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Relationship between the physico-chemical properties of "pompon" graphene and its electrochemical parameters

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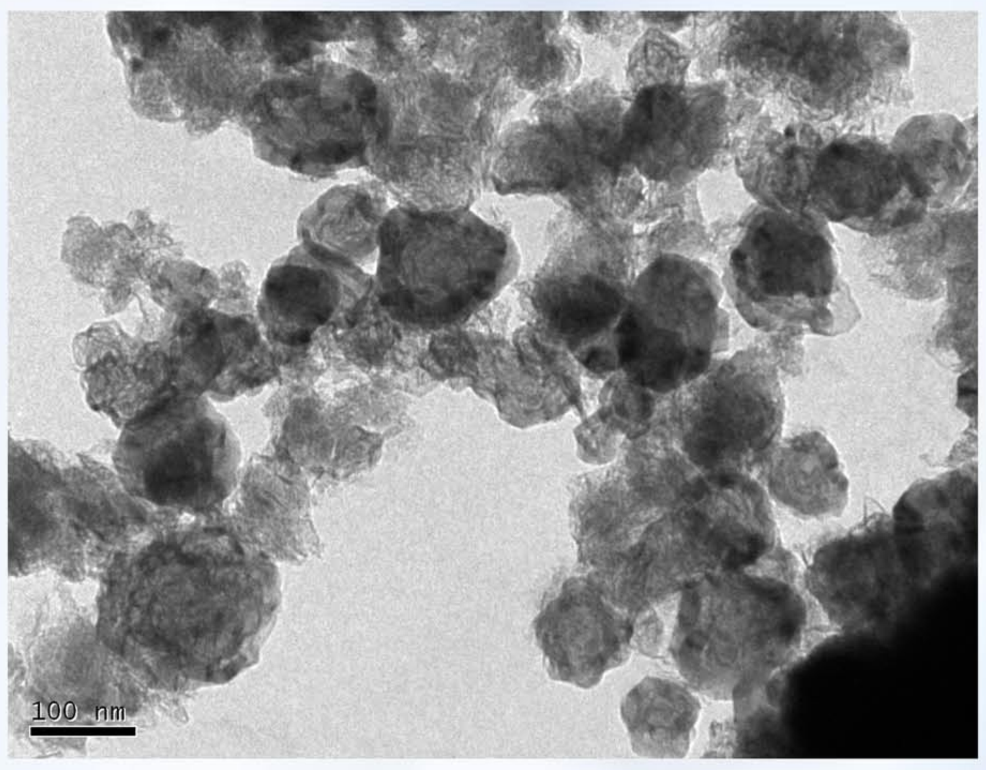
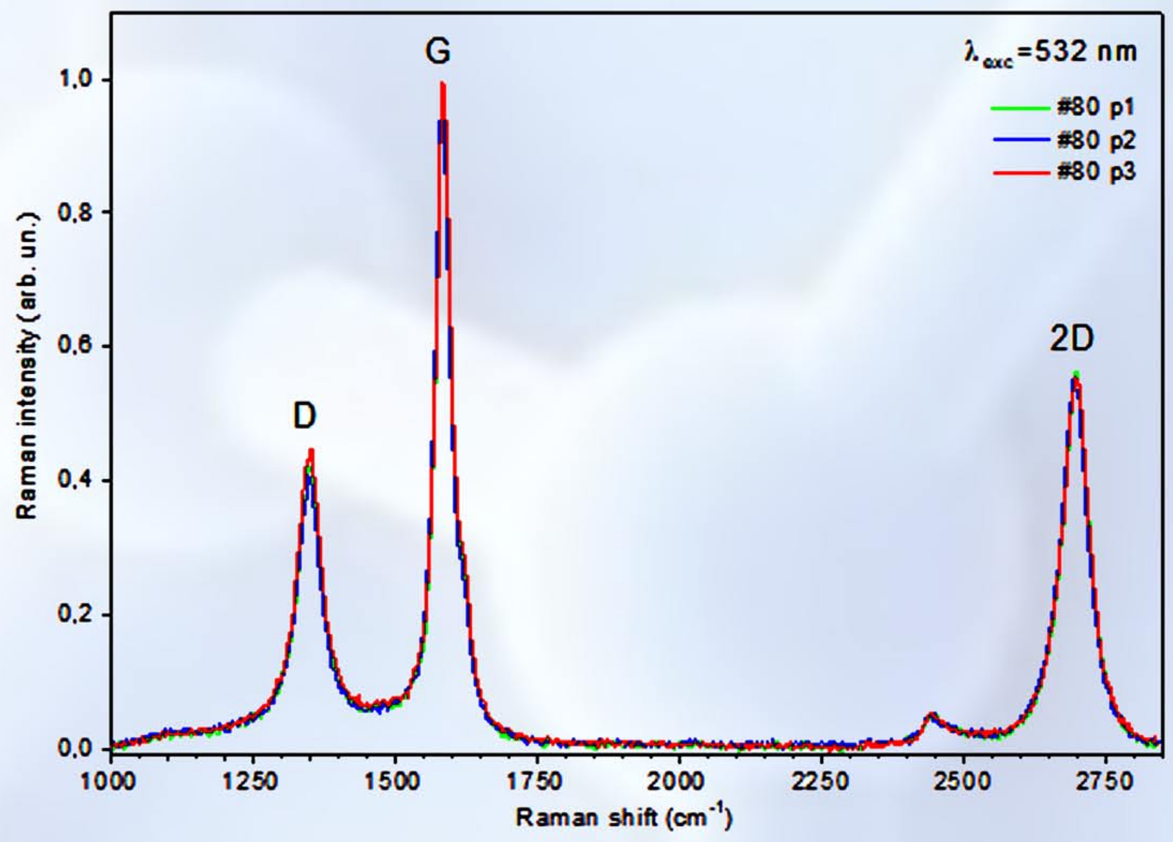
This work describes the electrochemical behavior of several modifications of "pompon" graphene as a LIB anode. Relationships between the specific surface, porosity, degree of disorder and electrochemical parameters of graphene anodes are considered. Compared with graphite, the traditional anode material in LIBs, graphene has a higher theoretical capacity of 740 mAh/g, since Li ions can be adsorbed on both sides of the graphene sheet, forming the C_3Li intercalates. The specific capacity of the "pompon" graphene obtained in our studies exceeds 600 mAh/g at i = 25 mA/g, which allows us to propose this material as an alternative to traditional graphite anodes.





