APPLICATIONS OF FLAKE GRAPHENE IN TISSUE ENGINEERING

LUDWIKA LIPIŃSKA*, JOANNA JAGIEŁŁO, MAGDALENA BARAN, KATARZYNA KURP

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

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Introduction

Graphene, as the material built primarily, or only (depending on the method of production) of the carbon atoms, which naturally occur extensively in all living organisms, seems to open up new possibilities for the fields of science associated with biology and medicine. Graphene, like all other allotropes of carbon, is considered to be biocompatible. The graphene family includes members such as graphene oxide (GO), reduced graphene oxide (rGO), graphene nanoplatelets (GNP) and functionalized graphenes containing various organic molecules or inorganic nanoparticles. Currently the investigations of biomedical applications of graphene are conducted in several main directions: drug and gene delivery, anticancer therapy, tissue engineering, biosensing and bioimaging [1]. To enhance stem cells growth on graphene scaffolds the graphene must undergo biofunctionalization. It was proved that decoration graphene flakes by gold nanoparticles induces osteoblast differentiation. Moreover the shape and size of metal nanoparticle impact on the differentiation process [2].

Materials and Methods

Graphene oxide was prepared by Marcano method. To obtain reduced graphene oxide several “green reductors” were used: citrate acid, glucose and amine compound. Both GO and rGO materials were modified by gold nanoparticles (AuNPs). To obtained GO/AuNPs composites metal nanoparticles were participated as a result of reduction process. After purification the colloidal suspension was combined with pure graphene oxide solutions and mixed using magnetic stirrer and mild sonication. To prepare rGO/AuNPs composites gold ions as hydrogen tetrachloroaurate(III) hydrate, ($HAuCl_4 \cdot 4H_2O$, 99.9%) were introduced to GO solutions. After adding the bioreducer, a simultaneous reduction of GO and gold ions occurred. Next, the material was purified by repeated centrifugation and final dialysis.
Elemental analysis was performed to estimate the level of reduction and oxygen content in rGO. Fourier-transform infrared spectroscopy (FTIR) allowed to determine functional groups in rGO materials prepared by reduction by various “green compounds”. X-Ray Diffraction (XRD) spectroscopy was used to examine the gold nanoparticle sizes and structure. Scanning Electron Microscopy (SEM) was used to investigate the uniformity of metal nanoparticles distribution on the graphene flakes.

Results and Discussion

The starting material for reduction and further modifications were GO flakes with diameter about 10μm (FIG. 1). The chemical composition of rGO depends on nature of reducer. By varying the synthesis conditions and the used reducers, metal nanoparticles of various shapes and sizes can be obtained. Gold nanoparticles were produced in the form of spheres with diameters of 20 nm (FIG. 2), 40 nm (FIG. 3) and 70 nm as well as rods with a length of 70 nm.

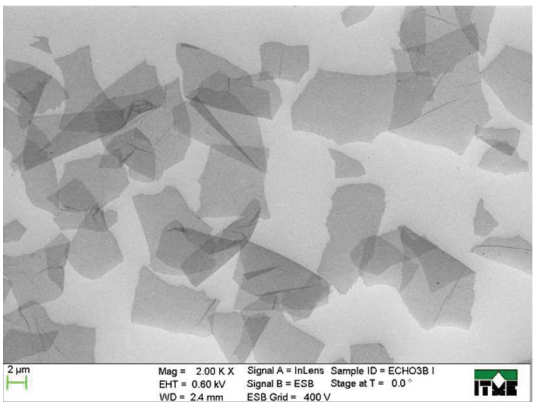

FIG. 1. SEM image of GO.

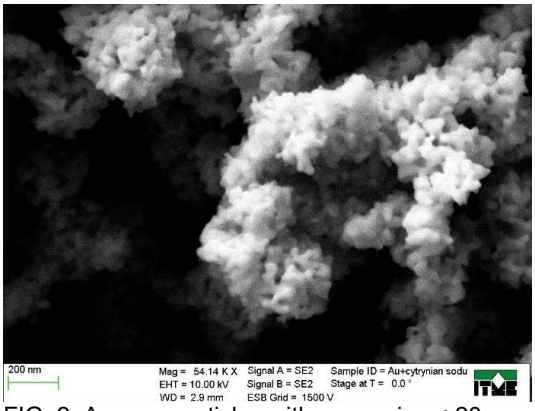

FIG. 2. Au nanoparticles with mean size < 20 nm.

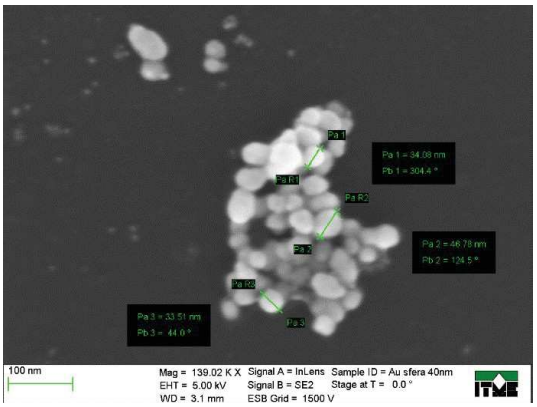

FIG. 3. Au nanoparticles with mean size 40 nm.

Conclusions

In this work we successfully developed green reduction of GO and gold ions to obtain rGO, AuNPs, GO/AuNPs and rGO/AuNPs composites intended for cartilage tissue cell growth. The citric acid, glucose and amine were used as biocompatible reducers. We expect that further biological studies will confirm that the graphene materials and composites produced with the use of amine compound will have great impact on cartilage tissue regeneration.

Acknowledgments

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References

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