Innovative composites based on collagen, hydroxyapatite and mesoporous silica loaded with polyphenols

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0D nanomaterials (nanoparticles) have unique properties mainly based on their high surface area and their high affinity of surface modification / functionalization and thus are used in emergent therapies, especially for those involving resistance (cancer and infections). The porous materials represent a versatile nanostructured material used as drug delivery support. Many medical applications are based on mesoporous silica (such as MCM-41 family), therefore it is a good candidate for bone-related applications [1]. Due to the great capacity for adsorption, the mesoporous materials loaded with different biological active agents (BAA) has led to growing interest in developing innovative nanostructures with improved functionalities, being used in fast healing but also in drug delivery especially for antimicrobial and antitumoral therapies. These nanostructures as well as their analogues loaded with the specific BAA can be entrapped in the composite materials, including collagen/hydroxyapatite (COLL/HA) composites in order to be used in bone regeneration.

In this study, Col/HA/MCM-41/BAA composite were obtained, characterized and used in hard tissue engineering, wound dressings or as drug delivery system. In the first step, mesoporous silica with different characteristics (structure and porosity) loaded with caffeic and gallic acid, were synthesized by the soft-templating method. In the second step, Col/HA/MCM-41/BAA were obtained, (developing ternary systems), using the direct mixing of the MCM-41 loaded with BAA into the COLL/HA matrix. Therefore, the release will have two individual mechanisms of release, a diffusional one from the matrix (faster) and one from the mesoporous system (slower). Col/HA composites were obtained using direct mineralization with hydroxyapatite precursors (calcium hydroxide and dibasic sodium phosphate) at pH 9.5 for fibrillary orientation [3]. Crosslinking of the biomaterial was performed with 1% glutaraldehyde. The obtained composite was washed several times in distilled water and then lyophilized to obtain a potentially reliable graft for cellular population.

The obtained materials were characterized from morphological and structural point of view by specific techniques: X-ray Diffraction (XRD), Scanning Electron Microscopy (SEM), Fourier Transform Infrared Spectroscopy (FTIR) and Thermogravimetric Analysis (TGA). The in vitro study was performed in two types of simulated biological fluids with different pH, simulated gastric fluid (SGF) and simulated intestinal fluid (SIF). Finally, the obtained materials will be tested for various biomedical applications as systems with controlled release of polyphenols extracted from natural sources, including tissue engineering with a focus on regeneration and antimicrobial activity.

Acknowledgement

The authors are acknowledging the support of the project 29ROMD/20.05.2024: “Nanostructured bone grafts with predetermined properties” and to the Romanian Government for providing access to the research infrastructure of the National Centre for Micro and Nanomaterials through the National Program titled “Installations and Strategic Objectives of National Interest”

References

[1] Petrisor, G., et al., Increasing Bioavailability of Trans-Ferulic Acid by Encapsulation in Functionalized Mesoporous Silica. Pharmaceutics, 2023. 15(2).

[2] Anton FICAI, Ecaterina ANDRONESCU, Georgeta VOICU, Cristina GHITULICA, Bogdan Stefan VASILE, Denisa FICAI, Viorica TRANDAFIR; Self assembled collagen/hydroxyapatite composite materials; Chemical Engineering Journal, 2010;160(2), 1385-8947

[3] Jian M., Ficai A., Ficai D., Nacu V., Cobzac V., Mostovei A., Solomon O., Chele D. Graft for bone defects repair. Innovator certificate nr. 6290, 2024.