Graphene as a material for energy applications

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Abstract

Statement of the Problem:

Geopolitical changes in Europe have caused, among others, energy crisis and the need to introduce changes in the supply chain of oil and gas, as well as coal. For this reason, intensive search for solutions to achieve energy independence with the use of Renewable Energy Sources began. Unfortunately, technical infrastructure has become a technical limitation, the limitations of which make it impossible to collect the surplus of energy produced. On the other hand, energy banks in the form of hydrogen storages are also at a relatively low level of advancement (except for high-pressure solutions). This fact significantly limits the development of modern systems for generating and storing energy from renewable energy sources. For this reason, high hopes are placed in graphene and materials produced on its basis with quasi2D properties of graphene not only in the field of energy, but also in relation to improving the quality of life (clean water and health).

Rising silicon prices led to the search for its substitutes. One such proposal is graphene quantum dots (QGD). The research conducted at the Institute of Materials Science and Engineering of the Lodz University of Technology led to the development of a method for producing QGD from natural precursors (extracts of fruits, vegetables, leaves or cut grass) and the construction of flexible and transparent photovoltaic cells based on them, the efficiency of which is currently at the level of several %. In this case, the ability to produce any large cell surface and its low cost is the main advantage compared to the currently used silicon wafers.

Conclusion & Significance:

The 3D material created using the oxidized form of graphene made it possible to achieve a hydrogen storage degree of 1% by weight. Another example are the processes of synthesis of graphene materials for the construction of Li-ion battery electrodes. The conducted galvanostatic tests showed that the material with finer crystallites, fewer graphene layers, higher degree of oxidation and defect reached a higher value of electrochemical capacitance. For this material, after the functionalization process, we have achieved an electric capacity of 1080 $mAhg^{-1}$, which is almost three times higher than the value recorded for commercially used graphite anodes.

Image

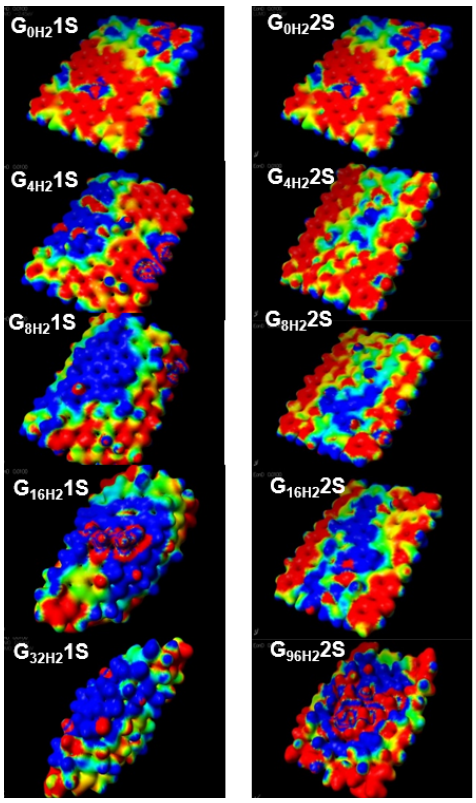

Fig. 1 Electrostatic potential of the hydrogenated graphene

Recent Publications

1. Lekshmi GS. (2024) Engineering of brewery waste-derived graphene quantum dots with ZnO nanoparticles for treating multi-drug resistant bacterial infections. Journal of Environmental Chemical Engineering 12 (2).
2. Leyko J. (2023) An experimental device for evaluation of hydrogen sorption. Metrology and Measurement Systems 30: 367-376.
3. Kaczmarek L (2021) Functionalization Mechanism of Reduced Graphene Oxide Flakes with BF3•THF and Its Influence on Interaction with Li+ Ions in Lithium-Ion Batteries. Materials 14 (3) 679.
4. Kaczmarek L. (2020) The Influence of the Size and Oxidation Degree of Graphene Flakes on the Process of Creating 3D Structures during Its Cross-Linking. Materials 13(3).
5. Kaczmarek L. (2019) The influence of the hydrogenation degree on selected properties of graphene as a material for reversible H2 storage. International Journal of Hydrogen Energy 44(41).

Photograph

Biography

Prof. Łukasz Kaczmarek The scope of my research and scientific interests concerns the possibilities of synthesis of graphene and Quantum Graphene Dots and their functionalization in terms of its use as spatial structures, for reversible hydrogen storage, for lithium ion batteries, carbon fibre composite structure, biological sensors. I use Molecular dynamics simulations In order to explain phenomena at the atomic level of different graphene structure during water filtration, lithium ion interaction, hydrogen interaction, carbon fibre/epoxy resin interaction and so on.

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