Carbon network modification; interesting way to improve energy storage in supercapacitors

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Introduction: The ever growing demands for clean energy and portable water challenge materials scientists and electrochemists alike. Green energy is one of the main challenges the world faces this century. The prime source of energy comes from non-renewable fossil fuel sources like coal, oil, and natural gas, generating greenhouse gases and causing climate change and global warming [1-2]. Renewable energy sources like solar, wind thermal are intermittent nature, so balancing supply and demand requires energy storage devices like batteries and supercapacitors. Better materials must be developed for these devices that, besides maximizing performance, are sustainable, durable, and non-toxic. New and tailored materials may find applications in energy storage devices particularly supercapacitors. Supercapacitors have attracted much attention recently because of their high power density, fast charging and discharging, and high capacitance. They store energy through electric double layer-formation in electrolyte-filled porous electrodes. Both the electrolyte and electrode materials crucially affect supercapacitor performance [3]. The main aim of this work is to explore carbon composites with modification of metallic particles as an electrode material with gel polymer electrolyte for supercapacitor application.

Materials: The carbon material was surface-modified using Cu nanoparticles using low-temperature hydrothermal process. The details of the work will be presented in the conference. Two-electrode set-up has been prepared using polymer gel electrolyte. The cell was evaluated using ac impedance spectroscopy, cyclic voltammetry and galvnotstatic charge discharge technique.

Results and Discussion: The SEM image of the composite material has been shown in Figure 1. As can be seen from the image, the material is dense and amorphous too. This kind of morphology is advantageous for supercapacitor application.

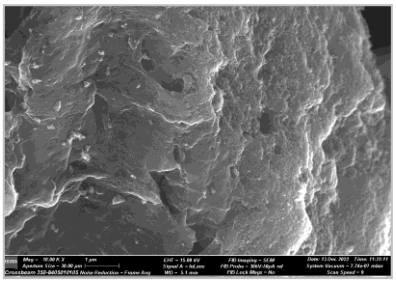

Figure 1. SEM morphology of the composite.

The two-electrode set-up was prepared by using symmetrical electrodes prepared by using composite material and magnesium ion based polymer gel electrolyte. The ac impedance spectroscopy was carried out in the frequency range of 200 kHz to 1 mHz and is shown in Figure 2.

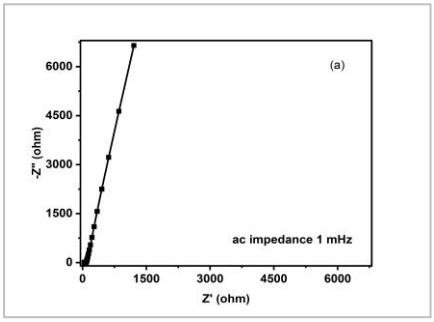

Figure 2: AC impedance spectrocopy of supercapacitor cell

As can be seen from the figure that impedance curve clearly shows a small semicircular spur followed by a straight line parallel to imaginary axis which is a typical characteristic of supercapacitor cell.

Conclusion: Using a low-temperature wet ultrasonochemical method that was simple, straight, economical and environmentally friendly, the surface of activated carbon with Cu particles was carried out. It has been observed that the modification significantly improved the performance of the device. The detailed results will be presented in the conference.

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References

[1] Poonam, K. Sharma, A. Arora, S.K. Tripathi, J Energy Storage 21 [2019] 801-825

[2] A. Jain, S.K. Tripathi, Mat Sci Eng B 183 [2014] 54-60

[3] H. Li, H. Yang, H. Sun, Y. Huang, P. An, Y. Yunhua, H. Zhao, Electrochim Acta 473 (2024) 143514

Dr A. Jain is working as an Assistant Professor in IPPT PAN, Poland. Her main research area is the development of sustainable materials for energy storage application like batteries and supercapacitor. She is also working on the development of materials for waste water treatment and dye adsorption studies.

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