Study on the Interactions and Electromagnetic Shielding Properties of Graphene Oxide/Platinum Nanoparticle Composites Produced via Low-dose Gamma Irradiation

Dejan Kepić[1]
Miloš Milović[1], Dušan Sredojević[1], Andjela Stefanović[1,2], James L. Mead[3], Muhammad Yasir[3], Warda Saeed[3] and Svetlana Jovanović[1]
[1]*Vinča Institute of Nuclear Sciences - National Institute of the Republic of Serbia, University of Belgrade, Mike Petrovića Alasa 12-14, 11351 Vinča, Belgrade, Serbia*
[2]*Faculty of Chemistry, University of Belgrade, Studentski trg 12-16, 11158, Belgrade, Serbia*
[3]*Department of Computing Science, University of Oldenburg, Oldenburg D-26129, Germany*
d.kepic@vin.bg.ac.rs

Graphene and its derivatives, such as graphene oxide (GO) and reduced graphene oxide (rGO), have a large surface area, which, in combination with the oxygen-containing functional groups within the GO structure, makes them excellent materials for covalent or noncovalent bonding of various molecules, polymer chains, or nanoparticles. The hybrid nanocomposite materials prepared this way often manifest superior properties than their components [1,2]. In this study, we synthesized GO/platinum nanoparticle (Pt-NP) composites in a single step using low doses of gamma irradiation (1-20 kGy), starting with hexachloroplatinic acid as a precursor. Spectroscopic and microscopic techniques were used to evaluate the structural and morphological properties of the produced composites, along with density function theory (DFT) to examine the nature of the interactions between platinum clusters and graphene oxide sheets. GO-PtNP composites prepared at doses of 10 and 20 kGy showed homogeneous coverage of GO sheets with PtNPs, while the GO-PtNP sample prepared at the lowest applied dose showed islands with scarce populations of PtNPs and areas where PtNPs appear large and grouped. The estimated crystallite size was ~20 nm for the PtNPs prepared at 1 kGy and around 14 nm for the ones prepared at 10 and 20 kGy. The binding energy calculations suggested significant noncovalent binding between GO and platinum nanoparticles. The electromagnetic shielding efficiency of all composites was investigated in the frequency range from 8-12 GHz. The interfacial polarization, which originates from the difference in electrical conductivity of the materials in the interface, contributed to the dissipation of electromagnetic waves.

References

[1] D. Kepić, A. Stefanović, M. Budimir, V. Pavlović, A. Bonasera, M. Scopelliti, B. Todorović Marković, Radiation Physics and Chemistry 202 (2023) 110545
[2] A. Stefanović, D. Kepić, M. Momčilović, J. L Mead, M. Huskić, K. Haddadi, M. Sebbache, B. Todorović Marković, S. Jovanović, Nanomaterials 14 (2024) 912