FABRICATION OF CELLULOSE ACETATE BRAIDED MEMBRANE WITH ADVANCED ANTIBACTERIAL PROPERTIES

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Introduction

Despite their wide application, hollow fiber membranes have insufficient mechanical strength and require the use of a reinforcing braid to provide sufficient membrane strength and improve their permeability [1-2]. Among various braided polymeric membranes, cellulose acetate (CA) has found wide application in industrial purification processes due to its high performance, environmental friendliness and relatively low cost [3]. However, CA-membranes are easily contaminated due to low antibacterial properties, which limits its application and progress [4].

The aim of this study was to evaluate the impact of a new eco-friendly biocide based on forest-chemical raw materials on structure, transport and antibacterial properties of braided CA-membranes. For this purpose, rosin acid imide was synthesized for the first time. Different amounts of rosin acid imide (from 0 up to 1,0 wt.%) were added to the CA casting solution and various structural and characterization analyses were carried out, such as scanning electron microscopy (SEM), Fourier transform infrared (FTIR), atomic force microscopy (AFM), transport and antibacterial properties of membranes.

Experiments

Cellulose acetate was used as the base polymer in the membrane casting solution. Calcium chloride was used as a pore forming agent. specially synthesized biocide based on imide of rosin acids at a concentration of 0-1,0 wt.% was introduced into the composition of casting solution. The synthesis of rosin acid imide was carried out by mixing diethanoltriamine and rosin acids in a chemical reactor with constant stirring at a temperature of 190±5°C for 6 hours. The braided CA hollow fiber membranes were fabricated via dry–wet spinning process. Figure 1 showed the dry–wet spinning apparatus. Commercial tubular braid with "diamond" type weaving was used as a supporting material. Room temperature water was used as coagulation bath.

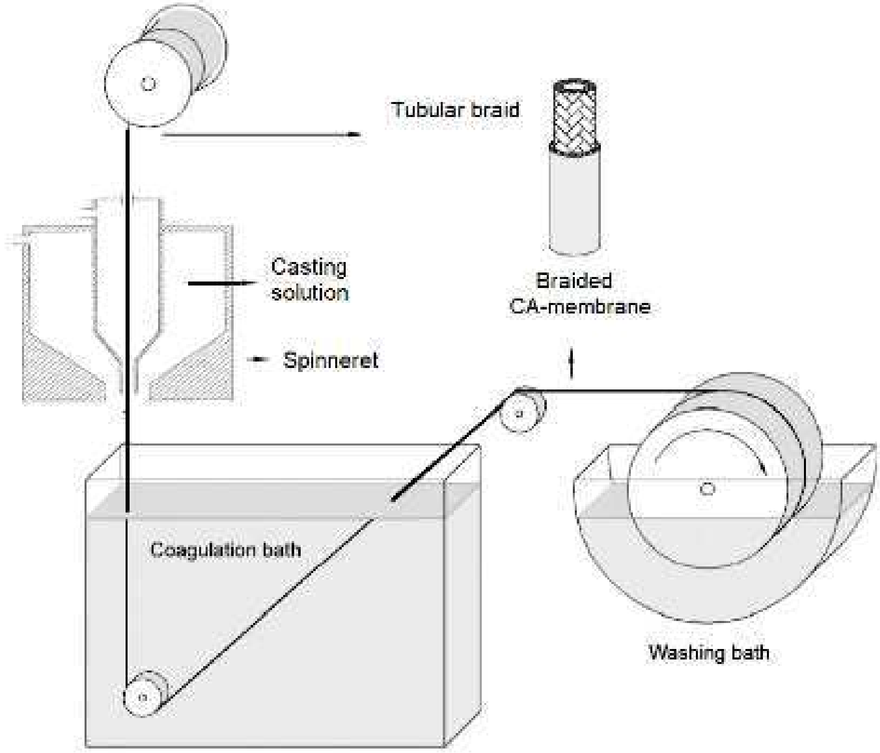


Figure 1. Schematic diagram of the dry-wet spinning process of braided CA-membranes.

