23. Polysulfone membranes modified with α-amylase, incorporated into polymeric micelles, for starch ultrafiltration

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Introduction. Immobilization of enzymes is one of the most promising methods for efficiency increasing of their usage, especially, stability, possibility of regeneration and reuse. However, the choice of the solid carrier and the method still stays the actual scientific task. Taking in account all advantages and disadvantages of current methods of enzymes immobilization, it was offered to incorporate enzymes in polymer micelles from modified chitosan.

Materials and methods. Polysulfone membranes UF-PES-030H (Microdyn Nadir, Germany) with cut-off 30 kDa were used for modification. α-Amylase from *Bacillus subtilis* (Fluka, Switzerland) was used as a model enzyme. Water-soluble starch, KI, and iodine (Miranda, Ukraine) were used for studying the α-amylase activity by visible spectroscopy.

Low-viscous chitosan (Fluca, USA) was modified with palmitic (PA) and stearic (SA) acids in order to obtain amphiphilic derivatives, which will be capable of self-assembling in micelles. Chemical structure of chitosan derivatives was confirmed by data, obtained from IR-spectroscopy analysis.

α-Amylase was incorporated in micelles by shaking of 0.1 % chitosan derivatives solution and 5 mg/ml solution of α-amylase during 24 hours. Then, micelles were immobilized on the membrane surface by adsorption during 30 min (Fig.1). In some cases modified membranes were UV-irradiated during 3 min for micelles grafting.

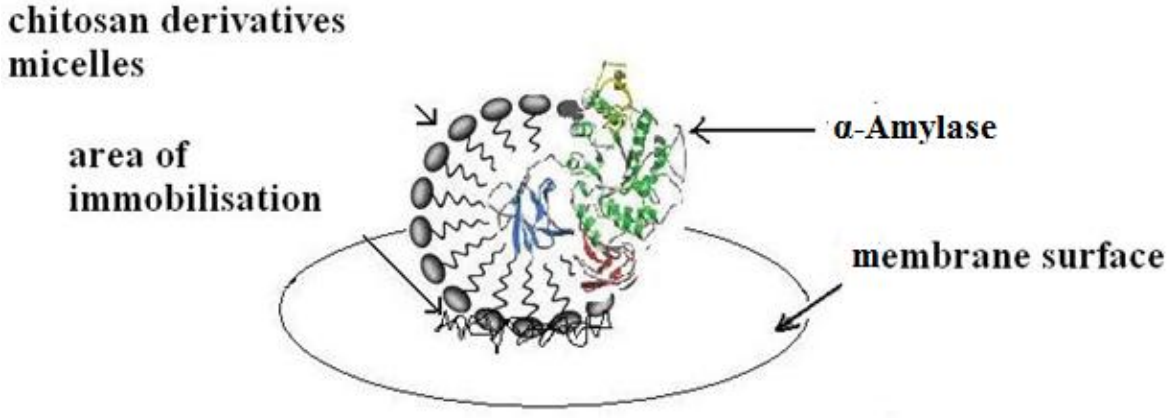

Fig.1. Schematic representation of membrane modification with enzymes incorporated in polymeric micelles.

Results. Membranes, modified with micelles, were stable during 190 hours. So, the adsorption of these surfactants was very strong. This can be explained by the

electrostatic interactions between positively-charged free amino groups of chitosan and negatively-charged polysulfone membrane surface.

The membranes biocatalytic activity was evaluated by the degree of starch conversion in permeate and retentate (Fig. 2). As can be seen, the highest index of starch conversion has unirradiated membrane, modified with micelles of chitosan-PA.

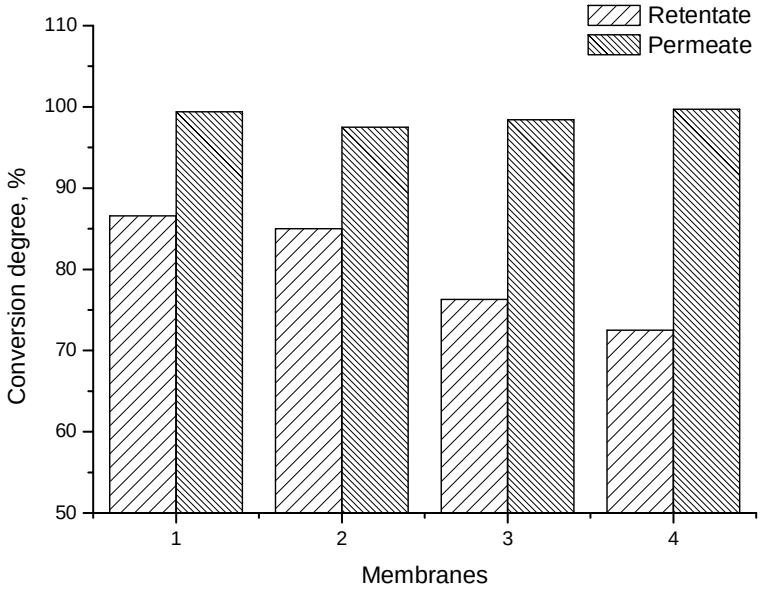

Fig.2. Degree of starch conversion at its initial concentration 0.03 % on polysulfone membranes with α-amylase, incorporated into polymeric micelles:
1) chitosan-PA, unirradiated; 2) chitosan-PA, irradiated; 3) chitosan-SA, unirradiated; 4) chitosan-SA, irradiated.

Mass transfer coefficients, measured from the transport characteristics evaluation, are given in the table.

Table. **Starch mass transfer coefficients**

Membrane	Mass transfer coefficient, m/s		K_n/K_0
	value	error	
Unmodified	$1{,}127\cdot10^{-5}$	$1{,}535\cdot10^{-6}$	1,0
Chitosan-PA, unirradiated	$7{,}266\cdot10^{-5}$	$7{,}387\cdot10^{-6}$	6,5
Chitosan-PA, irradiated	$3{,}631\cdot10^{-5}$	$2{,}089\cdot10^{-6}$	3,2
Chitosan-SA, unirradiated	$5{,}297\cdot10^{-5}$	$6{,}543\cdot10^{-6}$	4,7
Chitosan-SA, irradiated	$4{,}012\cdot10^{-5}$	$9{,}019\cdot10^{-6}$	3,6

Conclusion. It was established that modification of polysulfone membranes with polymeric micelles with incorporated α-amylase leads to starch mass transfer intensification in 3.0-6.5 times. It was also shown that the concentration polarization is significantly reduced in case of starch filtration through the modified membranes compared with unmodified ones.