Development of active carbons' porous structure for their application in supercapacitors

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INTRODUCTION

Emphatic successes in the development of obtaining methods and investigation of functional nanostructured carbon composites are directed to the providing of increasing demand of mankind in scientific production, is necessary for realization of innovative technologies in the field of energy conservation and development of new trends in science and technology.
Production of nanostructured electrode composites on the basis of porous carbon matrix, is made from activated carbon, which can be obtained by the methods of carbonization and activation of lignocellulosic fibers is of special interest [1]. At the present time, activated carbons on the basis of coconut shell, the production of which is smoothly on industrial scale are proved to be successful. However, numerous experimental studies, conducting with various types of biomass have shown that in capacity of applicable precursors can act many other samples of vegetable fibers, which currently are agricultural wastes such as rice husk, walnut shell. In general, the use of such materials are obtained from low-cost environment and renewable raw materials significantly extends the usability of "green chemistry" in the field of new development methods for the production of advanced composite electrodes for EDLC.

RESULTS AND DISCUSSION

Electrode materials for EDLC must satisfy a number of criteria in particular: developed specific surface and accessibility of the porous structures for ions and molecules of the electrolyte, easily in formation and others. Nanostructured carbon composites on the base of carbonized and activated rice husk and walnut shell presented in this study are satisfying most of these requirements [2].
X-ray diffraction analysis of the activated carbon produced from a rice husk showed the broad low intensity peak near 23 degrees. These data suggest about low crystallinity of this type of materials and can be attributed to amorphous carbon materials derived from lignocellulosic fibers. Note that mass fraction of carbon in the samples of carbonized and activated rice husk exceeds 88%.
The results of electron microscopic studies showed that for all samples derived by activation of carbonized rice husk at 500° C is characteristically the availability of porous nanostructured surface texture. The appearance of investigated samples have common morphological features (bulges in the outer wall, a channel structure of macropores) characteristic and carbonized plant material is chemically activated, wherein the higher magnification was found that substances represented by the presence of material of macroscopic ensembles of ultrasmall particles with sizes of several nanometers.
A BET surface area of 1266 m^2/g was obtained for the carbonized and activated rice husk, and its isotherm of low-temperature adsorption represents a combination of I and IV Types of isotherms (Fig. 1). The hysteresis loop indicates the presence of mesopores in the sample, which diameter are greater than 2 nm. The DFT pore distribution plot shows a relative wide distribution for this sample (Fig. 2). In case of carbonized and activated walnut shell its BET surface area was equal to 1433 m^2/g and that sample gave a Type I isotherm, a characteristic of microporous materials. The DFT pore size distribution showed a peak at 0.45 nm.

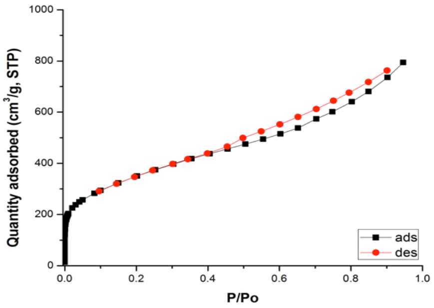

Fig. 1. Isotherm of low-temperature adsorption of nitrogen for active carbon derived on the basis of rice husk

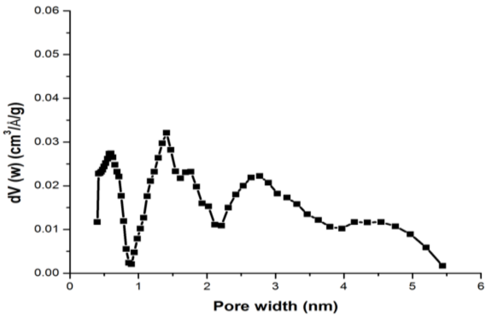

Fig. 2. Pore size distribution of active carbon derived on the basis of rice husk

By use the method of cyclic voltammetry with different voltage limits up to 1,6 V it was found that the resulting electrode composites on the basis of carbonized and activated rice husk with 1 M Li_2SO_4 as electrolyte have a relatively high specific capacity value equal to 109 F/g (Fig. 3). The cyclic voltammetric response curves and capacity characteristics for composite electrodes at different scan rates from 10 to 100 mV/s in the medium of EMITFSI (Fig. 4) show that the oxidation and reduction areas are quite regular, symmetric shape characteristic with high reversible capacity.

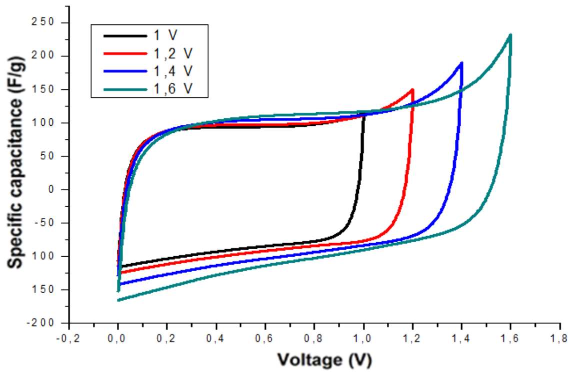

Figure 3 – Effect of voltage limits on cyclic voltammograms of composite electrodes with 1M Li_2SO_4

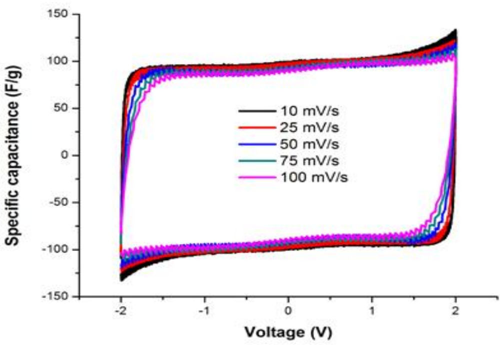

Figure 4 – Effect of scan rate on charge propagation and capacitance of composite electrodes with EMITFSI

CONCLUSIONS

By using a rice husk the micro-/mesoporous activated carbons were derived and composite electrodes on its basis were created. Resulting samples were electrochemically tested and investigated in terms of their composition, porous structure and surface texture. It was found that this composite electrode material in the medium of lithium sulfate aqueous solution and in the EMITFSI have high reversible specific capacity values equal to 109 F/g and 90 F/g respectively. The measured power density of assembled cell was equal to 1706 W/kg and the energy density equal to 61 Wh/kg at current density equal to 1 A/g. EDLC assembled cell was retaining its performance characteristics at numerous repeated cycling, and significant losses was not observed.

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