Peculiarities of the microstructure of gelatin hydrogel structured by bifunctional dioxirane crosslinkers

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Introduction

In the treatment of wounds of various origins, hydrogel dressings are increasingly used, which combine a number of properties, for example, intensive absorption of wound exudate, the creation of a protective barrier that protects the wound from infection, prolonged and targeted release of therapeutics. Most of the properties are greatly influenced by the porosity of the hydrogel, which depends on the presence of cross-linking bonds.

Materials and Methods

Gelatin (bloom-180) manufactured by Aldrich was used without additional purification. Polyethylene glycols (PEG) of molar mass 200, 400, 600, 1000 g/mol (Aldrich). The synthesis of structuring agents - dioxirane derivatives based on polyethylene glycols of different molecular weights of 200, 400, 600, 1000 was carried out according to the methods described earlier [1]. The purity of the substance was determined by the value of the integral of the signal from 2 protons of the oxirane ring with a displacement of 2.65-2.85 ppm. by the method of ^{1}H NMR spectroscopy at a frequency of 400 MHz in automatic scanning mode. A scanning electron microscope JEOL, JSM 6510 LV is used to see the microstructure of hydrogels. Samples were frozen with liquid nitrogen, lyophilized, broken, and covered with gold film before examination.

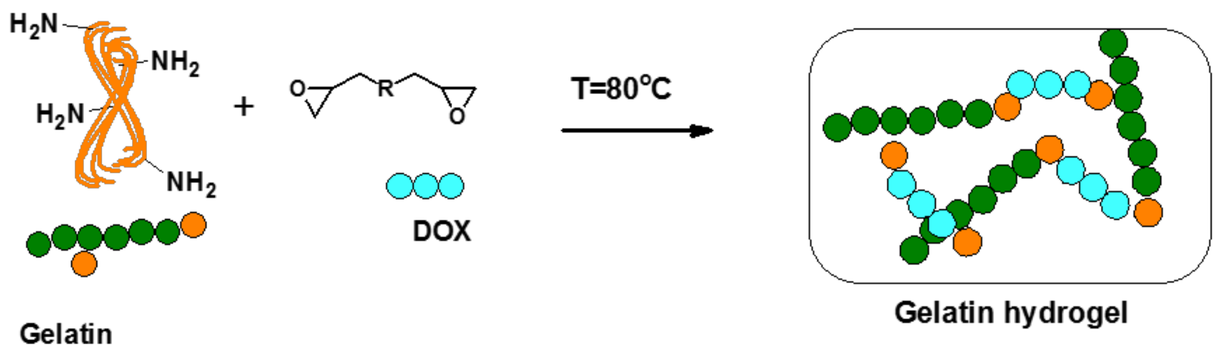

Fig.1. Scheme of hydrogel three-dimensional network formation (R-polyethylene glycols of molecular weight 200,400,600,1000)

Result

We obtain gelatin hydrogels structured by bifunctional dioxirane crosslinkers based on polyethylene glycols of various molecular weights (fig.1). Investigation of structure (SEM, TEM) showed a dependence of the pore size on the structuring agents and their concentration. Pores are irregularly shaped and of heterogeneous size. Table 2, for example, shows the results of studies of hydrogels based on a bifunctional dioxirane derivative of polyethylene glycol-400 (DOX-500) and type A gelatin (bloom 180). The results are given for unstructured gelatin and gelatin hydrogels with different content of the structuring agent (table 1).

