MODIFICATION OF GRAPHENE OXIDE AND REDUCED GRAPHENE OXIDE WITH INORGANIC NANOPARTICLES

JOANNA JAGIEŁŁO*, MAGDALENA BARAN, LUDWIKA LIPIŃSKA

DEPARTMENT OF CHEMICAL SYNTHESIS AND FLAKE GRAPHENE, INSTITUTE OF ELECTRONIC MATERIALS TECHNOLOGY, POLAND
*E-MAIL: JOANNA.JAGIELLO@ITME.EDU.PL

[ENGINEERING OF BIOMATERIALS 148 (2018) 50]

Introduction

Nowadays a lot of scientific effort is focused on the development of new materials for the biomedical use (e.g. for tissue engineering [1] and cancer treatment). One of the most promising material in this field are graphene derivatives: graphene oxide (GO) and reduced graphene oxide (rGO). GO is a defected graphene (carbon layer with one atom thickness arranged in hexagonal crystal lattice), where defects are formed because of reactive oxygen functional groups bonded to the surface. Great interest of GO is due to its physicochemical properties which enable its modification with different biomolecules. This, in turn, extend possibilities for interaction with different types of cells and tissues. The crucial fact is that GO was found to be nontoxic and biocompatible towards different cell lines, even human mesenchymal stem cells [2].
The aim of this study was to obtain composites of GO and rGO with inorganic nanoparticles (NPs): Ag, Ag_2O, SiO_2, hydroxyapatite and TiO_2. These inorganic particles were used due to their biomedical activities.

Materials and Methods

Graphene oxide was prepared via modified Hummers method and reduced graphene oxide was obtained through GO reduction with ascorbic acid and at a temperature of 90°C.
Ag nanoparticles were synthetized in three routes: by $AgNO_3$ reduction with ascorbic acid, with sodium borohydride and polyphenon. Ag_2O was prepared during the reaction of $AgNO_3$ with NaOH solution. To prepare TiO_2, titanium isopropoxide was used as a precursor. Hydrolysis of TEOS led to SiO_2 formation. As a precursors for hydroxyapatite synthesis, $Ca(NO_3)_2$ and $(NH_4)_2HPO_4$ were used. Excluding the last one, each kind of NPs was obtained directly in GO or rGO water suspension to provide better distribution on their flakes. The molar ratio between GO (and rGO) and NPs was 1: 0.08.
Scanning Electron Microscopy (SEM) was used to evaluate morphological properties of the synthetized materials. Raman spectroscopy and X-Ray Diffraction (XRD) were used to confirm the chemical structure of prepared materials.

Results and Discussion

Surface topography and distribution of NPs on GO and rGO surface was observed with the use of SEM (FIG. 1).
Pure NPs as well as NPs deposited on GO and rGO flakes were studied. Each kind of the synthesized NPs was of diameter below 100 nm what was stated during SEM measurements. The used 1: 0.08 molar proportion of GO and rGO to NPs occurred to be proper to provide good distribution of NPs on flakes and not to block the whole GO and rGO surface.

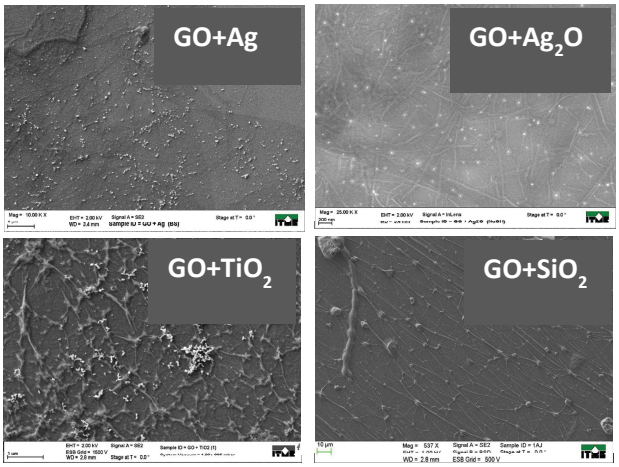

FIG. 1. SEM images of GO with NPs.

XRD measurements were conducted in order to show the chemical and crystal structure of inorganic nanoparticles. It confirmed that proposed synthesis methods led to obtain intended materials (FIG. 2).

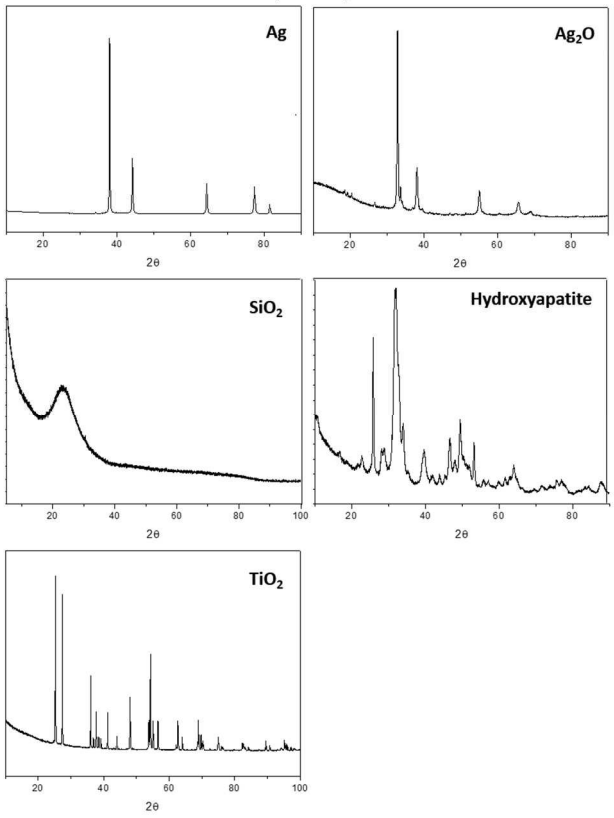

FIG. 2. XRD spectra of the synthesized NPs.

Conclusions

Different composites of GO and rGO with inorganic nanoparticles were synthesized. This work has shown that it is possible to obtain well distributed NPs on the surface of graphene derivatives flakes. Selected NPs are of great importance for bone tissue regeneration. Therefore the composites can be tested e.g. as a platform for tissue culturing and engineering.

Acknowledgments

This work was supported by NCBiR project: STRATEGMED3/303570/7/NCBR/2017

References

[1] M. Dozois et al., Carbon 120 (2017) 338-349
[2] M. Duran et al., Curr Mol Med. 17 (2017) 619-626