PREPARATION OF CELLULOSE-BASED SPONGES FOR WOUND DRESSING AND HEALING

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Abstract: *For healing of chronic or burn wounds, polymeric sponges have been recently applied. Due to a high absorption capacity, noncitotoxicity and good swelling capabilities, for their production natural polymers are often used. In this study, macroporous regenerated cellulose was evaluated as a matrix for wound dressing materials. Active compounds, such as antibiotic neomycin and phenolic compound quercetin were immobilized in the cellulosic matrix aimed to promote wound healing process. Active compounds in the sponges were immobilized alone or with water-soluble hydroxyethylcellulose or carboxymethylcellulose. It was found that the way of preparation of sponges can affect their porosity, moisture absorption and drying rate. The best sponges for wound dressing materials were formed from freeze-dried macroporous regenerated cellulose in which was later immobilised hydroxyethylcellulose or carboxymethylcellulos with active compounds.*

Keywords: *cellulose-based sponges; wound dressing; bandages*

1. Introduction

The rate of wound healing process depends on the immune system of the body. If it works appropriately, small wounds heal fast. Unfortunately, the healing process of chronic wounds (e.g. ulcers) takes months or even years. Special bandages are required to improve this process. They should maintain moisture in a wound, permit diffusion of gases, remove excess exudates, but prevent saturation of the dressing to its outer surface. Other properties like wound protection from micro-organisms and foreign particles (i), mechanical protection (ii), control of local pH and temperature (iii), stimulation of the growth factors (iv), easy and non painful removal from the wound (v), cost-effectiveness (vi), biocompatibility (vii) and elasticity (viii) are also required [1]. The bandages can also be used as modified drug release systems. New more effective and cheaper materials for production of appropriate dressings for chronic or burn wounds are being searched for. Due to a high absorption capacity, non-cytotoxicity and good swelling capabilities natural polymers are materials of special interest. Various active compounds can be immobilized in these polymers [2].
The aim of this work was to evaluate the applicability of cellulose-based sponges with immobilized active ingredients as a wound dressing materials.

2. Methods

2.1. Synthesis of macroporuos cellulose-based sponges

Cellulose-based sponges were prepared by the regeneration of cellulose from cellulose diacetate according to [3]. The obtained gel bulk was washed with water, and cut mechanically. The gel was lyophilized in Christ ALPHA 2-4 LSC freeze-dryer. Before freeze-drying the bulk was placed in 20% ethanol for 24 h.

2.2. Preparation of the sponges containing active ingredients

The sponges were placed into dispersions of active ingredients: quercetin and neomycin. As fillers hydroxyethylcellulose (HEC) and carboxymethylcellulose (CMC) were used. After immobilisation the sponges were freeze- or air-dried.

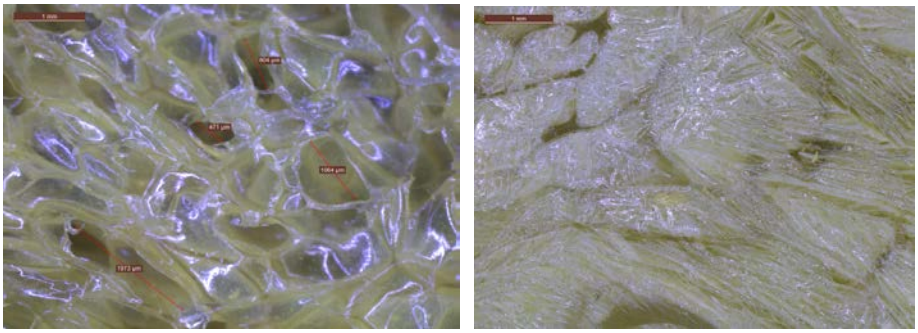
2.3. Morphology, moisture measurements, dynamic contact angle measurements and mechanical properties of the sponges

Morphology of the sponges was tested by 3D microscopy (Leicam 25 LAS VU.1 microscope). Moisture measurements were made by moisture analyzer (AND MS-70). Mechanical properties of the sponges were determined using dynamic mechanical analysis apparatus Zwick/Roell. Wetting dynamics of water droplets

on the sponges surfaces was evaluated using a contact angle measuring device OCA 40 Micro (DataPhysics, Germany) for microstructures.

3. Results

The sponges were prepared by lyophilization of macroporous gel of regenerated cellulose. To promote wound healing process the active compounds, such as antibiotic neomycin and flavonoid quercetin were immobilized in the cellulosic sponges. Active compounds in the sponges were immobilized alone or with water-soluble hydroxyethylcellulose (HEC) or carboxymethylcellulose (CMC).
Mechanical properties of cellulose-based sponges were studied. Tensile strength of the samples was approx. 140 kPa and Young's modulus approx. 2.7 N/mm^2. According to the literature [4] mechanical properties meet the requirements for wound bandage.
It was found out that the morphology of the sponges depends on the conditions of their drying after immobilization of active compounds. The pores of the samples dried at room temperature varied from 400 μm to 2000 μm (Fig.1A) whereas of freeze-dried samples from 20 μm to 100 μm (Fig.1B).



A **B**

Figure 1. The sponges after immobilization of quercetin with carboxymethylcellulose (magnification X20): **A** – sponge dried at room temperature; **B** – freeze-dried sponge

There are no general requirements for moisture absorption of bandages, but ability to absorb moisture, could be useful for wound healing and unpainful removal of a bandage from the skin. Moisture absorption was measured by keeping the samples in PBS bufer for 24 h. Moisture absorption ranges from 59% up to 80 % was found for the tested samples. Drying conditions after immobilisation of active ingredients have negligible effect, nevertheless moisture absorption of freeze-dried samples was approx. 3 % higher comparing with air-dried samples. Fillers like HEC and CMC increases moisture absorption from 59% to 77 % and 79 % respectively.

Dynamic contact angle results showed a very complex behaviour of small water droplets on the sponges surfaces which ranges from highly hydrophilic to highly hydrophobic behaviour in dependency on the modification applied.

4. Conclusions

It was found out that the way of preparation of sponges can affect their morphology and absorption capacity. Considering the porosity and moisture absorption the best sponges for wound dressing were obtained by immobilization of freeze-dried cellulose-based sponges with active ingredients together with hydroxyethylcellulose or carboxymethylcellulose and then lyophilized.

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