HIGHLY EFFICIENT TRACEABLE DRUG DELIVERY SYSTEM BASED ON CARBON NANODISKS DECORATED WITH FLUORECENT CARBON DOTS FOR CANCER THERAPY

K.M. Lyra[1]*, N. Karouta[3], K. Spyrou[1,3], A. Enotiadis[1], N. Chalmpes[3], A. Kaminari[1], M. Patila[3,4], M. Zachariadis[2], H.Stamatis[4], D. Gournis[3], Z. Sideratou[1]

[1]Institute of Nanoscience and Nanotechnology, NCSR ‘‘Demokritos”, Attiki, Greece

[2]Institute of Biosciences and Applications, NCSR ‘‘Demokritos”, Attiki, Greece

[3]Department of Materials Science & Engineering, University of Ioannina, Ioannina, Greece

[4]Department of Biological Applications & Technology, University of Ioannina, Ioannina, Greece

(*k.lyra@inn.demokritos.gr)

ABSTRACT

Various nanomaterials have been proposed for biomedical applications including detection, diagnosis and therapeutic systems [1]. Regarding these applications, the fluorescent carbon dots (FCDs) as well as other carbon-based materials have recently drawn increasing attention [2]. FCDs have been demonstrated to be a new type of fluorescent labeling material superior to conventional dyes in many respects [3]. On the other hand, nanostructured carbon materials such as carbon nanotubes, fullerenes, graphene, etc. have been extensively used as drug delivery systems [4]. Carbon nanodisks represent an interesting alternative to bulk graphite, produced through the so-called pyrolytic Kværner Carbon Black & H2 (CB&H) process [5]. In our previous work, we have proved that hydrophilic oxidized carbon nanodiscs (oxCNDs) can be used as a promising drug delivery system [6]. In this work, oxidized carbon nanodiscs decorated with fluorescent carbon dots were prepared, able to be used as traceable drug delivery system. Specifically, oxCNDs were interacted with FCDs through electrostatic interactions, affording a fluorescent hybrid nanomaterial oxCNDs@FCDs. This synthesized novel nanomaterial was characterized employing a combination of experimental techniques, SEM, TEM, AFM, XPS, FT-IR, UV-vis and CLSC. Following physicochemical characterization, doxorubicin (DOX), a well-known anticancer drug, was successfully anchored on oxCNDs@FCDs mainly via π–π stacking interactions. The inhibition of DOX-resistant human prostate adenocarcinoma DU145 and PC3 cell proliferation was assessed by the MTT assay. It was found that oxCNDs@FCDs was subtoxic, while the encapsulated DOX in nanocarrier caused a significant viability decrease in both cell lines compared to free DOX. The cellular uptake of oxCNDs@FCDs and oxCNDs@FCDs/DOX was determined by flow cytometry, while the intracellular localization of DOX as well as of oxCNDs@FCDs was visualized by CLSC. Based on the above results, the fluorescent hybrid nanomaterial combined the hydrophilic carbon nanodisks with fluorescent carbon dots is an excellent platform for the development of a traceable drug delivery system.

REFERENCES

[1] J. A. Barreto, et. al., Adv. Mater. 2011, 23, 18-40.
[2] N. Jia, et. al., Nanotechnolgy 2010, 21, DOI:10.1088/0957-4484/21/4/045606.
[3] A. D. Zhao, et. al., Carbon, 2015, 85, 309-327.
[4] Z. Lui, et. al., Materials Today, 2011, 14, 316-323.
[5] S. Lynum, et. al., (Patent). PCT/NO1998/000093, 18 Mar 2008.
[6] P. Zygouri, RSC Adv. 2018, 8, 122-131.

ACKNOWLEDGMENTS

This research is co-financed by Greece and the European Union (European Social Fund- ESF) through the Operational Programme «Human Resources Development, Education and Lifelong Learning» in the context of the project “Strengthening Human Resources Research Potential via Doctorate Research” (MIS-5002567), implemented by the State Scholarships Foundation (IKY). Also, it was partially supported by EU under the FP7 PEOPLE-2012-IAPP-SANAD (No 324443) project.