Table 1

Synthesis parameters and properties of obtained gelatin hydrogels

Sample number	Reagents ratio		DOX-500 concentration, %	Gelatin concentration, %	Gel-fraction content, %	Maximal swelling, g water/g polymer	Maximal loading*, kPa	
	DOX-500	Gelatin					20 °C	37 °C
1.	1	1	9.0	9.0	55.9	59.5	27	1.6
2.	1	2	6.0	12.0	64.9	57.2	30	3.2
3.	1	3	4.5	13.5	78.2	38.5	42	7.7
4.	1	4	3.6	14.4	81.5	35.1	45	8.5
5.	1	5	3.0	15.0	79.7	28.0	60	10.9
6.	0	1	0.0	15.0	0.0	0.0	10	-

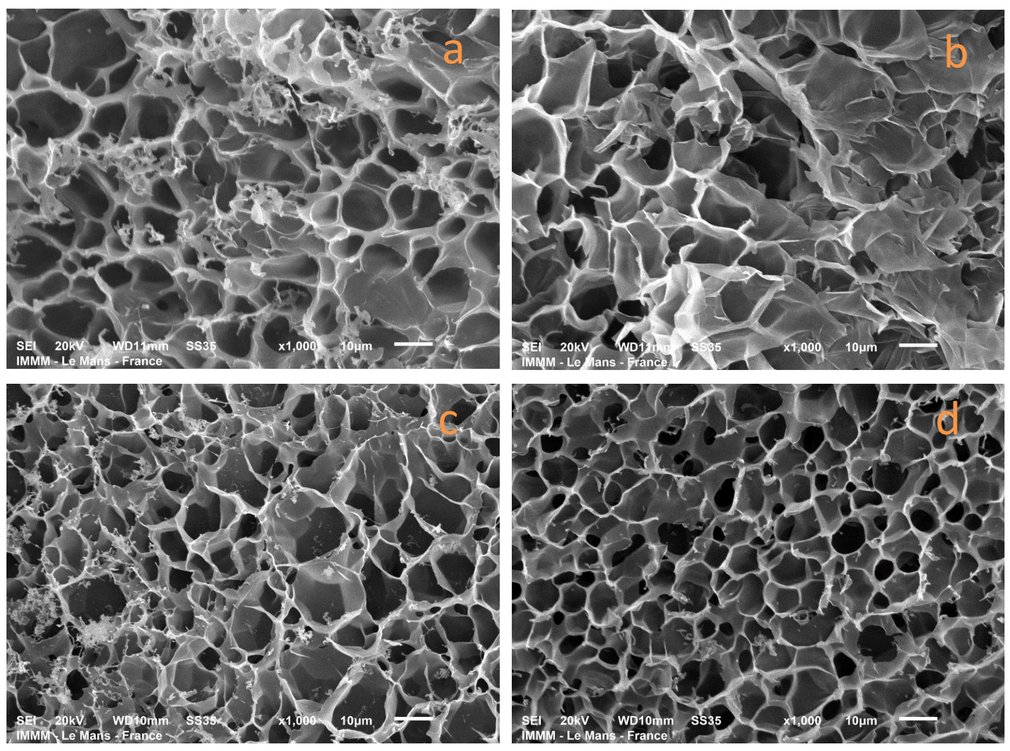

Fig.2. SEM photographs of the microstructure of samples of cross-linked gelatin hydrogels and Gelatin 15 % :
a – without cross-linked agent;
b – with 6 % DOX 500
c – with 4,5 % DOX 500
d – with 3 % DOX 500

Table 2

The pore size of Gelatin 15 % and cross-linked gelatin hydrogels

Sample name	Pore Size (µm)
Gelatin 15 %	25± 10
DOX 500 6 %	15 ± 7
DOX 500 4,5 %	12 ± 5
DOX 500 3 %	7 ± 3

Conclusion

Thus, we studied the structure of gelatin hydrogel materials depending on the synthesis conditions and the concentration of the structuring agent. The optimal conditions for their production are determined, making it possible to obtain hydrogels with satisfactory properties for using the obtained material as the basis of a specialized hydrogel dressing to treat chronic wounds.

References

[1] Zhang, L., Jeong, Y., Zheng, S., Kang, D., Suh, H., & Kim, I. (2013). Cross-linked poly(ethylene glycol) hydrogels with degradable phosphamide linkers used as a drug carrier in cancer therapy. Macromolecular Bioscience, 14(3), 401-410.

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