# СЕКЦІЯ XVIII.
# ФІЗИКО-МАТЕМАТИЧНІ НАУКИ

## EFFECT OF GADOLINIUM DOPING ON STRUCTURAL PROPERTIES OF CARBON NANOTUBES

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Currently, graphene-based materials, which have become the subject of intensive research in various fields, are very interesting. Gadolinium-doped multi-walled carbon nanotubes (MWCNTs) are a smart nanomaterial of great interest due to their wide potential applications in various fields. The presented article is devoted to the synthesis and analysis of flakes graphene oxide obtained by the Hammers method. The synthesized flakes graphene oxide was studied using SEM, EDX, X-ray diffraction, Raman spectroscopy, element analysis, temperature dependent of resistance and IR spectroscopy. As a result of calculating the results of X-ray analysis according to the Debye-Scherer's formula, the thickness of graphite flakes was about 12,9nm and the number of layers was 38. The result of the Raman analysis show that high quality flakes grapheme oxide was obtained. Based on the result of elementary analysis of grapheme oxide mass, the C/O ratio was determined to be 1,42. The grapheme layers inside the sample were 3,31nm thick and 14,8nm long by scanning electron microscope. The temperature variation of the resistance was determined. IR spectroscopy shows the results of the absorption of electromagnetic radiation in the infrared range by atomic groups of reduced grapheme oxide and the excitation of the molecule by light quanta. When a molecule is irradiated with infrared radiation, it is shown that only quantum absorption quantities are formed according to the frequencies of the molecules [1]. Graphene-based materials were purchased and investigated by various methods [13,16-17]. The presented article is devoted to the volt-ampere characteristic of carbon nanotube doped with 10 percent gadolinium. Thus, the volt-ampere characteristic of the carbon nanotube shaped into a rectangular parallelepiped was determined and the opposite differential effect was observed at certain voltage values. The observed effect is additive is more intense in carbon nanotubes, which is because of doping [2]. The presented article analyzes the carbon nanotube obtained by the electric arc discharge method after compression under normal conditions and under pressure. The synthesized carbon nanotube was first shaped into a rectangular paraleopiped and then studied by X-ray phase analysis. Changes in the mechanical properties of the carbon nanotube as a result of the compressive force. Changes in the curves observed in the X-ray diffraction graph were observed. The dimensions of the nanoparticle before and after pressing were also calculated using the Debye– Scherrer expression, which is considered an important method in particle measurement [3]. Thermal properties of graphene-based samples were investigated [4]. The doping of gadolinium ions onto the surface of MWCNTs has been studied for potential use in biomedical applications. The incorporation of gadolinium ions onto the surface of MWCNTs has been shown to enhance the magnetic resonance imaging (MRI) contrast of the nanotubes, making them useful for biomedical imaging [5] and drug delivery [6]. Additionally, gadolinium-doped MWCNTs have also been studied for their potential in cancer therapy [7]. Gd-doped multi-walled carbon nanotubes also have shown potential as a sensor material due to their unique properties, including high surface area, chemical stability, and sensitivity to to various gases, including hydrogen, ammonia, and nitrogen dioxide [8]. The sensitivity of the material can be tuned by adjusting the concentration of Gd dopant amounts and the surface functionalization of the nanotubes. By functionalizing the nanotubes with biomolecules such as antibodies or enzymes, the material can detect specific biomarkers or pathogens in biological samples [9]. Overall, the unique properties of gadolinium-doped MWCNTs make them a promising candidate for various applications. However, further research is needed to optimize the material properties depending on the synthesis method. There are several approaches for synthesizing gadolinium-doped MWCNTs, such as co-precipitation, hydrothermal method, chemical vapor deposition (CVD), arc discharge, laser ablation, and chemical functionalization. The «common synthesis» methods (co-precipitation, chemical vapor deposition) involves the precipitation of gadolinium ions on the carbon nanotubes during the high-temperature catalyst-supported decomposition of carbon source in a pressurized vessel at high temperatures and pressures. Another approach of Gd-doped MWCNTs obtaining by hydrothermal route allow using the commercial or previously synthesized MWCNTs [10]. The advantage of hydrothermal approach is the simply control of the amount of Gd dopant by adjusting the concentration of gadolinium precursors in the reaction chamber. The doping of MWCNTs with Gd can be realized at respectively low temperatures [11] using previously tested methods for doping graphene materials [12].

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