BIOACTIVE HYDROCOLLOID-TYPE BIOMATERIALS FOR POTENTIAL MANAGEMENT OF HIGHLY EXUDING WOUNDS

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Introduction

The problem of treating chronic wounds that are difficult to heal is common in regenerative medicine. Thus, bioactive wound dressings are applied more often to accelerate the healing process. Recently many trends in the production of dressing materials composed of natural polymers are observed in the engineering of biomaterials field [1]. It has become very common to use β-glucans (natural immunomodulators) as a matrix for the production of biomaterials for wound care. Special attention has been paid to curdlan (β-1,3-glucan), which has anti-inflammatory properties and supports wound healing [2]. The main purpose of this work was to create superabsorbent biomaterials with typical hydrocolloids properties for the care of exudative wounds. Within this study, curdlan has been combined with other natural polymers such as agarose or chitosan to create hybrid biomaterials for exuding wound management [3].

Materials and Methods

The curdlan/agarose biomaterial (marked as Cur/Aga) was prepared by mixing the appropriate ratio of curdlan and agarose. The polymers were dissolved in deionized water at high temperature, creating a gel. The curdlan/chitosan material (marked as Cur/Chit) was composed of the suitable proportion of curdlan and chitosan suspended in acetic acid. After obtaining homogeneous mass, the mixture was transferred to containers and incubated in a water bath at 95°C for 20 min. Afterwards, the Cur/Chit material was neutralized in NaOH. Both samples (Cur/Aga and Cur/Chit) were frozen at -80°C for 1-2 hours and subjected to lyophilization process for 16 hours. The chemical composition of the biomaterials and their production methods were described in details in Polish Patent no. 236367, 2021 (Cur/Aga) and patent application no. P.430455, 2019 (Cur/Chit). The resulting foam-like materials were subjected to further tests.

The cell culture experiments were carried out using human normal skin fibroblasts (BJ) obtained from ATCC. To evaluate cytotoxicity of the produced foam-like biomaterials, an indirect test was conducted in accordance with ISO 10993-5 (2009). Cell viability next to and on the biomaterials was evaluated by Live/Dead staining. Moreover, biocompatibility tests (cell proliferation and collagen synthesis) were performed using a two-compartment model with cell culture inserts. Tested samples were placed into the wells of multiwell plate, however BJ cells at a concentration of 1×10^4 cells were seeded into the inserts. The cells were cultured for few days and then cell number was specified using WST-8 assay, whereas collagen synthesis was visualized by immunofluorescence using human-specific anti-type I collagen (Col1a1/Col1a2) antibodies with secondary antibodies conjugated to Alexa Fluor 647. Images were acquisitioned using CLSM.

Assessment of exudate absorption ability of biomaterials was carried out by immersion of the samples in human blood plasma and serum. At specified time intervals, the samples were removed from the physiological fluids, weighted, and put back in the liquid.

Results and Discussion

MTT cytotoxicity assay showed that the developed materials were not-toxic to human skin fibroblasts. Compared to the control, cell viability was not under 83 % after 48 h incubation of the cells in the presence of Cur/Aga and Cur/Chit extracts. Visualization of fibroblasts by CLSM showed monolayer of viable BJ cells around the materials and only single spherical cells (unattached) on the surface of tested biomaterials, which means, that their surface prevents adhesion of skin fibroblasts. Based on the results of biocompatibility tests, it may be concluded that tested biomaterials did not have a negative effect on cell proliferation and type I collagen synthesis. Foam-like biomaterials were highly absorbent and their structure changed to the gel after contact with the exudate, acting as the hydrocolloid material (FIG. 1).

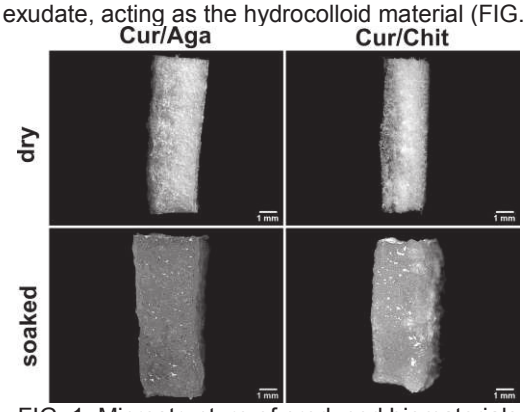

FIG. 1. Microstructure of produced biomaterials (scale bar = 1 mm).

TABLE 1. The exudate absorption capacity of tested biomaterials presented as volume [µl] of plasma absorbed by 1 g of the biomaterial.

Sample	Time [s]			
	3s	6s	12s	21s
Aga/Cur	8382.3 ± 979.3	10162.5 ± 728.6	11447.4 ± 282.7	11905.9 ± 701.2
Aga/Chit	3546.6 ± 1304.6 *	7551.3 ± 779.4 *	10799 ± 1448.9	11752 ± 1225.4

*statistically significant results compared to Aga/Cur; $P < 0.05$, unpaired t-test

Conclusions

Obtained results demonstrate that fabricated biomaterials are characterized by high biocompatibility. However, they hinder adhesion of human skin fibroblasts to their surface, allowing for painless removal of the dressing after healing. The foam-like biomaterials have the ability to transform into typical hydrocolloid dressings with superabsorbent properties after contact with physiological fluids. All mentioned features of the biomaterials prove their promising potential to be applied for highly exuding wound management.

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References

[1] I. Negut, *et al.,* Polymers. 12(9), (2020), doi:10.3390/polym12092010.
[2] Y. Rubaiya, *et al.* Macromol. Mater. Eng. 303 (1800234), (2018), doi:10.1002/mame.201800234.
[3] M. Wójcik, *et al.,* Mater. Sci. Eng. C Mater. Biol. Appl. 124 (112068), (2021), 10.1016/j.msec.2021.112068.