsorption capacity, easy to use and excellent in regeneration. In recent years, ACF have attracted attention as an adsorbent that satisfies these demands and is excellent in adsorption performance and processability.

ACF is known to carbonize and activated fibers such as cellulosic fibers, polyacrylonitrile (PAN) fibers, pitch carbon fibers, and phenolic resin fibers. ACF has a larger specific surface area than GAC and has various unique characteristics. Since the basic form is fibrous, it can
be processed in the form of woven or nonwoven fabric, easy to handle, and micropores are developed on very fine (less than 15 μm) fibers, allowing rapid adsorption of pores in gas and liquid adsorption. Also, it is easy to desorb at low temperature and is excellent in regeneration. ACF has a higher price than GAC, but has a higher specific surface area and faster adsorption rate.

There are physical and chemical methods for producing ACF. The physical activation method refers to a

method of activating a precursor in a high temperature using an activated gas such as CO_2 [2] or H_2O [4], and is also referred to as a gas activation method. Physical activation activates precursor by considering parameters such as temperature, kind of gas and activation time.

Unlike physical activation, the chemical activation method is produced by depositing an activating agent on a raw material to be made of activated carbon by dry or wet method, and then carbonizing. Activated carbon is produced by the dehydration and oxidation reaction of the activator in the carbonization process. KOH [3], NaOH, $ZnCl_2$ [5], and H_3PO_4 are used as the activator of the chemical, and KOH and $ZnCl_2$ are widely used because they have excellent pore development due to activation compared with other activators.

In this study, activated carbon fibers were fabricated by using water vapor in isotropic pitch and applied to EDLC.

II. EXPERIMENT

The activated carbon fibers were produced by using isotropic pitch carbon fibers. After the temperature was raised to 900 C in a N_2 atmosphere, activation was carried out in a H_2O for 0 to 40 minutes. After activation, it was cooled in a N_2 atmosphere. The morphology of activated carbon fiber was analyzed by SEM and XRD. The pore characteristics of the activated carbon fibers were analyzed by using BET and BJH equations using N_2/77K isothermal adsorption curves. Activated carbon fiber was prepared by supercapacitor electrode using carboxymethylcellulose (CMC) and styrene-butadiene rubber (SBR) as a binder. Electrochemical properties of the prepared electrode were analyzed by using 1M $TEABF_4$/PC solution.

III. RESULT AND DISCUSSION

Figure 1 shows the change in specific surface area of activated carbon fiber with activation time. As the activation time increased, the specific surface area of activated carbon fiber increased continuously. The specific surface area and pore volume of activated carbon were 3230 m^2/g and 1.89cm^3/g, respectively. The activated carbon fibers maintained the fibrous shape well despite the high specific surface area. The change in specific surface area can be divided into two stages, from 0 to 20 minutes and from 20 to 30 minutes. The specific surface area was greatly increased due to the development of micropores from 0 to 20 minutes. The micropores constitute the majority of the total pores, presumably due to amorphous oxidation. After 20 minutes, the mesopore was developed with the specific surface area, and the medium pore was developed due to the collapse of the micropore. In addition, as the activation progressed to the interior of the fiber, the specific surface area continued to increase.

Figure 1 shows the specific capacitance of the activated carbon fibers produced. In the initial cycle, the specific capacitance of activated carbon prepared at the activation time of 10 ~ 20 min was very low compared to the specific surface area. However, as the activation time increased, the specific capacitance increased to more than 18 F/g. This is because the pore diameter of the activated carbon fiber is very small and it is difficult to transfer the ions into the pores. In addition, when the cycle was carried out 20 times, the cost of activated carbon fiber produced at activation time of 10 to 20 minutes was greatly increased to 20 F/g or more. It is considered that the migration of the electrolyte ions extended the crystal plane of the activated carbon fiber.

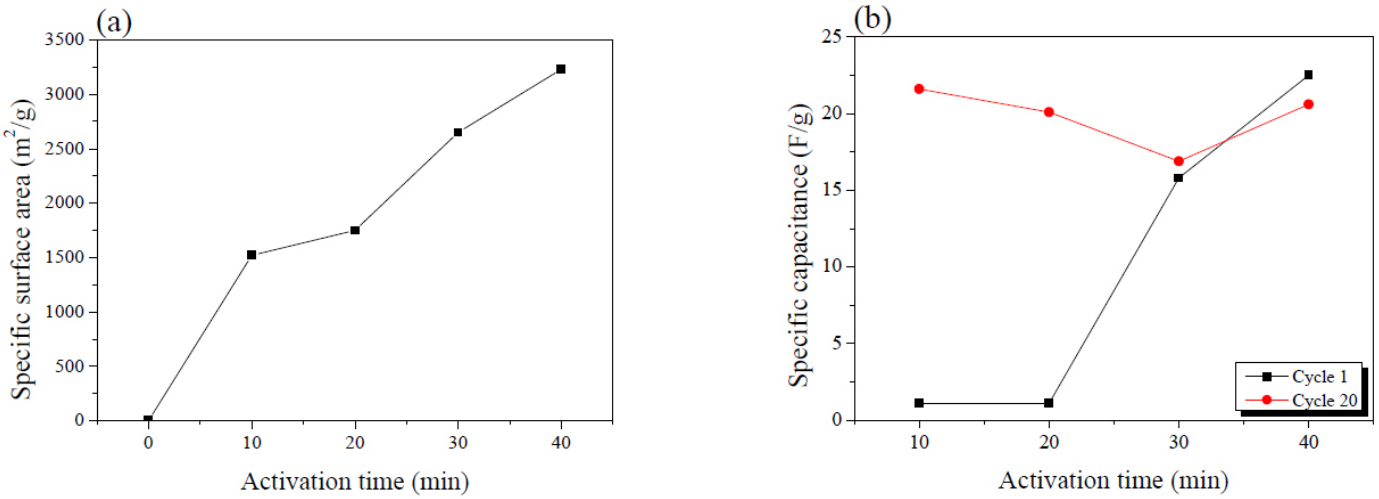

Figure 1 (a) Specific surface area of LDPE based activated carbon with various steam activation conditions and specific capacitance of LDPE based activated carbon with various steam activation conditions.

IV. SUMMARY

In this study, activated carbon fibers with high specific surface areas were fabricated using isotropic pitch carbon fibers. The specific surface area of the prepared activated carbon fibers was observed up to 3230 m^2/g. Activated carbon fibers prepared at an activation time of 10 to 20 minutes had a very small pore diameter, which made it impossible to store electrolyte ions and a low specific capacitance was observed. However, as the charge/discharge cycle increases, the pore expands and a high specific capacitance of 22 F/g is observed.

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