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Sorption properties of radiation-cross-linked polymer hydrogels containing ion-exchange fibers

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Abstract. Polymer hydrogel modification for soft contact lenses by ion-exchange fibers was studied in this work. The obtained results showed that the ion-exchange fiber modifiers have a number of advantages as compared with ion-exchange resin modifiers.

1. Introduction

Polymers are widely used in all fields of human activity. Medical devices polymers that exhibit high hydrophilicity, lack of toxicity, and many other useful properties are of particular interest. Currently, polymeric materials have been widely used in the development of new-generation wound healing. It is bandaging materials, wound dressings, adhesive bandages and other. Polymeric ion-exchange hydrogels are promising materials for the development of this field.

The ability to modify the hydrophilic polymeric material for soft contact lens (SCL) based on N-vinylpyrrolidone and methacrylic acid methyl ester with ion exchange resins (IER) to produce the polymeric sorptive materials for eye burn treatment [1-3] has been shown in previously published works. Soft contact lenses are one of the effective means for comprehensive treatment of recent chemical and thermo-chemical eye burns. The implemented functions in their use are neutralization of the damaging agent, acceleration of the cornea epithelialization, prevention of symblepharon, at a later date - the healing of post-burn lesions of the cornea. The appearance of new ion-exchange polymeric materials based on the material for soft contact lenses made possible to expand the indication range for their use.

Polymer hydrogel modification for soft contact lenses by ion-exchange fibers was studied in this work. Fibrous ion-exchangers have developed active surface and better kinetic characteristics compared with granular ion-exchangers (high baud rate, the greater availability of ionic groups for exchanging ions, including a large organic ions) [4]. Their ion-exchange capacity is high enough for practical use, and is not reduced by repeated regeneration cycles of acids and alkalis. High ion-exchange capacity, heat resistance and chemical resistance of synthetic ion-exchange fibers should also be noted.

The object of study is ion-exchange fiber brand MION AK-22 in OH^--form; MION K-5 in H^+-form and MION K-5, Na^+-form (fiber length: 0.5-1.0 mm Diameter: 20-50 microns) and material for soft contact lenses [5].

2. Results and Discussion

Values of water content and ion-exchange capacity (IEC) were determined for the study of ion-exchange fibers. Water mass in the fibers was related to the mass of air-dry samples in determining the water content of the hydrated samples. Water content measurement was carried out on reaching the maximum swelling of the fibers (24 hours). The water content average value was determined according to the results of five replicates for each type of ion-exchange fibers (it is shown in Table 1).

Table 1. The water content of the ion-exchange fibers, granular ion-exchange analogue and material for soft contact lenses.

Type of material	Water content (%)
Ion-exchange fiber MION K-5, Na^+	80 ± 3
Ion-exchange fiber MION K-5, H^+	65 ± 2
Ion-exchange fiber MION AK-22, OH^-	55 ± 1,5
Ion-exchange resin D-113, Na+	49,8 ± 1,2
Hydrogel for SCL	70 ± 2

Comparison between the ion-exchange resins water content and ion-exchange fibers water content showed the value of the characteristics for the ion-exchange fibers is higher than the same parameter for granular inoculants. Swollen hydrogel water content values and swollen ion-exchange fibers water content values are similar, therefore, the swelling of the fiber modified hydrogel is uniform and has no void formations. Thereby, fibrous materials are preferred for use as hydrogel modifiers according to this result. This kind of ion-exchange hydrogel will have greater strength and elasticity.

Determining of the alkali and acid sorption degree was carried out using the method of acid-base titration [6]. The fibers were placed in a volume of acid / alkali with a concentration of 0.1 g / mol at various periods of time. An aliquot of the acid / alkali was titrated and the mass difference in the original volume and the volume was calculated after sorption absorbed weight of acid or alkali.

Dependence of the degree of sorption on time is presented in graphical form (Figure 1, Figure 2, Figure 3).

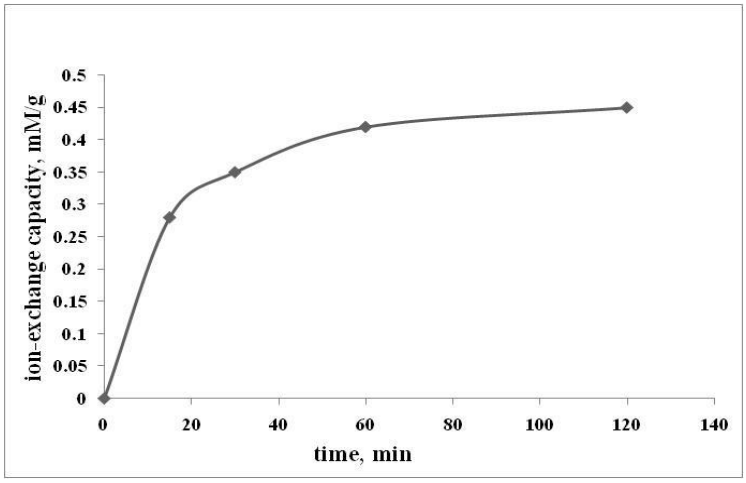

Figure 1. The dependence of ion-exchange capacity on time for ion-exchange fiber MION K-5, H^+ of relatively alkali.