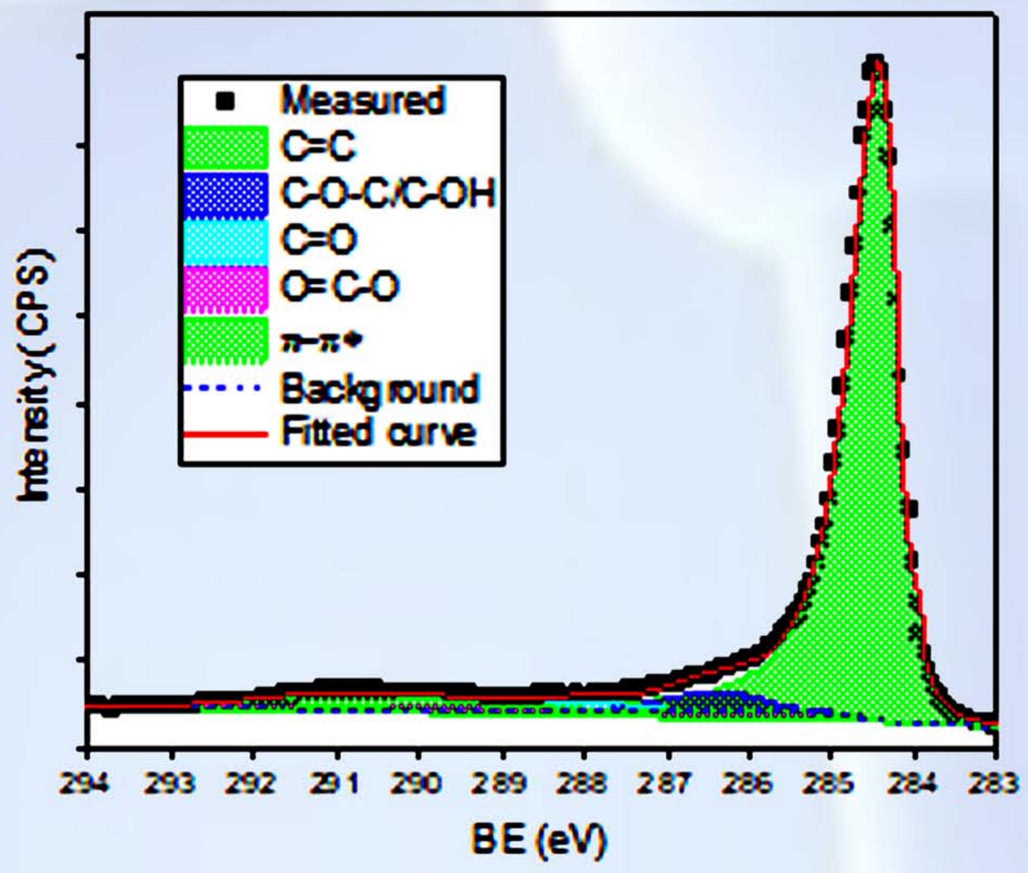


Figure 1. (a) TEM images, (b) Raman spectra (G, D and 2D bands) and (c) XPS spectra of pompom graphene.

The use of the method of detonation of hydrocarbon precursors makes it possible to obtain graphene materials in the form of pompons. Changing the synthesis parameters (pressure, temperature, etc.) makes it possible to control the size and structure of the synthesized graphene "pompons".

Thermomechanical activation allows separating graphene pompons into individual sheets and/or groups of sheets. Processing the results of Raman spectroscopy shows the presence of 2 - 8 layers. The content of oxygen groups in graphene materials does not exceed 1.5%.

Influence of thermomechanical activation time on structural, physicochemical and electrochemical properties on graphene materials used as an anode in LIB.

Samples	Specific surface, m^2/g	Pore volume, cm^3/g	Pore size, nm	I_D/I_G	Specific capacity, mAh/g (i = 37 mA/g)	Coulombic efficiency (first cycle), %
4	28.2	0.16	11.37	-	127	43.5
5	314.5	0.589	3.747	0.75	252	36.8
6	474.0	0.702	2.96	1.34	489 (596 *)	52.3

(*) – current density i = 25 mA/g

Changes in the Physicochemical Parameters of Graphene Materials under Changing Detonation Synthesis Conditions

Samples	Specific surface, m^2/g	Pore volume, cm^3/g	Pore size, nm	I_D/I_G
1	68.6	-	9.997	0.57
2	34.9	0.621	35.52	0.51
3	22.3	0.547	49.01	0.27

