Impedance spectroscopy of capacitor systems based on saccharide-derived porous carbon materials

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The aim: to investigate the passing of electron-ion processes in symmetric capacitor systems based on porous carbon material (PCM) and to compare the results with the data of cyclic voltammetry and galvanostatic studies [1].

Materials: crystalline monohydrates of glucose (**G**) and lactose (**L**) and anhydrous saccharose (**S**) were used as precursors of chars prepared at 400°C for 30 min in air. Oxidizing activation of chars was carried out in ceramic crucibles at **800°C** or **1000°C** for 30 min.

Methods: low-temperature porometry, impedance spectroscopy.

Results

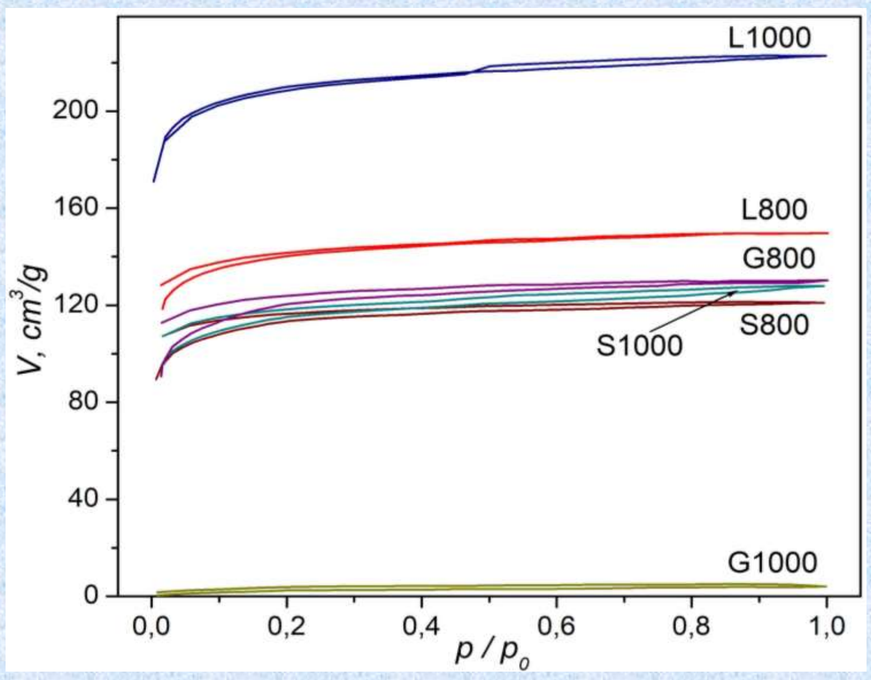

Fig.1. Nitrogen adsorption-desorption isotherms for PCMs.

Table 1. Parameters of the porous structure of PCMs

Standard	S_{BET}, m^2/g	S_{micro}, m^2/g	S_{meso}, m^2/g	V, cm^3/g	V_{micro}, cm^3/g	V_{meso}, cm^3/g
G800	383	181	202	0.201	0.086	0.113
G1000	46	10	36	0.016	0.003	0.013
L800	437	318	119	0.232	0.162	0.070
L1000	652	497	155	0.345	0.226	0.118
S800	356	204	152	0.187	0.092	0.095
S1000	362	225	137	0.198	0.115	0.083

