PREPARATION OF CNT ELECTRODES FOR ENHANCED ELECTROCHEMICAL PROPERTIES

Hyun-Ju Kim, Dong-Yoon Lee, Bo-Kun Koo, Won-Jae Lee and Jae-Sung Song
Electric & magnetic devices group of Korea Electrotechnology Research Institute (KERI), 28-1 Sungju-dong, Changwon-city, Gyungnam-do, Korea 641-120
dylee@keri.re.kr

There is great interest in novel carbon nanotubes(CNT)-based electrode materials for fabricating future nanoelectronic applications, including displays, interconnects, memories and sensing devices, since it provides remarkably good electrical, physical and chemical properties; good electrochemical stability, low resistivity, large surface area, etc.[1]. In order to use such good physical and chemical properties, we consider to apply CNT to the electrochemical devices like a dye-sensitized solar cells(DSSCs). Here, we may expect it to be superior to conventional grapite in electrochemical catalytic properties. Upto now, the use of CNT electrodes was mainly considered for electron emission in display, for electrical capacitor in storages and for electrodes in fuel cells. However, remarkable enhancement on electrochemical behaviors has been not reported.

In this respect, we need to improve preparation process of CNT electrode for realsing electrode potential of electrochemical cells. In order to enhance electrochemical properties of CNT electrode, we prepared CNT paste, using CNT powder, Carboxyl Methyl Cellulose(CMC) and D.I. water. CNT electrodes were fabricated as follow method [2]; CNT powder was prepared by Carbon Nanotech Co. using Fe catalyst by thermal chemical-vapor process. CNT has multi-wall type having diameter of 10~20nm and length of about 5 ㎛. First, CNT powder, de-ionized water and CMC (Carboxyl Methyl Cellulose) for paste manufacturing are prepared. Mixture of these was mechanically ball-milled for 24hrs. CNT electrodes as working electrode for electrochemical properties measurement were coated on the F-doped SnO_2 (FTO) glass by doctor-blade methode, following drying and heat-treatment.

We carried out TGA analysis of CNT paste in order to understand chemical dissociation of CMC and water. CNT paste was prepared by Dr blade, following 80^{o}C conventional heat treatment. In this case, we expect to avoid disadvantage reaction between water residual and Iodine-embedde electrolyte of DSSCs. For eliminating disadvantage of CMC and residual water in CNT electrode, we carried out heat traetment in the range of 80 to 390^{o}C on the basis of TGA. It was heat-treated at various temperatures in air; 80^{o}C, 230^{o}C, 260^{o}C, 290^{o}C and 390^{o}C. Also, we measured electrochemical properties of heat-treated CNT samples for optimising heat-treatment conditon of CNT electrode.

Fig.1 shows result of TGA on CNT pastes having CMC and water. The dissociation and carbonization temperature of CNT pasted was observed. On the basis of such results, we dicided condition of CNT heat-treatmenet temperature.

Cyclic-voltammetry (CV) and electrochemical impedance spectroscopy (EIS) measurement of test cells having CNT electrodes were investigated. Here, CNT electrodes prepared from various heat-treatment were used in order to understand performance of novel CNT electrodes for DSSCs. Fig. 2 shows cyclic-voltamogram of electrochemical cells having CNT and Pt electrodes. In this electrochemical cell, CNT electrode is a working electrode and Pt plate is a counter and reference electrode. As we can see in this fugure, we can compared to degree of electrode reaction, current density, electrode potential, and interfacial resistance, etc in our samples. In conclusion, it was understood that enhanced electrochemical properties of CNT electrodes was obtained via optimal heat treatment temperature, 230^{o}C for 1hr. on the basis of TGA, CV and EIS measurements.

References:

[1] A. Bachtold, P. Hadley, T. Nakanishi, C. Dekker, Science 294 (2001) 1317
[2] H.J.Kim, D.Y. Lee, B.K. Koo, W.J. Lee, and J.S. Song, KIEEME, Vol.17 (2004) 1090

Figures:

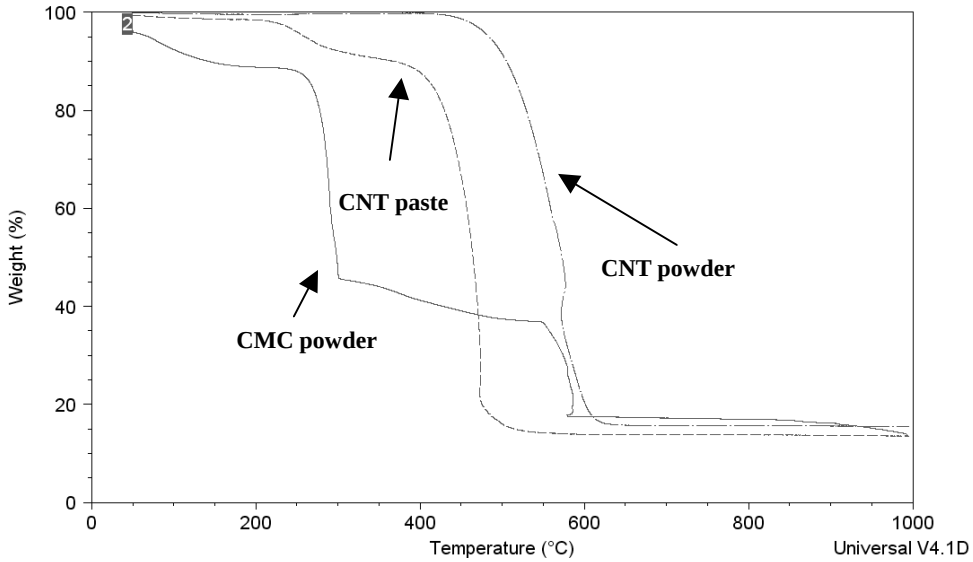

Fig. 1. TGA graphs of CNT paste, CNT powder and CMC powder.

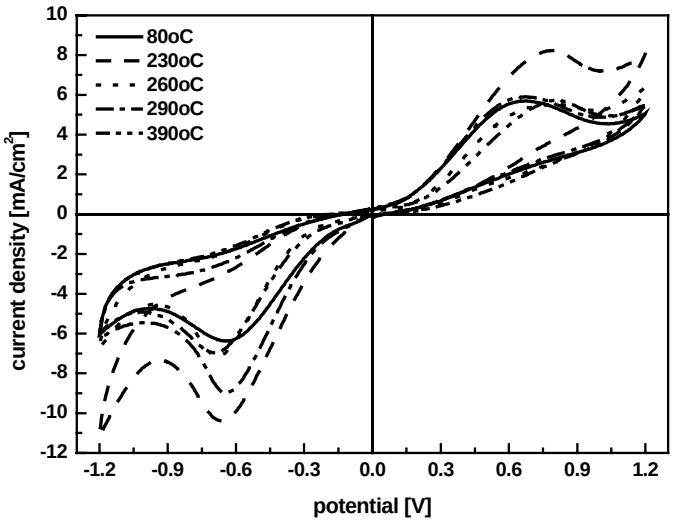

Fig 2. CV graphs of redox reaction of electrolyte on the CNT electrodes heated at the various temperature conditions.