

Lithium ion diffusivity in nanoporous carbon material

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The aim: to determine the diffusion coefficient of lithium ions in nanoporous carbon materials by the method of galvanostatic intermittent titration technique (GITT) [1].

Materials: nanoporous carbon materials (NCMs) obtained by hydrothermal carbonization of plant raw materials at a temperature of 600, 750 and 1000°C.

Methods: low-temperature porometry, galvanostatic intermittent titration technique.

Results

Fick's second law at small currents and short periods of time ($\tau \ll L^2/D$):

$$D = \frac{4}{\pi} \left(\frac{mV}{MA} \right)^2 \cdot \left(\frac{\Delta E_s}{\tau \left(\frac{dE_\tau}{d\sqrt{\tau}} \right)} \right)^2$$

M, m - molar mass and mass of NCMs; V - molar volume of the formed intercalation compound; A, L - area and thickness of the electrode; dE_τ - change in the voltage of the electrochemical element under the applied current during time τ ; ΔE_s - relaxation voltage during time τ_{rel} .

The dependence $E = f(\tau^{1/2})$ (E is the voltage of the electrochemical element) is straight-line when discharge current is $10 \mu A$, $\tau = 0.3 h$, $\tau_{rel} = 0.9 h$. At these conditions

$$D = \frac{4}{\pi \tau} \left(\frac{mV}{MA} \right) \cdot \left(\frac{\Delta E_s}{\Delta E_\tau} \right)^2$$

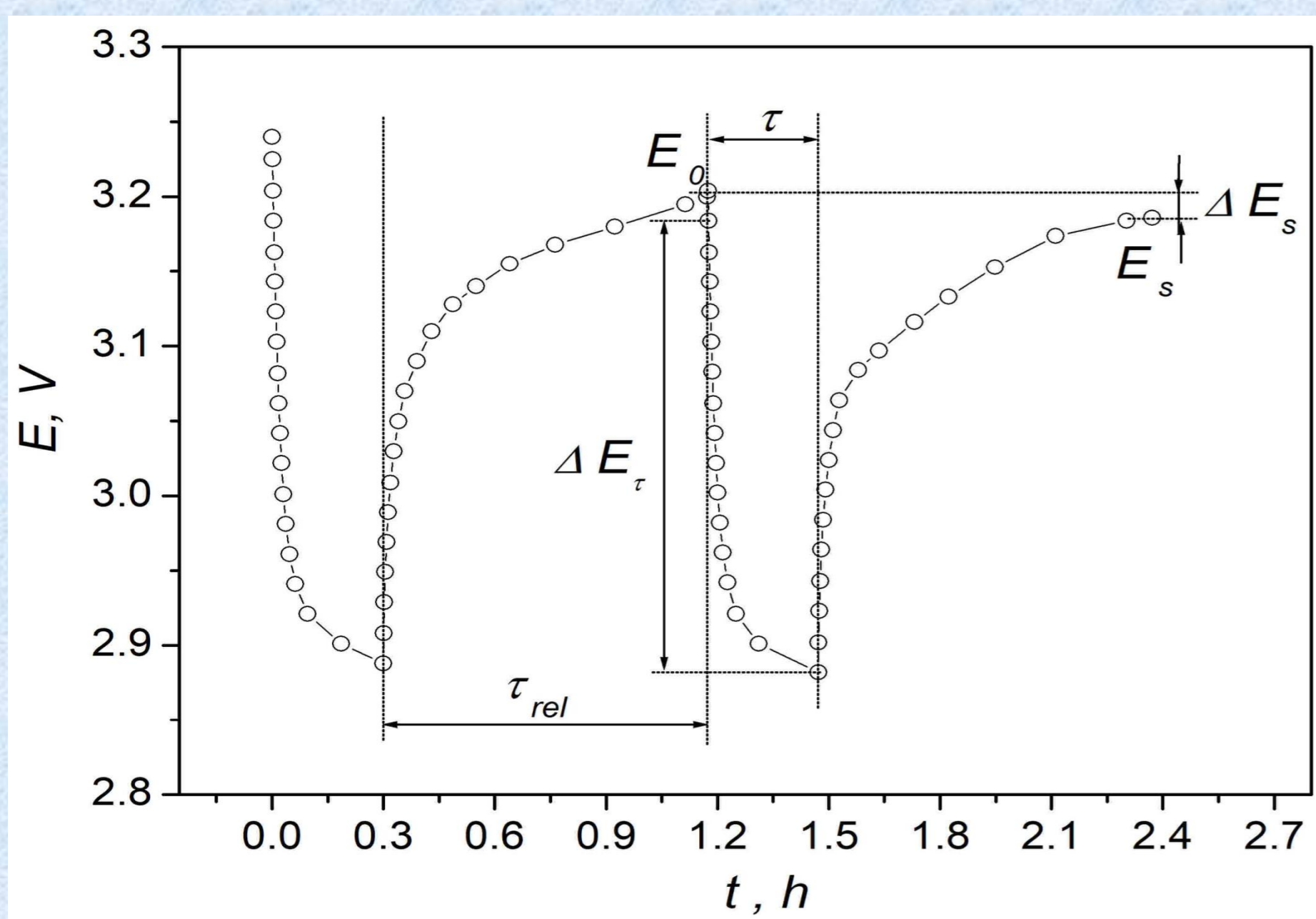


Fig.1. The fragment of GITT curve.

