Optical methods for studying the composition of hydrogels based on human tissues for 3D bioprinting and regenerative medicine

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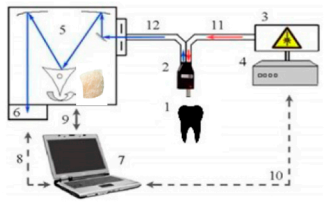
INTRODUCTION

Today, the number of patients who face the problem of restoring bone and cartilage tissue is increasing all over the world. However, to solve this problem in medicine, special materials are already being used to ensure the best biocompatibility. The current direction of regenerative medicine, at present, is 3D bio-printing or bioprinting using hydrogels obtained on the basis of allogeneic material in combination with the cells of the patient himself. At the same time, the composition of hydrogels affects the final product during 3D bioprinting. Therefore, the study and control of the composition of hydrogels at different stages of their production is a very important task for obtaining a high-quality final bio-product.

METHODS AND MATERIALS



Raman Spectroscopy experimental stand:
1 – subject;
2- Raman probe RPB785;
3 – laser module LuxxMaster Raman Boxx;
4 – laser module power source;
5 – spectrometer Shamrock sr303i;
6 – build-in cooling camera DV420A-OE;
7 – computer;
8, 9, 10 – command cable;
11 – transmitting optical fibre;
12 – receiving optical fiber.

Laser power 400 W

Exposure time 30 s

The distance from the probe to the object 7.5 cm

Research range 400-2050 cm-1

Laser cooling -60 C°

Resolution of the spectrograph 0.15 nm

The study materials were 4 groups of samples:

I – mineralized bone tissue, II –demineralized bone tissue, III – hydrogel of collagen-containing material (liquid form), IV–lyophilized collagen-containing material (lyophilizate).

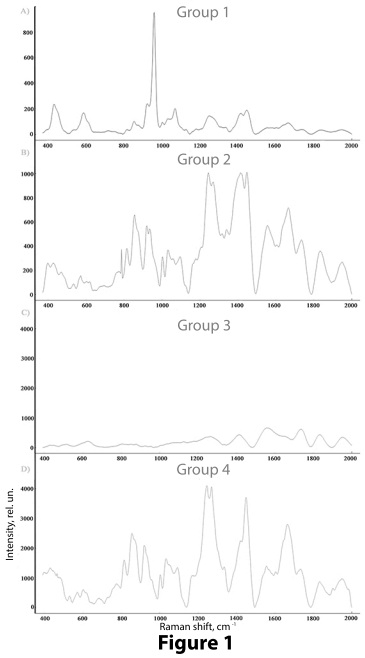


Figure 1
Averaged Raman spectra of the studied groups of samples

RESULTS OF RESEARCH

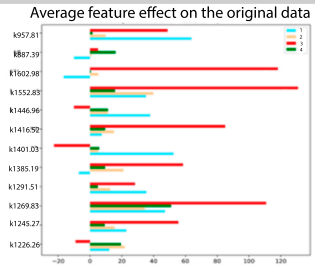


Figure 2
Averaged coefficients of discriminant functions of the most significant variables in the model

Table 1
Top 5 features per class

	Group 1	Group 2	Group 3	Group 4
1	k957.81	k1552.83	k1552.83	k1269.83
2	k1401.03	k1269.83	k1602.98	k1226.26
3	k1269.83	k1226.26	k1269.83	k887.39
4	k1446.96	k1385.19	k1416.52	k1552.83
5	k1291.51	k1245.27	k1385.19	k1446.96

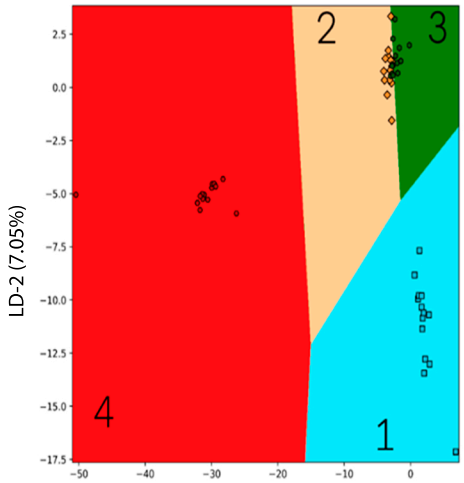


Figure 3
Graph of values of linear discriminant functions

CONCLUSION

Using optical methods, the hydrogel of an allogeneic collagen-containing material was analyzed at different stages of its processing in various aggregate states (hydrogel and its liphilizate). The technique we used allows us to obtain a hydrogel by chemical means from demineralized bone tissue with the preservation of a complex of skeleton proteins and extracellular matrix proteins. It is established that using the method of Raman and IR spectroscopy, it is possible to successfully monitor the evaluation of the quality of the resulting product in various aggregate states at all stages of the technology being developed for its production.