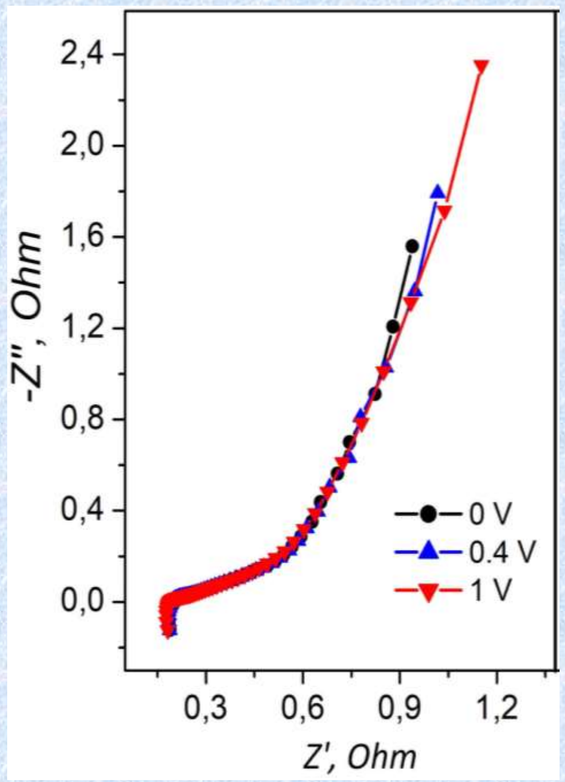

Fig.2. The Nyquist diagrams for G800 capacitor system at different bias voltages.

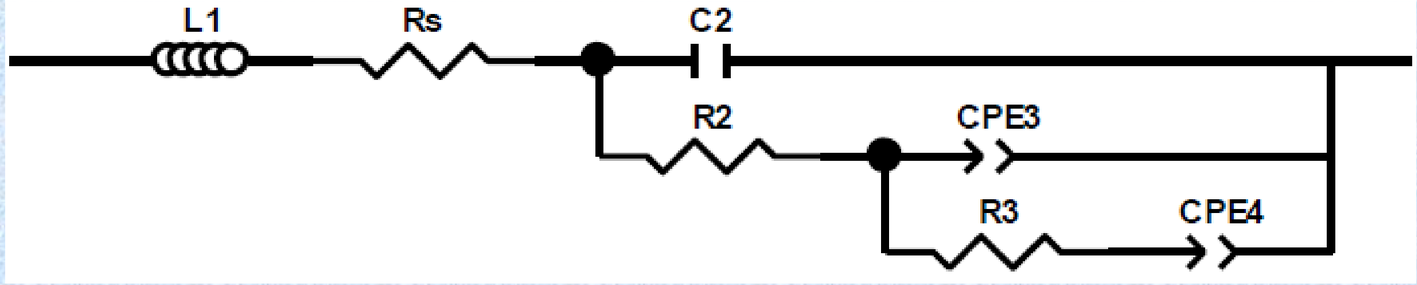

Fig.3. The equivalent electrical circuit of capacitor systems.

L_1 - inductive behaviour of the electrochemical system; R_s - resistance of the electrolyte, contacts and supply wires; $C_2||R_2$ and $CPE_3||$ R_3-CPE_4 links - the diffusion processes and the accumulation of electric charges at the electrolyte-electrode boundary in the transport pores (macro- and mesopores) and micropores of PCM, respectively.

Table 2. Specific capacity of the PCM, F/g

Standard	Method		
	Chrono-potentiometry	Cyclic voltammetry	Impedance spectroscopy
G800	117	110	112
G1000	36	32	33
L800	160	154	154
L1000	91	87	88
S800	94	89	91
S1000	77	74	75

Conclusions:

The passing of electron-ion processes in capacitors based on saccharide-derived PCM in the frequency range 10^{-2}-10^5 Hz has been studied. The equivalent electrical circuit is selected and a physical interpretation is proposed for each element of the circuit. The obtained results indicate the dominance of the double electric layer capacity over the capacity due to the redox-reactions.

References:

[1]. V.I. Mandzyuk, I.F. Myronyuk, V.M. Sachko, B.I. Rachiy, Yu.O. Kulyk, I.M. Mykytyn. Structure and electrochemical properties of saccharide-derived porous carbon materials // Journal of Nano- and Electronic Physics. 2018. V.10, N.2. 02018 (7p.) *(in Ukrainian)*.