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# Synthesis of polymer nanocomposites reinforced with graphene oxide

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**Abstract**
Since the beginning of the new millennium, the concept of "3D" has firmly entered our daily life. 3D printing technologies open up new possibilities in creativity, science, technology and everyday life. A 3D printer, or three-dimensional printing machine, is a unique modern tool with which we can print both small and large objects. In 3D printing technology, a digital model of the structure of the object is initially created in the computer, which interacts with the printer and starts forming the product layer by layer as a result of the corresponding command. The advantages of 3D printing compared to conventional printing are high speed, simplicity and relatively low cost. That is why this work deals with the synthesis of polymer nanocomposites reinforced with graphene oxide, where polydimethylsiloxane is used as a matrix. First, graphene oxide was synthesized by the modified Hammers' method and mixed with polydimethylsiloxane at different percentage concentrations. Polydimethylsiloxane was dissolved in chloroform and mixed by ultrasonication for homogenous dispersion of graphene oxide plates. We removed solvent from the resulting mixture and made 1 mm thick polymer filaments using an extruder. Here is important to select the temperature regime and relevant solvent for the production of polymer nanocomposites in order to obtain final products with desired properties.

**Keywords:** Graphene oxide, polydimethylsiloxane, extruder, filament

## Introduction

21$^{th}$ century is often called the century of polymers, because if we look around, we are surrounded by polymers everywhere: at home, in transport, and at work. We can meet polymers, more precisely polymer materials, in many products [1].

First of all, polymer composite materials are distinguished by their mechanical properties and resistance to heat, much higher than pure polymers. Another advantage of composites is that they can take any shape. The formation of products is relatively cheap and of high quality, which requires less work. Also, polymer composite materials are characterized by durability, thermal stability, and have a relatively low price compared to metal alloys [2-3].

One of the methods of preparing polymer composites is melt mixing. The melt mixing method of preparing polymeric materials involves melting the polymer followed by the addition of nanomaterials piece by piece. The melt compounding process is influenced by the following factors, the type of polymer and nanoparticles, temperature, and the process duration. Well melt mixing of polymeric materials can be done with shearing or extruders. This process allows a continuous, fast and easy transformation of raw materials into desired products. However, high temperatures during the melt compounding process can cause thermal degradation of the polymer. Therefore, it is important to select the temperature regime for the production of polymer nanocomposites in order to obtain final products with desired properties.

Graphene-reinforced 3D printing polymer filaments have the potential to advance the manufacturing process of strong, conductive composites. There are many uses for these carbon nanostructured additives in 3D printer filaments, including sensors, electromagnetic and radio frequency shielding devices [4-5].


**Fig 1:** Extruder for the production of polymer threads

Carbon nanostructures combine with other chemical elements and increase the potential of their use in various fields. Carbon nanostructures are used in adsorbents, energy accumulation and storage systems (Batteries, hydrogen storage systems and supercapacitors), catalysts or supports for catalysts, sensors or substrates for sensors, additives in polymers, ceramics, metals and metal alloys, etc. Currently, carbon nanoparticles as nano-fillers are widely found in commercial products of modern technologies [6-7]. Graphene oxide is typically produced by chemical exfoliation of graphite. A well-known technique for obtaining it is the improved Hammers method [8].

A common structural model of graphene oxide shows that its sheet edges are mainly composed of ionizable carboxylic acid groups that are hydrophilic. Meanwhile, the basal plane consists of both hydrophilic oxygen-containing functional groups and hydrophobic aromatic domains.

## Results and Discussion

Graphene is the world's thinnest material, which is a two-dimensional lattice consisting of hexagons with carbon atoms on the tips. Since its discovery, many studies have been focused on new ways of obtaining this material, its physical and chemical properties, and the creation of new graphene-based nanomaterials. Based on the planned tasks, first, the synthesis and research of graphene oxide was carried out.