Table 1. Parameters of the porous structure of NCMs and lithium ion intercalation degree x

Carbonization temperature, °C	S_{BET} , m ² /g	S_{micro} , m ² /g	V_{total} , cm ³ /g	V_{micro} , cm ³ /g	x
600	357	274	0.186	0.114	0.28
750	343	292	0.166	0.123	0.44
1000	46	31	0.033	0.016	0.19

Conclusions:

GITT studies showed the significant decrease in the D value (Fig. 2) when the intercalation degree x increases due to the formation of solid electrolyte interphase on the electrode surface enriched with introduced lithium ions, the electrostatic interaction of which complicates the process of further intercalation. The differences in the D value for NCMs obtained at different carbonization temperatures are due to value of their specific surface area, the total pore volume, and the degree of ordering of the crystalline structure of the materials.

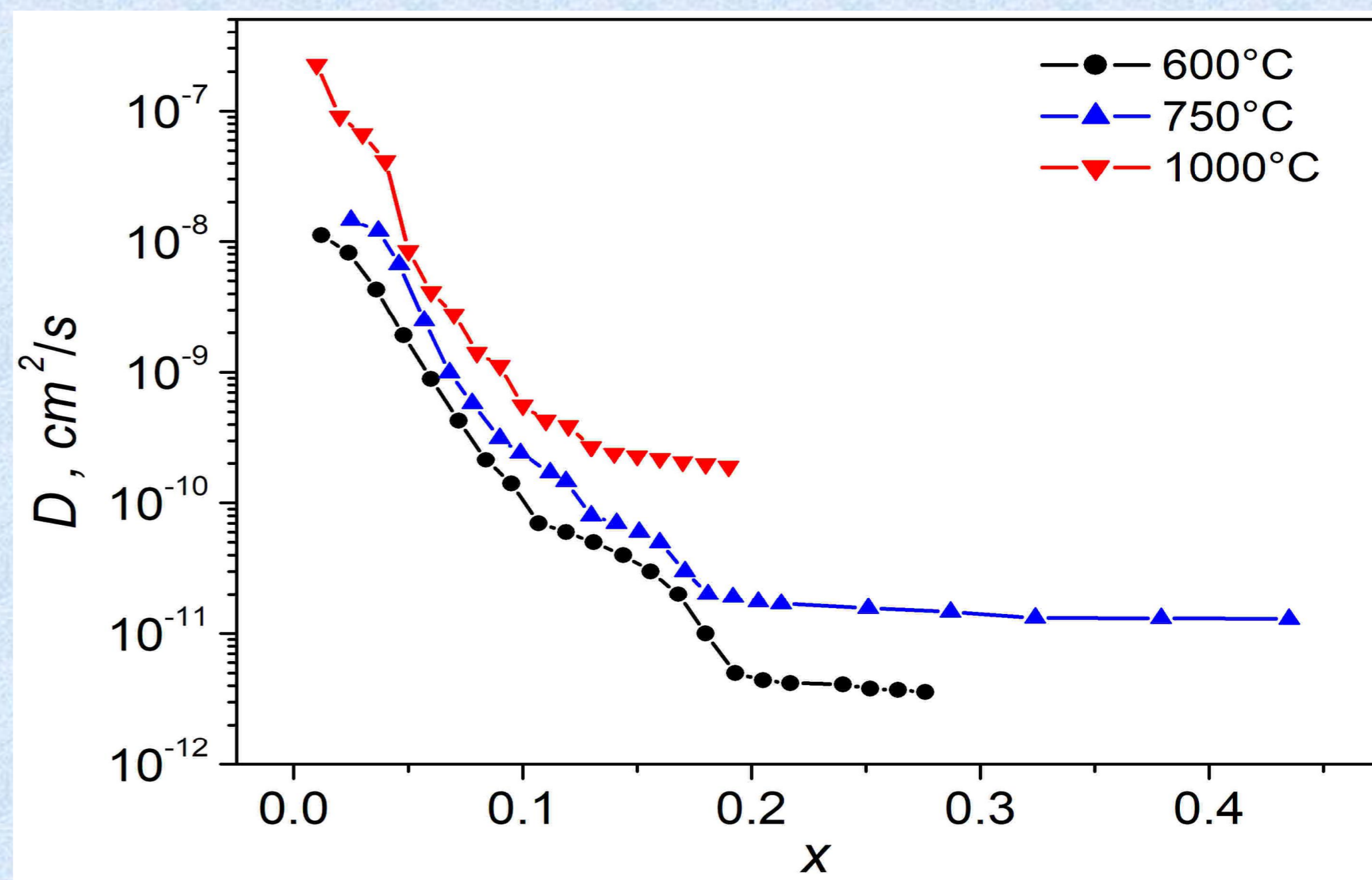


Fig.2. Dependence D versus x for NCMs at different carbonization temperatures.

References:

[1]. Deesa D.W., Kawauchi S., Abraham D.P., Prakash J. Analysis of the galvanostatic intermittent titration technique (GITT) as applied to a lithium-ion porous electrode // J Power Sources.-2009.-P. 263-268.