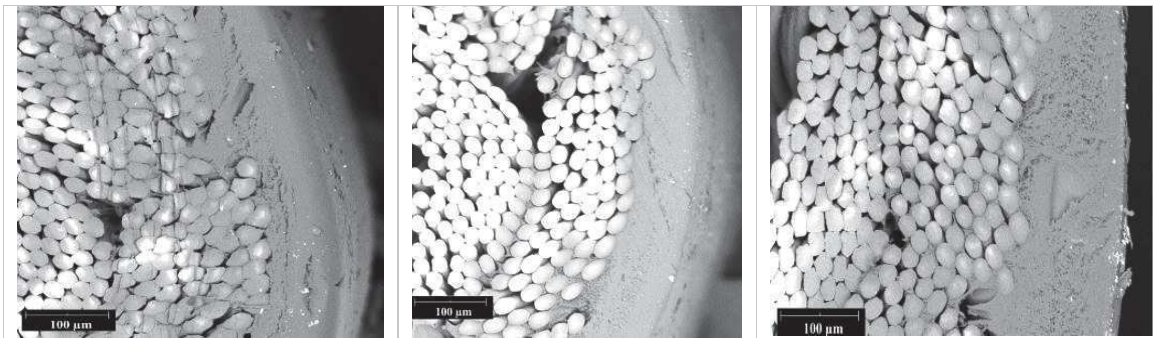
Results and Discussion

The introduction of 0.1-1.0% of rosin acid imide into the composition of the polymer solution led to a gradual increase in the viscosity of the casting solution, as well as to an increase in its turbidity, see table 1. The presence of rosin acid imide on the surface of CA-membranes was confirmed by the FTIR spectroscopy. At the same time, the introduction of 0,1–1,0% of the biocide into the composition of the casting solution had practically no effect on the pure water flux (PWF) and selectivity of the membranes. The performance of the membranes was in the range of 600 – 674 $L \cdot m^{-2} \cdot h^{-1}$. While the selectivity of the membranes for polyvinylpyrrolidone K-30 was 13,5-21,1%.

Table 1: Properties of casting solutions and transport properties of membranes depending on the rosin acid imide concentration

C (rosin acid imide), %	η, cP	Turbidity, NTU	PWF, $L \cdot m^{-2} \cdot h^{-1}$	R_{K-30}, %
0	6625	16.5	612	19.6
0.1	6969	24.6	647	21.1
0.3	7719	29.1	624	13.5
0.5	8125	29.9	600	14.2
1.0	8462	34.7	647	18.7

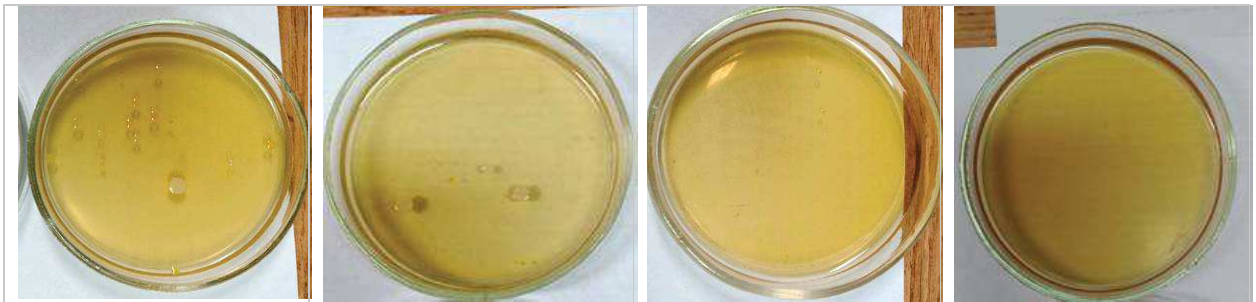
The structure of braided CA-membranes also does not undergo significant changes with an increase in rosin acid imide concentration in the composition of the casting solution. macrovoids formation in the membrane structure is not recorded in all cases. All membranes have a nice spongy structure, see Fig.2.



0 wt.% | *0,5 wt.%* | *1,0 wt.%*

Figure 2. Braided CA-membranes structure depending on rosin acid imide concentration.

The antibiofouling properties of the prepared membranes were evaluated against E. coli and the results are shown in Fig.3. Initial CA-membranes has no antibacterial activity. However, the decline of bacteria cells was recorded for CA-membranes modified with rosin acid imide. Furthermore, there were almost no bacteria colonies on the plates for membranes modified with 0,5-1,0 wt.% rosin acid imide. It means that modified membranes exhibited good antibacterial properties.



0 wt.% | *0,3 wt.%* | *0,5 wt.%* | *1,0 wt.%*

Figure 3. Antibacterial performances of CA-membranes membranes depending on rosin acid imide concentration.

Conclusion

The introduction of resin acid imide in the amount of 0,5-1,0% into the composition of the casting solution allows to obtain braided CA-membranes with an excellent antibacterial properties and at the same time does not adversely affect the transport properties of the membranes.

References

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