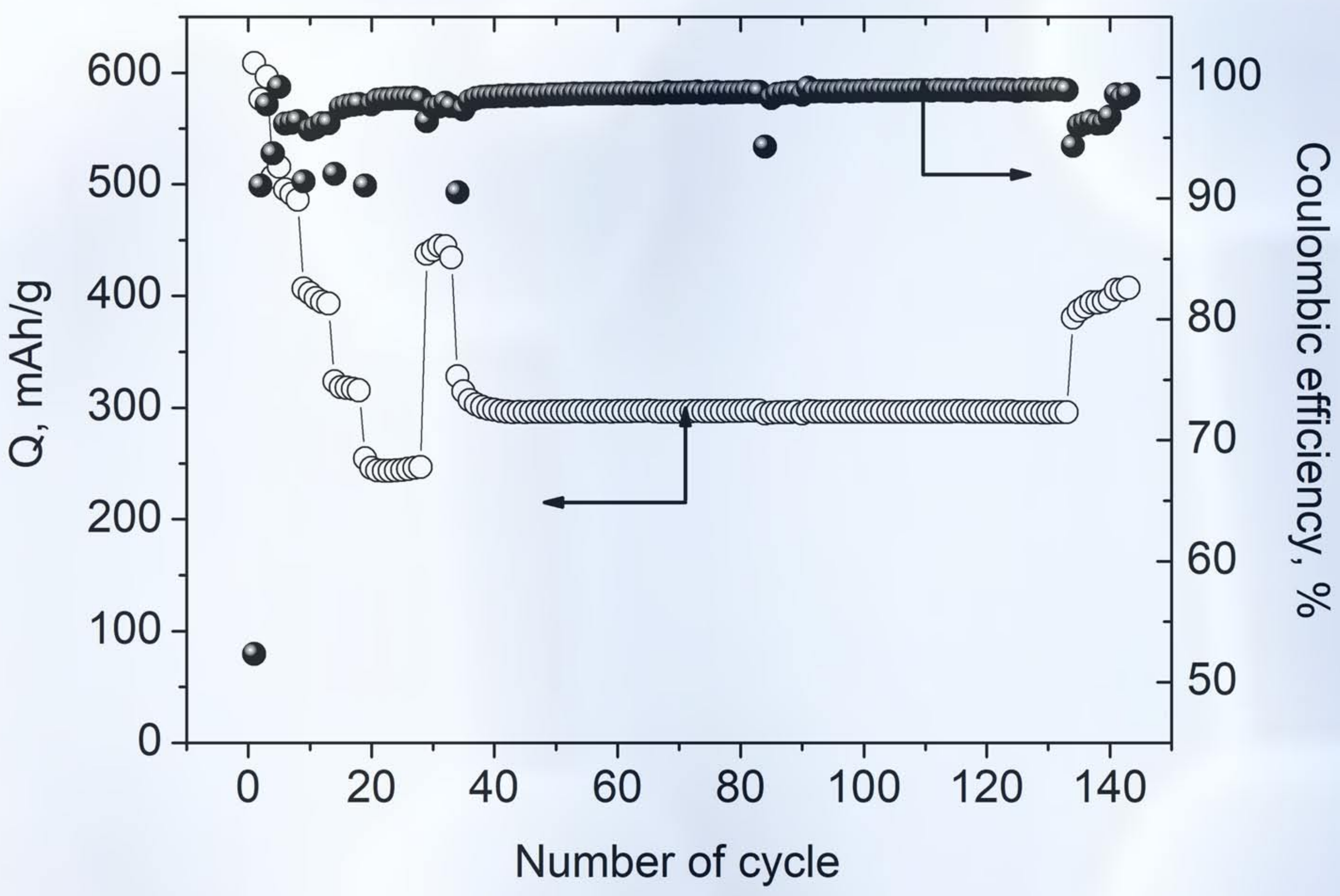


Figure 2. Change in specific capacitance and Coulomb efficiency during cycling of graphene (sample 6). Electrolyte: 1M $LiPF_6$ - EC:DEC; t = 25 ^oC. i = 25 - 400 mA/g (1 - 30 cycles); i = 50 mA/g (31-35 and 136 - 145 cycles); i = 200 mA/g (36 - 135 cycles).

Graphene materials obtained by detonation of a hydrocarbon precursor have been studied. The results of our study confirm the possibility of controlled synthesis of graphene materials, as well as the effect of thermomechanical activation time on the properties of the obtained graphene's: the degree of disorder (I_D/I_G), specific surface, porosity. Changes in these parameters affect their physicochemical and electrochemical properties witch effects the specific capacitance of graphene used as an anode for LIB. The best results for the specific capacity of the graphene material were obtained for sample 6 and amounted to 596 mAh/g at a current density of 25 mA/g. An increase in current density leads to a corresponding decrease in specific capacitance. However, even at a current density of 100 mA/g, the specific capacity of the graphene material exceeds the theoretical capacity (372 mAh/g) of graphite widely used in LIB.