



# Characterization and Antibacterial Activity of a Nickel Nanocomposite Based on Graphene

M. Duarte, K. O. Gonçalves, S. K. Sakata

*miguelduarte@usp.br, sksakata@usp.br, Instituto de Pesquisas Energéticas Nucleares (IPEN / CNEN - SP)  
Av. Professor Lineu Prestes 2242, 05508-000 São Paulo, SP, Brazil*

## 1. Introduction

Graphene oxide is one of the carbon allotropes with the most interest in the last decade, especially due to continuous advances in nanotechnology [1]. Due to properties such as high surface area, excellent thermal conductivity, high mechanical strength, and the availability of functional groups for reactions, graphene oxide has emerged as a material with great potential for applications [2].

Despite the various properties of graphene oxide, its production process leads to the formation of many defects in the carbon structure. These defects negatively affect properties such as heat and electron transfer through the material [3]. A commonly used approach is the partial reduction of the material to reduced graphene oxide, to partially reverse the results of oxidation without completely losing desired characteristics, such as the availability of functional groups [4].

This approach could also be used to the synthesis of metallic graphene-based nanocomposites. Which can have a wide range of applications in areas such as batteries, capacitors and sensors [5]. However, despite the growing research and production of these materials, there is a significant lack of information regarding their metabolic and immunological influences on living organisms and the environment, highlighting the need for the behavior of these particles to be studied and monitored from the planning stage [6].

Therefore, this work aimed to synthesize, characterize, and conduct an initial study of the antibacterial activities of the graphene-based nanocomposite.

## 2. Methodology

### Materials

Graphite powder 99.99% and Plate-Count Agar (105463), marketed by Merck; sulfuric acid P.A., potassium permanganate P.A., hydrochloric acid P.A., isopropanol P.A., ethanol P.A., and sodium hydroxide P.A. from Synth; 30% hydrogen peroxide produced by Sigma-Aldrich; Luria Bertani medium produced by KASVI; bacteriological agar from Gibco; Escherichia coli MG1655 bacteria.

### Syntheses of Graphene Oxide

The procedure for synthesizing graphene oxide consists of an adaptation of the method by [7].

### Synthesis of Hexaamminenickel(II) chloride

The procedure followed was based on the experimental method described by [8].

### Synthesis of Nickel Nanocomposite on Graphene-Based Support (Ni/rGO)

The synthesis was carried out following the procedure described by [9].

#### Study of the antibacterial activity of the nanocomposite (Ni/rGO)

The procedure followed was based on the methods described by [10].

It consisted of the growth of Escherichia coli at concentrations of 10, 50, 100, 200, and 300 mg.L<sup>-1</sup> of the Nickel Nanocomposite.

#### Characterization

The characterization of graphene oxide (GO) and the nickel nanocomposite on graphene-based support (Ni/rGO) was performed using X-ray diffraction from Rigaku, model SmartLab SE available at the Nuclear Reactor Center (CERPq-IPEN/CNEN-SP) and Jeol JEM 2100 Transmission Electron Microscope at the Center for Science and Technology of Materials (CECTM-IPEN/CNEN-SP).

### 3. Results and Discussion

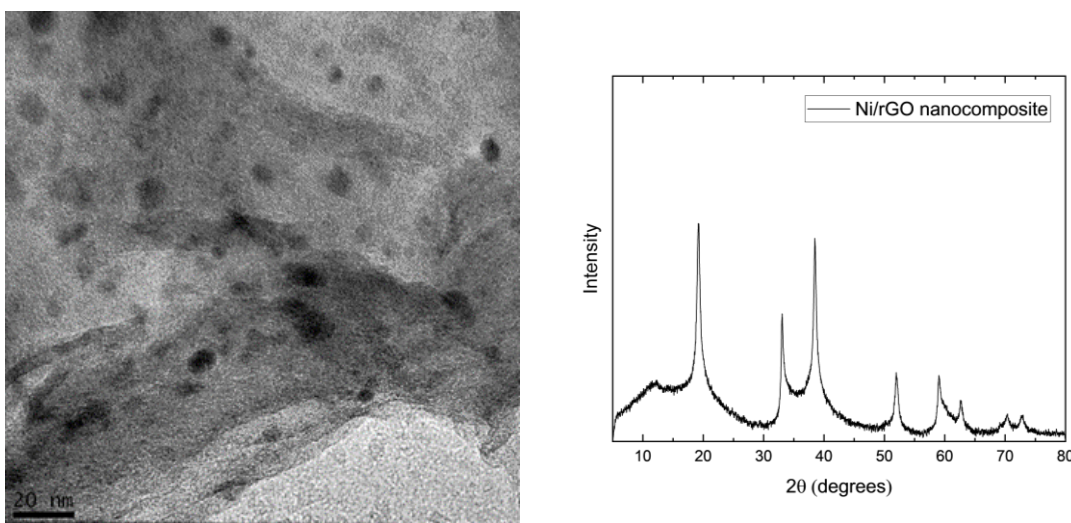


Figure 1: On the left: Transmission Electron Microscopy of the nanocomposite. On the right: Diffractogram obtained from the nanocomposite.

From the microscopy image, it was possible to notice the presence of dark spots on the surface and inside the graphene material. In transmission electron microscopy (TEM), different materials exhibit variations in electron scattering, leading to differences in contrast within the image, since metallic nanoparticles have distinct scattering behavior compared to the graphene matrix the images indicated the formation of nanoparticles in the material. The diffractogram obtained, have several peaks that indicated the presence of a mixture of Ni/NiOH material inside the graphene matrix [11].

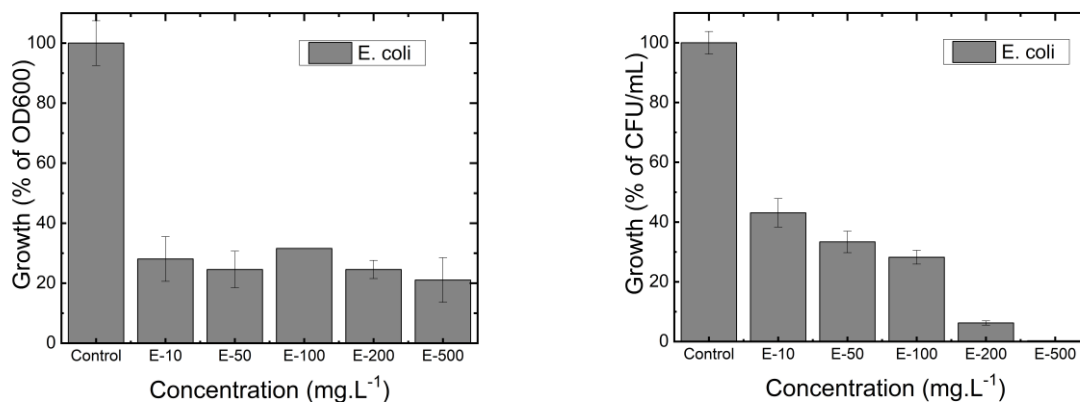


Figure 2: On the left: UV/VIS measurement of the culture media after 4 hours. On the right: Plate Count experiment of the bacterial growth.

The tests conducted on bacterial growth showed a positive correlation between the inhibition of growth and the mortality of bacteria as the concentration of the nanomaterial in the culture medium increased. This demonstrated the potential negative impact of the synthesized nanocomposite on living organisms, especially bacteria, as utilized in the tests.

#### 4. Conclusions

The study conducted, showed the successful obtention of a nickel-graphene nanocomposite that exhibited significant antibacterial activity. This demonstrates the material's potential for further research into its effects regarding cytotoxicity and environmental toxicity.

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