Full Paper _______________________________ *Thematic Section:* Research into New Technologies.
Reference Object Identifier – ROI: jbc-02/18-54-5-82 *Subsection:* Chemical Technology.
Publication is available for discussion in the framework of the on-line Internet conference "*Butlerov readings*".
http://butlerov.com/readings/
Submitted on April 19, 2018.

A new raw material to produce activated carbon as a material for electrodes of supercapacitors

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Keywords: activated carbon, hogweed, methylene blue, double electric layer, adsorbtion capacity, capacity, electrodes.

Abstract

A multilevel structural organization of plant fibers makes herbaceous plants a promising initial material for obtaining the carbon structures on their basis to create highly effective electrodes. Activated carbon (AC) was obtained from the herbaceous plant – hogweed (*Heraclum sphondylīum*). In order, to find effective ways of obtaining an active material with optimal properties we chose two ways to activate. Carbonization to 400 °C, then impregnation in a 5% H_3PO_4 aqueous solution, followed by activation at 900 °C as well as impregnation in 5% aqueous solution of H_3PO_4, continuous carbonization and activation at 900 °C. The activation of the samples was carried out in a stream of carbon dioxide, followed by cooling to room temperature in an argon stream. Based on activated carbon, we made electrodes for the supercapacitor (SC). Through the cyclic voltammetry and galvanostatic charge-discharge, we obtained the electrochemical characteristics of the supercapacitor. According to the curves of the galvanostatic charge, as well as cyclic voltammetry, it is revealed that the flow rate of gas has no significant effect on the result of capacity. This shows that the order of activation and impregnation of the initial material doesn't have much effect on the electrochemical characteristics. Comparing the capacitive characteristics of the tested samples, the most optimal for the electrochemical properties is the sample which was activated at 900 °C with the flow rate of gas of 200 ml/min (BSh_200_900). Data on the adsorption capacity of methylene blue, as well as data on isotherms of adsorption/desorption N_2 by the BJH method, it was shown that the working fraction of all pores, are the pores diameter between 3-10 nm. The values of the adsorption capacity for methylene blue for all samples coincide and it is ~370 mg/g, but the specific surface areas measured by the BET method are differed.

References

[1] E. Frackowiak. Carbon materials for supercapacitor application. *Phys. Chem. Chem. Phys.* **2007**. Vol.9. P.1774-1785.
[2] E. Frackowiak, F. Béguin. Carbon materials for the electrochemical storage of energy in capacitors. *Carbon.* **2001**. Vol.39. P.937-950.
[3] Y. Huang, J. Liang, Y. Chen. An overview of the applications of graphene-based materials in supercapacitors. *Small.* **2012**. Vol.8. P.1805-1834.
[4] F. Ran, K. Shen, Y.Tan, B. Peng, Sh. Chen, W. Zhang, X. Niu, L. Kong, L. Kang. Activated hierarchical porous carbon as electrode membrane accommodated with triblock copolymer for supercapacitors. *Journal of Membrane Science* 514. **2016**. P.366-375.
[5] V. Presser, M. Heon, Y. Gogotsi. Carbide-derived carbons-from porous networks to nanotubes and graphene. *Adv. Funct. Mater.* **2011**. Vol.21. P.810-833.
[6] E. Frackowiak, F. Béguin. Electrochemical storage of energy in carbon nanotubes and nanostructured carbons. *Carbon.* **2002**. Vol.40. P.1775-1787.
[7] S. Sulaiman1,2 & A. Mat1,2 & A. K. Arof2 Activated carbon from coconut leaves for electrical double-layer capacitor. *Ionics.* **2016**. Vol.22. P.911-918.
[8] Li X, Xing W, Zhuo S, Zhou J, Li F, Qiao S-Z, Lu G-Q. Preparation of capacitor's electrode from sunflower seed shell. *Bioresour Technol.* **2011**. Vol.102(2). P.1118–1123.

[9] A. Elmouwahidi, Z. Zapata-Benabithe, F. Carrasco-Marín, C. MorenoCastilla. Activated carbons from KOH-activation ofargan (Argania spinosa) seed shells as supercapacitor electrodes. *Bioresour Technol.* **2012**. Vol.111. P.185-190.

[10] J.P. Tey, M.A. Careem, M.A. Yarmo, A.K. Arof. Durian shell-based activated carbon electrode for EDLCs. *Ionics*. **2016**. Vol.22. P.1209-1216.

[11] Amrita Jain, S.K. Tripathi. Almond shell-based activated nanoporous carbon electrode for EDLCs. *Ionics.* **2015**. Vol.21. P.1391-1398.

[12] K.H. Teoh, Ch. Lim, Ch. Liew, S. Ramesh, S. Ramesh. Electric double-layer capacitors with corn starch-based biopolymer electrolytes incorporating silica as filler. *Ionics*. **2015** Vol.21. P.2061-2068.

[13] O. Barbieri, M. Hahn, A. Herzog, R. Kotz, Capacitance limits of high surface area activated carbons for double layer capacitors. *Carbon*. 2005. Vol.43. P.1303-1310.

[14] J. Chimola, G. Yushin, Y. Gogotsi, C. Portet, P. Simon, P. Taberna. Anomalous Increase in Carbon Capacitance at Pore Sizes Less than 1 Nanometer. *Science.* **2006**. Vol.313. P.1760-1763.

[15] P. Simon, Y. Gogotsi. Materials for Electrochemical Capacitors. *Nat. Mater*. **2008**. Vol.7. P.845-854.

[16] G. Salitra, A. Soffer, L. Eliad, Y. Cohen, and D. Aurbach. Carbon Electrodes for Double-Layer Capacitors I. Relations Between Ion and Pore Dimensions. *Journal of The Electrochemical Society.* **2000**. Vol.147(7). P.2486-2493.

[17] G. Gryglewicz, J. Machnikowski, E. Lorenc-Grabowska, Gr.Lota, E. Frackowiak. Effect of pore size distribution of coal-based activated carbons on double layer capacitance. *Electrochimica Acta*. **2005**. Vol.50. P.1197-1206.

[18] V.F. Olontsev, A.A. Minkova, K.N. Generalova The study of the adsorption activity of carbon materials. *Fundamental Research*. **2013**. P.90.