Biocomposites Based on Functionalized Mesoporous Silica

Daniela BERGER*[1], Mihaela DEACONU[1], Simona IONIȚĂ[1], Ana-Maria BREZOIU[1], Ana-Maria PRELIPCEAN[2], Roxana-Cristina POPESCU[3], Cristian MATEI[1], Mona MIHAILESCU[4], Diana-Iulia SAVU[3]

[1] National University of Science and Technology "Politehnica", Bucharest, Faculty of Chemical Engineering and Biotechnologies, 1-7 Polizu Street,011061 Bucharest, Romania

[2] National Institute of R&D for Biological Sciences, Bucharest, Romania

[3] National University of Science and Technology "Politehnica" Bucharest, Centre for Research in Fundamental Sciences Applied in Engineering, Holographic Imaging and Processing Laboratory, Bucharest, Romania,

[4] "Horia Hulubei" National Institute for Research and Development in Physics and Nuclear Engineering, Department of Life and Environmental Sciences, Magurele, Romania

daniela.berger@upb.ro

Development of new treatments by combining therapies or the design of efficient targeted drug delivery systems represents a hot topic of research for human health [1]. Mesoporous silica nanoparticles (MSN) are widely used as carriers for many biological substances not only due to their ability to host organic molecules, but also because of the possibility to modulate their surface properties [2] by attaching either organic moieties or inorganic nanoparticles.

In this regards, we develop new targeted co-delivery systems of doxorubicin (Dox) and resveratrol (Resv) based on MSN functionalized with phenylboronic acid moieties (MSN-BA). Boronic acid groups are able to interact with various molecular targets, enzymes, receptors, nucleic acids etc. and can bind on sialic acid groups of cancer-associated mucin-1 protein [3]. The developed drug delivery systems were characterized by various techniques such as wide-angle X-ray diffraction that evidenced the presence of organic molecules in amorphous state into silica mesopores, FTIR spectroscopy, which emphasized strong interactions between doxorubicin and carrier, thermal analysis (DTA-TG) that was used to quntify the amount of active pharmaceutical ingredients in drug delivery systems. Doxorubicin and resveratrol release profiles were determined in phophate buffer solution pH 5.5 and respective pH 7.4. If Dox,Resv@MCM-BA is compared with Dox@MCM-BA, the presence of resveratrol in the drug delivery system caused a faster release kinetics of the cytostatic agent, as well as a higher cumulative doxorubicin release after 24 h. The cytotoxicity of developed drug delivery systems was assessed on BJ fibroblast dermal cells and BT474 breast cancer cell line. The results revealed an enhanced antiproliferative effect when resveratrol was present as co-delivery drug besides doxorubicin. For both systems the cytotoxic effects on BJ cells in culture was lower than on BT474 cells. Hyperspectral imaging was used to investigate interactions between nanoparticles and the two mentioned cell-types to observe their preferential accumulation inside cells. A higher amount of Dox@MCM-BA nanoparticles BT474 cells than in the case of BJ fibroblasts was noticed.

Many efforts are focused on developing new composite materials based on phytocompounds as antibacterial agents for replacement of antibiotics or as anti-inflammatory agents. In this context, we obtained polyphenolic extracts from wild berry leaves that were further encapsulated into MSN functionalized with organic groups or modified with ZnO or Ag to enhance their stability over time. The properties of extracts were evaluated before and after encapsulation into functionalized MSN. Generally, the results showed improved properties for encapsulated extracts than for the corresponding free extracts. For instance, quantification of TNF-α cytokines showed that the wild bilberry leaves extract encapsulated in hollow mesoporous silica modified with ZnO (HS-ZnO) provided a better anti-inflammatory activity than that of the free extract. The composite containing HS-ZnO showed a synergistic antibacterial activity due to both extract and ZnO nanoparticles attached to silica surface. We developed biocomposites by including encapsulated extract in mesoporous silica into colaggen matrix [4].

Acknowledgement: The financial support from UEFISCDI through projects PCE no. 117/2022 and 576PED/2022 is highly appreciated.

References

[1] S. Tran, P.J. De Giovanni, B. Piel, et al., *Clin. Transl. Med.* **2017**, *6*, 44.
[2] H. Ahmed, S. Sudhakar Gomte, E. Prathyusha, et al., *J. Drug Delivery Sci. Technol*., **2022**, *76*, 103729.
[3] X. Zhang, S. Zhang, S.J. Baek, et al., *ChemBioChem*. **2017**, *18*, 1578.
[4] M. Deaconu, A.M. Prelipcean, A.M. Brezoiu, et al., *Pharmaceutics* **2023**, *15*, 312.