Study of Porogens in Polymer-0D Nanomaterial Composite membrane

Acharya Ashok Kumar
Department of Chemistry Ranchi College, Ranchi-Jharkhand, INDIA

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Abstract

Polymer nano particle composite membrane has drastically increases the efficiency in purification process. In view of its practical applicability it leaves a platform for the researcher to synthesize, characterize and study of pore size of 0D-nonmaterial composite membrane. Metal nanoparticles of different size are introduced into a polymer solution and dispersed by continuous stirring. The polymer nanometal particle membrane is isolated by removing the solvent. The samples were structurally characterized by SEM analysis, Porosimetry by mercury intrusion and measurements of weight by immersion, for ion exchange capacity, morphology, and performance.

Keyword: Polymer-Ag, nanomaterial, composite membrane, antifouling PVDF.

Introduction: Polymer-Ag, nanomaterial, composite membrane, antifouling PVDF.

Methodology

Synthesis of Polymer -0D Nanomaterial Composite Membrane. Ag –nanoparticles synthesis is mostly based on the colloidal route. A solution of polymer is coated on a substrate and metal precursor is incorporated to it. The metal nanoparticles are then embedded by heat treatment. The organic PVDF matrix and metal nano Ag particles are mixed together in solution with definite concentration and pH. By solution blending method it is easy to fabricate polymer nanometal particle composite membrane. Polymer PVDF matrix in a solvent to form a homogeneous solution with specified concentration to that Ag metal nanoparticles are added in to the solution drop by drop with constant stirring. The polymer nano metal particles composite membrane is cast by removing solvent. The permeability, strength, and pore size may varied by adding amount of Ag-nano particle with specified concentration. Due to the presence of heterogeneous nuclei (Ag-nanoparticle) the possibilities of formation of the crystal like PVDF spherulitic is discouraged in the slowly cooling process. It is found that, it improve its capacity of filtration of these nanometal composite membrane because of its porosity and mechanical strength. Selected concentration of Ag-nanoparticles during the synthesis of polymer Ag nano material composite membrane effectively enhances membrane permeation, tensile strength, and biofouling capacity. Two partially hydrolyzed molecules can link together by a condensation reaction leading to form polymeric gel. Generally metal salt, soluble in water, are taken as the starting material Gelatin is introduced by dehydration of the solution. When the pH of the solution increases, the repulsive force between particles reduces, leading to spontaneous coagulation.
Nanomaterials and Porogens: Nanomaterials are not enough hydrophilic to originate with specific dimension of pores in liquid phase separation method. The existence of polyethylene glycol in polymer solution as a foreign substance for pore initiator, smaller Ag nano nanoparticles (10nm) could increase the separation of impurities efficiency. It is because of crystallization changes in polymer matrix and nanomaterial composite solution reduces the mean pore size on surface of membrane. To avoid hydrophobicity of nanoparticles, some composite (PES/Ag) has been synthesized nano ultra filtration membranes in the presence of polyvinylpyrrolidone (pvp K40). After the mechanical and chemical modification of Ag nanoparticles, Size of pores could be controlled in the polymer nano composite membrane. The higher impurities separation ratio and presence of least undesirable contain in the filtrate part possible with small amount of Ag nanomaterial loading in composite membrane. Yan et al. prepared polyvinylidene fluoride (PVDF) ultra filtration membrane along with Al₂O₃ nanoparticles in the presence of hex disodium phosphate as the dispersant and PVP as the porogen. When Al₂O₃ is added, it has no influence in controlling the pore size/dimension in the polymer nano composite membrane but increase its hydrophilicity character of membrane which enhance the removing impurities capacity of the membrane. The presence of FeCl₂ or FeCl₃ and CaCl₂ as the porogens, along with metal nanoparticles could changes the characteristics like, viscosity, thermal stability and mutual diffusion.

Discussion
Silver nano particles with (1-10nm) dimension were interacted with poly vinilidene fluoride matrix results high impurity recovery ratio, increase its hydrophilility, thermal stability, viscosity. Controlling of pore size is enhanced in presence of nano materials in the polymer membrane. Different pore size are obtained in the Ag nano material composite membrane which are corroborated by pore size distribution count per micro meter. The longer mailing time reflect the homogeneous distribution of pore in Ag-nano composite membrane. Average size of 0.012-0.01 micro meter has been observed in Ag doped layer in polymeric membrane. Membrane permeation and antibacterial tests were carried out to characterize the antifouling performance of PVDF membrane. This biological testing indicates that the water is totally clean and it does not have any micro-organism. That might be because of the photo thermal effect of nanocomposites which raise the temperature and cause bacteria death or because of silver nanoparticles which has super antiseptic and anti bacterial activity.

Pores with average size 0.22-0.34 micro meter are found in PVDF –Ag nano composite membrane respectively. Introduction of 50 vol. % of porogenic agent caused an apparent porosity of 39 and 33% vol in the PVDF and Ag nano composite membrane.

Table-1
Filtration process based on Porosity dimension

<table>
<thead>
<tr>
<th>Pore dimension</th>
<th>Molecular weight</th>
<th>Process</th>
<th>Filtration</th>
<th>Impurities</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;10</td>
<td></td>
<td>Classic filter</td>
<td>&lt;2 bar</td>
<td>Larger bacteria, Yeast</td>
</tr>
<tr>
<td>&gt;0.1 micro. m</td>
<td>&gt;5000kDa</td>
<td>Micro filtration</td>
<td>1-10 bar</td>
<td>Bacteria, macromolecules, proteins, larger viruses.</td>
</tr>
<tr>
<td>100-2nm</td>
<td>5-5000KDa</td>
<td>Ultra filtration</td>
<td>3-20 bar</td>
<td>Viruses, 2-valent ions</td>
</tr>
<tr>
<td>2-1 nm</td>
<td>0.1-5KDa</td>
<td>Nano filtration</td>
<td>10-80 bar</td>
<td>Salts, small organic molecules</td>
</tr>
<tr>
<td>&lt;1nm</td>
<td>&lt;100Da</td>
<td>Reverse osmosis</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table-2
Comparison porosity supported with nanocomposite

<table>
<thead>
<tr>
<th></th>
<th>PVDF supported on Ag nano composite</th>
<th>Porous PVDF membrane 2 h milling</th>
<th>Porous PVDF membrane 20 min. of milling</th>
<th>Ag nano non supported composite</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total porosity%</td>
<td>58.78</td>
<td>62.76</td>
<td>61.88</td>
<td>49</td>
</tr>
<tr>
<td>Apparent porosity%</td>
<td>33.23</td>
<td>41.21</td>
<td>37.29</td>
<td>21.67</td>
</tr>
<tr>
<td>Apparent density</td>
<td>2.26</td>
<td>2.25</td>
<td>2.22</td>
<td>3.98</td>
</tr>
<tr>
<td>Closed pores%</td>
<td>31.89</td>
<td>29.9</td>
<td>30.01</td>
<td>31.11</td>
</tr>
</tbody>
</table>

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Conclusion
Flux recovery ratio (FRR) increased about 40% after the presence of silver nano particles on the PVDF membrane surface, elucidating the anti organic fouling performance of PVDF membrane was elevated by silver nano particles. Anti bacterial test confirmed that PVDF membrane showed superior anti-biofouling activity because of Ag nanoparticle.

Reference