DESCRIPTION FOR THE GENERAL PUBLIC

The recent years are characterized by extremely rapid development of nanotechnology. Electronic devices are getting smaller and better quality, which leads to faster processing and storing data. Progress in the development of nanoelectronics and nanotechnology allows a theoretical discussion of the properties of the new model of nanomaterial systems. The potential benefits that may result from the use of carbon materials in these areas, cause interest in the energy and electronic industry and optimization of new technologies. However, advances in this field depend on knowing the nature of physico-chemical phenomena, which are conditioned by future benefits. This project is a contribution to the basic research needed to determine the conditions of production and basic properties of new group of hybrid materials with advanced optical properties. Sulfur-rich oligomers and polymers have attracted growing interest due to their desirable properties such as electronic, optical and magnetic, ones which are useful for the manufacturing of electronic and optical devices. OLED displays based on oligothiophene dyes have many advantages, for instance they: emit more light, have shorter response time and consume less energy than other organic dyes. Conducting polymers, in particular polythiophenes are widely used in the construction of new light-emitting diodes (photodiodes), field effect transistors, optical sensors, reversible galvanic cells (lithium polymer batteries), OLED displays, and infrared absorbing foils. Any progress in these applications requires a lot of work and time to learn the basic phenomena leading to the above mentioned materials. Oligomers and polymers rich in sulfur are very attractive due to the synthesis that guarantees the reproducibility and controllability of selected properties. Nevertheless, in the literature, apart from a few work, there is lack of systematic reports in this field. The results of the project are intended to contribute to the developmnet of knowledge in this field and the fulfillment of the so-called empty space.

The goal of the project is the design, experimental verification and synthesis production of innovative hybrid materials with the desired optoelectronic properties, and their particular characteristics, including the theoretical model of these materials. The essence of the synthesis is the use of various carbon materials as a carriers (nitrogen-rich acitvated carbons, 3D structured graphene) to deposit thin layers of oligothiophenes. Particularly important is the optimum choice of carbon materials due to their structure and surface chemistry (heteroatomic functional groups). Appropriate hybrid synthesis pathways enable the retention and/or improvement of optical properties of oligothiophenes due to the synergistic interaction with graphene carriers. Through extensive modifications of graphene carriers, it will be possible to obtain structures with the desired morphology, adsorption properties and stability. The obtained results of the research are aimed at the developing, understanding the influence of structural and chemical properties of various carbon materials such as graphene, nanotubes grafted on graphene on the properties of hybrid materials obtained by combining these two different phases. Combinations of graphene nanomaterial-heterocyclic compounds can create a new class of material that will combine the advantages of both systems and eliminate their disadvantages. We expect that the obtained hybrid materials will also be interesting from the point of view of other areas of research.

In the first place we will deal with the synthesis of graphene materials from the most commonly used substrate, i.e. graphite. By using author's exfoliation methods of transition products, we will obtain three-dimensional graphene structures obtained by a self-designed method in our team. Apart from the purely graphene materials obtained in the above-mentioned way, commercial carbon nanotubes and nanotubes grafted on graphene according to the original method developed in the applicant's scientific team will be analyzed. In the case of nanotubes, it will be performed by liquid oxidation using $KMnO_4$ to obtain reactive groups on their surface and open them for encapsulating agents.

The biggest research challenge is, apart from the synthesis and modification of graphene nanomaterials, the construction of unique DSSC cells in which both the anode and the cathode will be made on the basis of 3D structured graphene. Analysis of electrode graphene materials will be performed with a porosity and surface analyzer (ASAP 2010, Micromeritics Instrument Corp.) and a Gemini VI analyzer (Micromeritics). By contrast, SEM, SEM/EDX, TEM, XRD and XPS techniques will analyze the morphology, structure and composition of the studied systems. **One of the key tasks of the project will be the construction and testing of DSSC cells containing dye-modified carbon electrodes.**

The project relies on the interplay between the nanotechnology and optoelectronics with using methods of computational chemistry, which consequently can lead to significant development of optoelectronics. Obtaining such hybrid nanomaterials would in the future to develop an alternative method of production of third generation solar cells and contribute to the reduction of production costs of electronic materials.