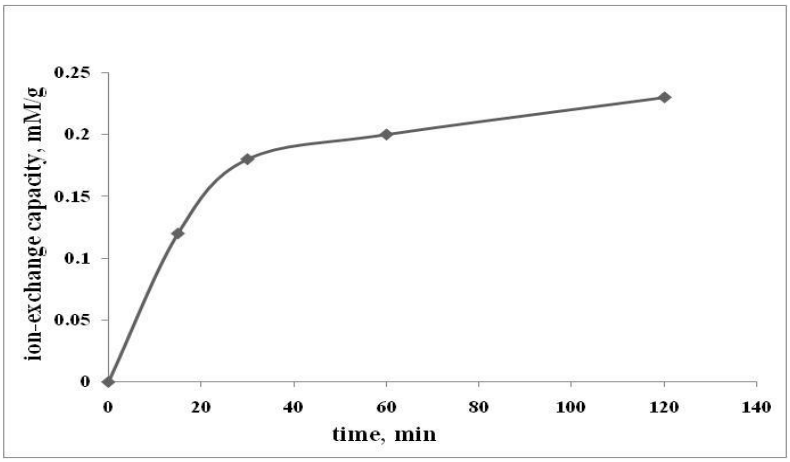

Figure 2. The dependence of ion-exchange capacity on time for ion-exchange fiber MION K-5, Na^+ of relatively acid.

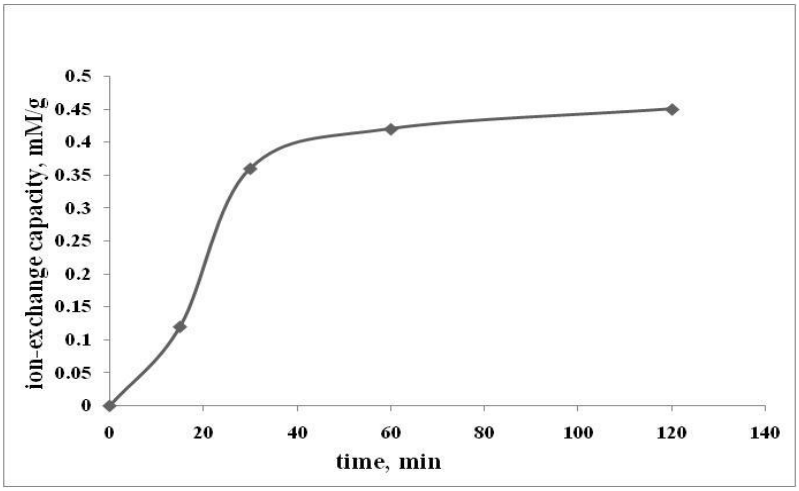

Figure 3. The dependence of ion-exchange capacity on time for ion-exchange fiber MION AK-22, OH^- of relatively acid.

The graphs show that ion-exchange fibers sorb significant proportion of acid/alkali by the maximum possible amount within a short period of time (about 40 minutes). This occurs by reason of a large active surface area of the fibers. The high speed of the process is achieved due to the short ion diffusion path inside the ion-exchange fiber.

Fiber MION K-5, Na^+ was investigated at the first stage of the ion-exchange polymer hydrogel synthesis. Composition of polymer hydrophilic material for SCL was used as a basic hydrogel [4]. Synthesis was carried out on the installation of ionizing radiation from Co^{60}RHM-γ-20 [7,8]. A prepolymer was obtained by irradiating a mixture of N-vinylpyrrolidone, methyl methacrylate and divinylcross-linker dose 10kGy. After the fiber (5% by weight) was added into the prepolymer under an inert atmosphere. The mixture was stirred placed in special molds and irradiated the absorbed dose 25kGy to fully cure. After hydration the samples were examined for the ion-exchange hydrogel water content and acid sorption. Water content of the samples obtained almost the same as the water content of the hydrogel base. Acid sorption is shown in Figure 4 compared with the ion-exchange hydrogel containing pellet filler, and ion-exchange resin D-113.

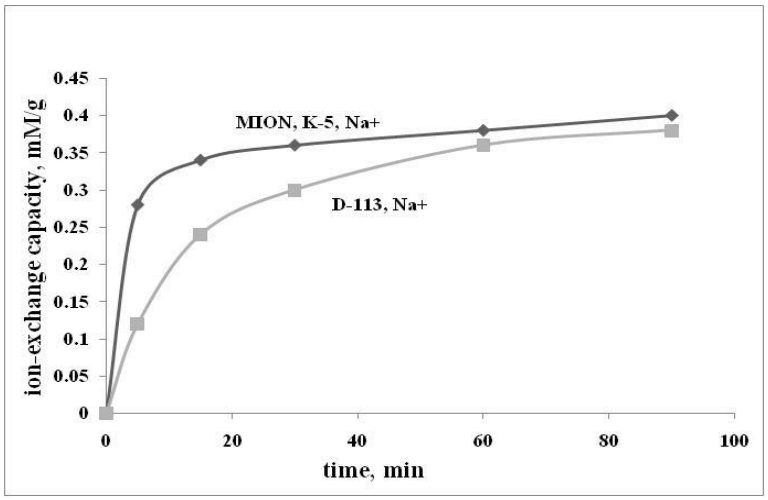

Figure 4. The dependence of ion-exchange capacity on time for ion-exchange fiber MION K-5and the ion-exchange resin D-113 of relatively acid.

3. Conclusion

Comparative evaluation of the ion-exchange fibers properties and granular analogs properties showed advantage of usefibrous materials as modifiers in the synthesis of ion-exchange polymeric hydrogels. Higher values of water content and active ion-exchange reaction were achieved due to the developed surface of the fiber. At the graph of hydrogels sorption degree it is seen that at the initial stage of the ion-exchange hydrogel, modified by fiber material,is more active, than modified by pellet filler.

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