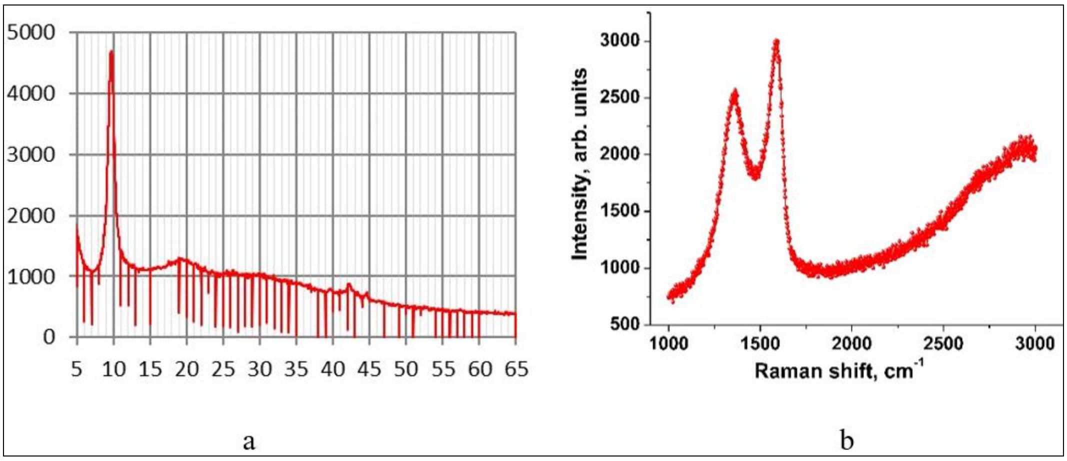


**Fig 2:** XRD and Raman spectra of graphene oxide

The modified Hammers method (tested in the literature) was used as a synthesis method and graphene oxide with a layer thickness of >30 was obtained. The obtained graphene oxide was studied by XRD (Figure 2a) and Raman spectral (Figure 2b) methods. XRD structural analysis is a technique used to characterize crystalline materials. With this method, it is possible to determine the orientation or size of a crystal or grain. In XRD (Figure 2a) we observed a peak at 200 which belongs to GO. The Raman spectroscopy results in Figure 2b show a "D" peak at 1590 cm-1 and a "G" peak at 1350 cm-1, which confirmed the lattice deformation.

In the next step, graphene oxide was added to polydimethylsiloxane in different concentrations. In order to homogenous disperse the graphene oxide plates in the matrix, we first dissolved the PDMS in chloroform, added the graphene oxide plates and stirred for 1 h. Then we removed the solvent from the mixture and obtained polymer nanocomposite plates, which we crushed and made into 1 mm-thick threads using an extruder (Figure 4).

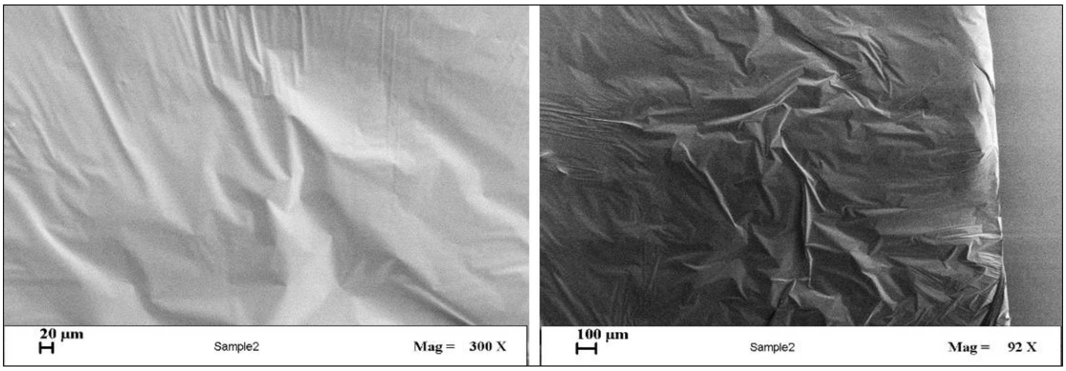


**Fig 3:** Micrograph of polymer nanocomposite

The morphology of the polymer nanocomposite was studied by electron microscope (Figure 3), where it can be seen that the graphene oxide plates are fairly evenly distributed in the polymer and no agglomerates are observed.

**Fig 4:** Filaments of graphene/polymer composites made by extruder

## Conclusion

The synthesis of polymer nanocomposites reinforced with graphene oxide was carried out, where polydimethylsiloxane is used as a matrix. First, graphene oxide was synthesized by the modified Hammers' method and mixed with polydimethylsiloxane at different concentrations. Polydimethylsiloxane was dissolved in chloroform and mixed by ultra-sonication for homogenous dispersion of graphene oxide plates. We removed solvent from the resulting mixture and made 1 mm thick polymer filaments using an extruder for further research.

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