ASSESSMENT OF MECHANICAL AND BIOLOGICAL PROPERTIES OF SODIUM ALGINATE/GELATINE HYDROGELS DEDICATED FOR BIOPRINTING PREPARED WITH THE USE OF VARIOUS SOLVENTS

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Introduction

According to the report [1], the industry of additive manufacturing methods will increase from USD 6.1 trillion in 2016 to USD 21 trillion in 2020 (from use in medicine, it accounts for 11% of the total AM market). 3D printing allow the development of implants, tissue engineering, artificial organs, controlled drug delivery systems as well as planning operations [2]. Intensively developing field of 3D printing is bioprinting – layer by layer printing of biomaterials with living cells in a recommended pattern [3]. The use of bioprinting methods in tissue engineering has many advantages. First of all, it allows to obtain anatomically appropriate tissues based on previously obtained data from medical imaging. It allows to obtain complex geometries with controlled porosity. Due to the significant development of the bioprinting technology, it is possible to print structures with different types of cells. Cells, as well as other biological components, can be precisely placed in accordance with the pattern previously planned [4]. Printing of functional organs is not yet possible. Achieving this goal is possible through further development of methods of bioprinting and, above all hydrogels provide a good environment for the cell's growth and proliferation, appropriate mechanical properties and printability.

Materials and Methods

For the preparation of hydrogels sodium alginate/gelatin in various conversations, two solvents were used: deionized water and Dulbecco's Modified Eagle Medium medium (DMEM, Corning) supplemented with 10% fetal bovine serum (FBS,Corning) and 1% vol. antibiotics penicillin/streptomycin P/S (Corning). Hydrogels were evaluated for chemical analysis (FTIR), mechanical properties (Young's modulus and compressive strength) and biological response using the EA.hy 926 cell line (ATTC). Hydrogels were tested for stability over time by placing them in a PBS buffer (Corning) solution in 37°C. After incubation time (24h, 48h, 7 days, 14 days, 21 days), the chemical and mechanical properties as well as mass loss were investigated. For hydrogels with the best parameters direct bioprinting test were carried out. Living cells were introduced into the hydrogels with the best parameters and direct bioprinting test were carried out on the custom designed and built bioprinter. The temperature of the nozzle was changed during the bioprinting and its impact on the bioink extrudability and cell viability was assessed. Rheological properties of hydrogels were tested on a rheometer at nozzle temperatures during bioprinting.

Results and Discussion

Regardless of the choice of solvent and the percentage content of sodium alginate and gelatin, the prepared hydrogels do not induce a cytotoxic effect in the reaction with EA.hy926 cells line. Cell adhesion and proliferation depends on the topography of the surface of the prepared hydrogels. The use of a culture medium as a solvent promotes cell proliferation.
In the case of mechanical properties, the use of various solvents primarily affects compressive strength - higher values for hydrogels prepared using water as a solvent. Increasing gelatin content increases the value of compressive strength, as already noted in the research carried out by the Giuseppe's team [5]. The method of sample preparation (temperature and mixing time, crosslinking time) has a significant influence on the values of the determined mechanical parameters.
As a result of incubation in a PBS solution at 37 Celsius degrees, the compressive strength values drop, the mass and pH of the buffer change, what indicates that the degradation processes is taking place.

Conclusions

The properties of hydrogels depend on the concentration and the used solvent. The ability of cells to grow further depends on the topography of the surface of the hydrogels. During the bioprinting, it is necessary to select the temperature that ensures the appropriate viscosity of the hydrogel and to limit the shear stress when extruding through the nozzle.
There are many studies carried out using hydrogels of sodium alginate / gelatin prepared using physiological saline [6], deionized water [7], HEPES medium [8] or PBS as the solvents. As a final aim of our work is to use the hydrogels for the direct bioprinting, we took up an investigation on the effect of a various solvent used at the same content of gelatine and sodium alginate for the chemical, mechanical and biological properties of bionks.

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References

[1] Wohlers T., Wohlers Report (2017).
[2] Ventola C. L., Pharmacy and Therapeutics 39 (2014) 704-711.
[3] Thomas D. J., Jessop Z. M. i Whitaker I. S., Woodhead Publishing, 2018.
[4] Ozbolat I. T., Academic Press (2017).
[5] Giuseppe M.D. *et al.,* Journal of the Mechanical Behavior of Biomedical Materials 79 (2018) 150-157.
[6] Neufurth M. *et al.*, Biomaterials 35 (2014) 8810-8819.
[7] Pan T. *et al.* Journal of Materials Science and Technology 32 (2016) 889-900.
[8] Colosi C. *et al.,* Advanced Materials 28 (2015) 677-684.
[9] Bandyopadhyay A. *et al.* Biocybernetics and Biomedical Engineering 38 (2018) 158-169.