Modified carbon materials for energy storage application

A Jain[1*] and M Michalska[2]

1Institute of Fundamental Technological Research, Polish Academy of Sciences, Pawińskiego 5B, 02-106 Warsaw, Poland

2 Department of Chemistry and Physico-Chemical Processes, Faculty of Materials Science and Technology, VŠB-Technical University of Ostrava, 17. listopadu 2172/15, 708 00 Ostrava-Poruba, Czech Republic

(*) ajain@ippt.pan.pl

Keywords: Supercapacitors; Activated carbon; Polymer gel electrolyte

Interest in the application that requires high energy density like consumer portable electronic devices, energy back-up systems, hybrid vehicles has led research towards low-cost, high-performance and environmentally friendly device called "Supercapacitors". Supercapacitors can store and deliver energy by simply utilizing the charge separation at the electrode-electrolyte interface. The thin electrolyte film and high surface areas of electrode materials significantly contribute to the high capacitance of the device. Power densities of supercapacitors are thousand times higher than those of lithium ion batteries, along with much larger energy density values as compared to conventional capacitors. The construction of supercapacitor is same as that of traditional capacitors, the difference is that the metal electrodes are replaced by highly porous electrodes. Depending upon the charge storage mechanism and the active material used, supercapacitors are divided into two classes: electrical double layer capacitors (EDLCs) and pseudocapacitors [1-2]

Variety of carbon-derived materials have been intensively studied as electrode materials for supercapacitors because of their quality to transformed into various forms to facilitate high surface area, excellent electrical conductivity and high energy capacity. While choosing the materials, the most important factors affecting the performance of EDLCs are the specific surface area and pore size distribution of the material. The maximum capacitance is achieved when the pore size of the electrode material is close to the size of electrolyte ions so that ions of the electrolyte can access more area of the electroactive material. Activated carbon has been chosen in the present studies because of its cost effectiveness and good processability. It is inexpensive as compared to other competing materials [3]. In the present studies, activated carbon was modified with silver nanoparticles, the introduction of silver nanoparticles helps in improving the performance by decreasing the polarization.

For electrolyte, gel polymer electrolyte (GPE) is attracting a lot of attention because of their flexibility, high ionic conductivity, leakage free and stable electrochemical performance. Generally, GPEs are composed of electrolyte salt which can provide electrolyte ions and polymeric material which act as a matrix and its designing helps to improve the electrochemical and capacitive performance of the devices [4]. In the present case, Poly(vinylidene fluoride-co-hexafluoropropylene) was used as a polymer, propylene carbonate as a plasticizer and magnesium perchlorate as a salt.

The supercapacitor cells were fabricated by using two-electrode system, in which electrolyte films were sandwiched in between activated carbon modified with silver nanoparticle electrodes. It has been found out that 3wt% of silver particle in activated carbon gave best electrochemical results and hereon refers as ACAg3

Fig. 1a shows the SEM image of ACAg3. As can be seen from the figure deposition of silver particles were confirmed and observed as a small balls and also the morphology confirms the porous nature of material. Fig 1b shows the nitrogen adsorption-desorption curve of ACAg3. The surface area studies confirms the surface area of ~824 m^2 g^{-1}. The isotherm shows Type II ce, SLOVAKIA

lso shows the good bal-
studies. The pore size of

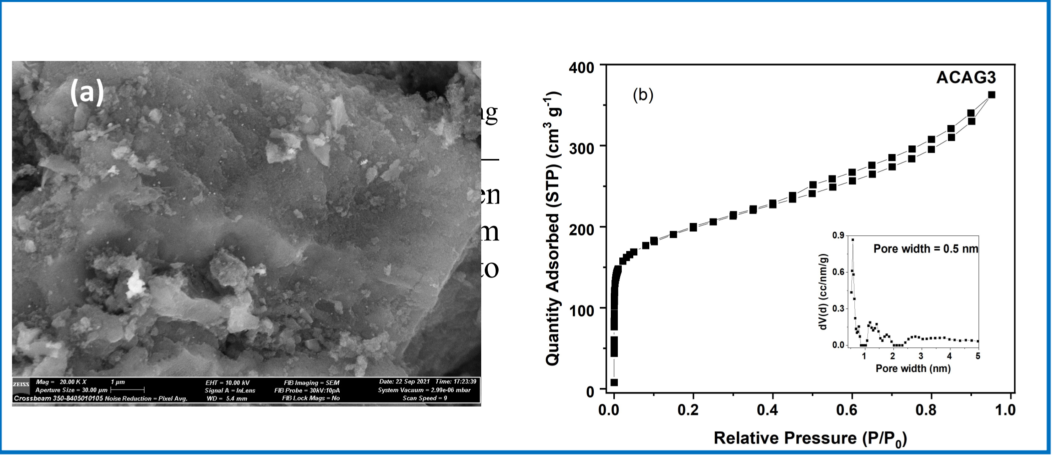

Fig 1 (a) SEM image of ACAg3 (b) N_2 adsorption-desorption study of ACAG3

In order to check the material for supercapacitor application, galvanostatic charge-discharge was carried out. Fig 2 depicts the GCD curve of capacitor cell at a current density of 1.0 mA cm^{-2}. The non-linear pattern of the curves confirms the redox-nature of cell. The capacitance was calculated by using the discharge branch excluding the ohmic drop. The formula used is $C_S = \frac{4\,(I \times \Delta t)}{(\Delta V \times m)}$, m is the mass of the electrode material, Δt is the discharge time and ΔV is the potential difference. The capacitance value is found to be of the order of ~398 F g^{-1}.

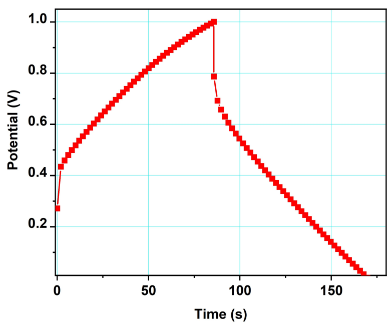

Figure 2: GCD curve of supercapacitor cell

Modified carbon was silver was carried out successfully and was investigated for supercapacitor application. The capacitance values was found to be of the order of ~398 F g^{-1}.

Acknowledgment

This work was financially supported by the National Centre for Research and Development (NCBR, Poland); Project number: V4-Japan/2/17/AtomDeC/2022 and the Ministry of Education, Youth and Sports, Czech Republic (contract no. 8F21007) under the Visegrad Group-Japan 2021 Joint Call on Advanced Materials in cooperation with the International Visegrad Fund.

References

[1] S. Chakraborty, Mary N.L. J. Electrochem. Soc. 169 (2022) 020552
[2] M. Pershaana, S. Bashir, S. Ramesh, K. Ramesh, J. Energy Storage 50 (2022) 104599
[3] A. Jain, M. Ghosh, M. Krajewski, S. Kurungot, M. Michalska, J. Energy Storage 34(2021)102178
[4] W.Li, Y. Pang, J. Liu, G. Liu, Y. Wang, Y. Xia, RSC Adv. 7(2017)23494-23501