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FABRICATION AND DMMP GAS SENSING CHARACTERISTICS OF ELECTRON-BEAM TREATED PAN-BASED ACTIVATED CARBON FIBER

Min-Ji Kim[1,2], Eun Ji Song[1,2], Su Hyun Kim[1,2], Kyung Hoon Kim[1,2], Seung-Kon Ryu[3] and Young-Seak Lee[1,2,*]

[1] *Department of Chemical Engineering and Applied Chemistry, Chungnam National University, Daejeon, 34134, Republic of Korea*
[2] *Institute of Carbon Fusion Technology (InCFT), Chungnam National University, Daejeon, 34134, Republic of Korea*
[3]*Institute of Carbon Technology, Jeonju University, Jeonju, 55069, Republic of Korea*

*Presenting author's e-mail: jih0210@cnu.ac.kr

Introduction

Recently, the threat of terrorism has emerged as a very important global issue. Chemical weapons can be used in terrorism and can lead to very deadly consequences, so preparation is essential. The chemical agents used as weapons are extremely dangerous and highly toxic, and the types of agents have been classified into four groups: nerve agents, blister agents, blood agents and choking agents. Among these dangerous agents, nerve agents are known to be the deadliest to humans [1]. Among these nerve agents, sarin is a typical member of the organophosphorus family and is widely known to be one of the most toxic chemical agents. For this reason, to protect humans, the development of highly sensitive and rapid response devices for detecting chemical gases is urgently needed.

Materials and Methods

In this study, polyacrylonitrile (PAN)-based stabilized fibers (Kolon Industries, Inc., Korea) were used. The stabilized fibers were carbonized under an N_2 atmosphere under the following conditions: 10 ℃/min heating rate, 800 ℃ reaction temperature, 1 h holding time and 100 cc/min N_2 feed rate. To develop a porous structure, potassium hydroxide (KOH, 95%, Samchun Chem., Korea) was used as a chemical activation agent. The prepared carbon fibers were immersed in 2 M KOH solution for 3 h and then placed in an alumina boat within a pipe for KOH chemical activation, which was conducted at 750 K for 2 h in an N_2 atmosphere with the following conditions: 5 ℃/min heating rate and 100 cc/min N_2 feed rate. The DMMP gas (Rigas Co., Korea) concentration was 10 ppm with nitrogen to balance. E-beam irradiation was carried out at doses of 50, 100, and 200 kGy in the atmosphere. The change in electrical resistance was measured with a programmable electrometer (Keithley 6514 System Electrometer) to evaluate the gas-sensing properties of the prepared electrode.

Results and Discussion

The untreated ACFs had a total pore volume of 0.1860 cc/g and an SSA of 380.23 m2/g, and the

relative micropore volume of this sample was the lowest among all the ACFs studied. In contrast, the micropore volumes of the E-beam-treated ACFs were higher than those of the R-ACFs, confirming that micropores were generated by the E-beam treatment. These results indicated that E-beam irradiation produced micropores because of the high energy of the E-beam. Among the E-beam-treated ACFs, the ACF-E-100 sample exhibited the highest SSA and total pore volume (429.93 m2/g and 0.1924 cc/g, respectively). These changes in the textural properties indicated that the nanocrystallinity of the ACF surface was transformed by the E-beam radiation dose.

Table 1. Textural properties of the untreated and E-beam-treated ACFs

Sample	BET specific surface area (m^2/g)	Total pore volume (cc/g)	t-plot Micropore volume (cc/g)	Mesopore volume (cc/g)	Micropore/ Total pore volume ratio (%)
R-ACFs	380.23	0.1860	0.1550	0.0310	83.3
ACF-E-50	329.30	0.1495	0.1335	0.0160	89.3
ACF-E-100	429.93	0.1924	0.1730	0.0194	90.0
ACF-E-200	410.34	0.1893	0.1602	0.0291	84.6

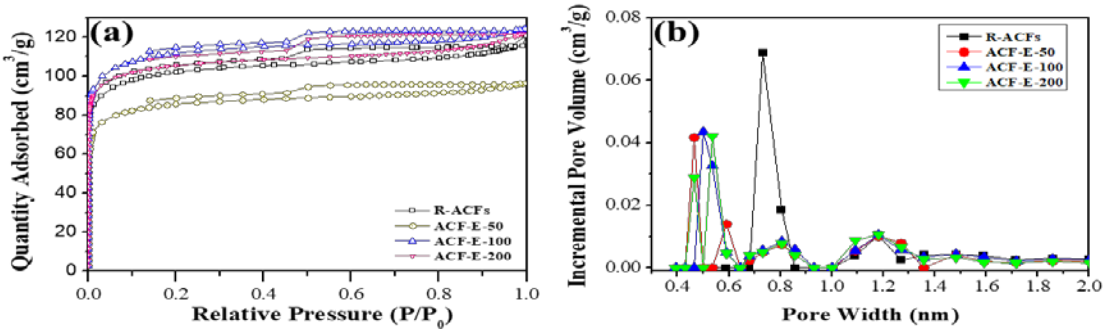

Figure 1. Nitrogen adsorption-desorption and pore size distribution plots of untreated and E-beam-treated ACFs.

Conclusions

As the dose of E-beam increased, the SSA and the content of oxygen functional groups introduced on the ACF surface increased. The E-beam-irradiated ACFs had better DMMP gas-sensing abilities than the untreated ACFs. The maximum resistance change was approximately 6.3% for an E-beam radiation dose of 100 kGy. The hydroxyl groups on the ACF surface and the DMMP gas interacted through hydrogen bonding, which increased the gas detection ability by facilitating electron transfer to the ACFs.

References

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