HYDROGELS FOR 3D BIOPRINTING

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Introduction

The biofabrication of three-dimensional (3D) biomimetic tissue analogs, which accurately mimic the properties of native tissue, has enormous potential for research in organ physiology, pathology, cancer research and regenerative medicine. A significant impediment for the development of therapies is the shortage of available tissues and the inability to sustain mature tissue cultures. Bioprinting is one of the dynamically rising techniques to biofabricate biomimetic tissues, based on in vivo development (cellular self-assembly and -organization) [2,3].

One of the strategies to improve the bulk and surface properties of biomaterials is the incorporation of bioactive substances. Although for hydrogels a number of nanoparticle-incorporation strategies were investigated, they are mostly related to carbon, metals, and oxides. Here, we propose a new approach for embedding bioactive substances nanoparticles via a one-step sonochemical method, i.e. simultaneous formation and anchoring. The proposed approach is versatile and opens a plethora of possibilities to form nanoparticles of various bioactive substances. This makes a possibility for releasing therapeutic agents from the generated nanoparticles with controlled kinetics. It results from the fact that the size, morphology, and incorporation depth of nanoparticles can be easily tuned by adjusting the parameters of the sonochemical process.

The aim of the study was to optimize the sonochemical parameters in order to obtain homogenous dispersion of nanoparticles in the hydrogel without damaging the chemical structure of the material.

Materials and Methods

Methacrylamide-modified gelatin (GelMA) was prepared following the protocol [3], in the studies, 10 w/v% GelMA hydrogel in PBS was used.

Metal and oxide nanoparticles of Au (5 and 35 nm) and Fe_3O_4 (5 nm and 30 nm) were incorporated in the GelMA matrix. For the dispersion of nanoparticles in the prepared GelMA solution Ultrasonicator Sonics Vibracell was used while the following parameters were changed: sonication time 10-30s, mode pulse or continuous, amplitude 20-40%. After the synthesis, the obtained materials were lyophilized and characterized with the use of TG/DTA, ATR-IR spectroscopy, and Scanning Electron Microscopy.

Results and Discussion

The materials were carefully evaluated after each set of sonochemical treatments in order to check the GelMA stability. For the applied parameters none of them caused damage to the GelMA chemical structure which was confirmed with TG/DTA (no changes in melting point) and ATR-IR spectroscopy (no changes in the molecule fingerprint, see spectra in FIG. 1). However, the amplitude above 30% causes overheating of the samples and their foaming especially the latter one counteracts the crosslinking process. As a result, the optimal sonochemical parameters (10s of continuous mode, 30% amplitude) were somehow the compromise between homogenous dispersion of the nanoparticles in the GelMA and its macroscopic morphology after sonochemical treatment.

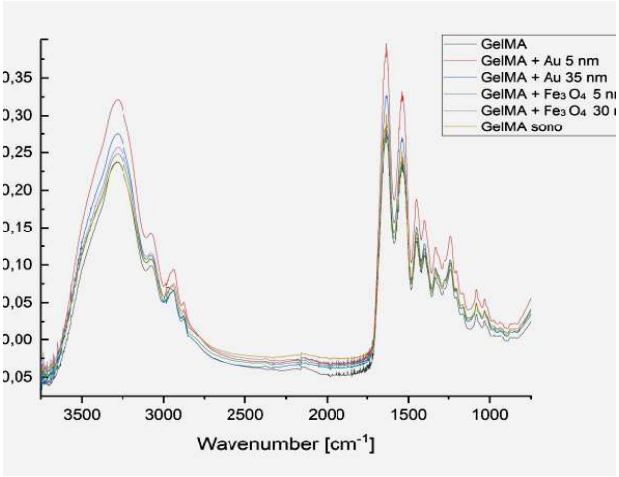

FIG. 1. Representative ATR-IR spectra of parent hydrogel GelMA as well as nanoparticles-functionalized GelMA treated sonochemically (10s of continuous mode, 30% amplitude).

The resultant morphologies of nanoparticles-functionalized GelMA were then observed with the use of SEM (FIG. 2).

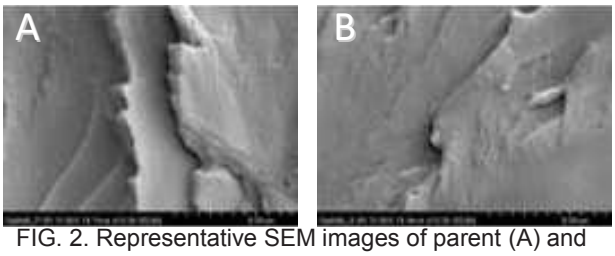

FIG. 2. Representative SEM images of parent (A) and nanoparticles-functionalized (B) GelMA hydrogels.

Conclusions

The obtained results showed that the optimized parameters of ultrasonic functionalisation of GelMA do not change the native chemical structure of hydrogel and incorporated bioactive substances. In broader context the sonochemical functionalization can be used as a versatile method for bioinks fabrication with adjusted both realogical and biological properties.

Acknowledgments

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References

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