MASTER'S THESIS

Preparation and characterization of nanofiltration membranes fabricated from several selected polymers and their uses in separation process

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Preparation and Characterization of Nanofiltration Membranes Fabricated from Several Selected Polymers and their Uses in Separation Process

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Abstract

The development of novel and durable materials plays a crucial role in expanding the scope of applications of membrane separation technology. Nanofitration (NF) has rapidly emerged as a new separation technology in water softening, removal of color, dyes and low molecular weight organic compounds.

To extend our effort in developing new materials in NF membrane separation process, we have synthesized two different classes of film forming polymeric materials, polysulfoneamide (PSA) & polyamidesulfonamide (**$PASA_{Am}$**). PSA was readily accessible from the condensation polymerization reaction of commercially available materials. In contrast, **$PASA_{Am}$** was obtained in overall 40% yield from *p*-acetamidebenzenesulfonyl chloride via a three-step synthetic sequence established in our laboratory.

To facilitate the determination of the optimized casting conditions for the fabrication of the NF membranes from PSA and **$PASA_{Am}$**, based on the Uniform Design (UD) method, two experimental systems, PSA-24 and PASA-24 were developed. With the aid of the chemometric method, the influences of one qualitative (i.e. types of additive) and four quantitative variables (i.e. evaporation time, evaporation temperature, gelation temperature and amount of additive) of the fabrication conditions of membranes on the membrane performances were elucidated with a limited number of

experiments. Guided by the UF method, 24-sets of represented treatment points from the studied experimental domain incorporating all five variables were selected to prepare the NF membranes. Subsequently, the permeation flux and retention ability of **$PASA_{Am}$** NF membranes prepared at each of the selected 24 experimental points toward the permeation of four carbohydrate reference solutions, namely glucose, sucrose, raffinose and β-cyclodextrin, and that of PSA NF membranes toward the permeation of raffinose solution were determined. The response data collected from each of the selected 24 experimental points were then regressed with the studied casting conditions by using the SAS software. Acceptable regression equations were obtained in all cases studied. Based on the predictions of the regression equations, several optimized **$PASA_{Am}$** NF membranes intended to retain glucose, sucrose, raffinose and β -cyclodextrin respectively and the optimized PSA NF membrane to retain raffinose, were prepared. Over 70% of the predicted values of the response of the membranes can be validated by the real experimental measurements.

With the purpose to define the application scope of the membranes, a detailed characterization that included the effect of feed concentration and applied pressure on the membrane performance was conducted. Furthermore, the retention selectivity of different **$PASA_{Am}$** membranes was investigated. To sort out the best performed NF membrane, separation characteristics of NF membranes from four **PASA** copolymers,

four **PASA** homopolymers; PSA, polyetheramide (PEA) and regenerated cellulose were determined and compared. To compare the performance of different **PASA** polymeric membranes, besides the well studied $\mathbf{PASA_{Am}}$, membranes derived from copolymers $\mathbf{PASA_{ACm}}$, $\mathbf{PASA_{BCp}}$ and homopolymers $\mathbf{PASA_{Bm}}$ stood out to be more desirable materials in NF applications. Based on the comparative study of membranes from different polymeric materials, $\mathbf{PASA_{Am}}$ also emerged as the best material for the NF applications.

Besides, the application of NF membranes in oil separation was examined. As the applied pressure was increased from 20 to 100 psi, the retention ability of the $\mathbf{PASA_{Am}}$ NF membrane to oil increased from 99.20 to 99.80%. Compared to PSA and PEA membranes, the $\mathbf{PASA_{Am}}$ membrane showed a high retention ability and fast stable flux rate. Under a 400 h durability test, no fouling was observed for the $\mathbf{PASA_{Am}}$ membranes. The high and stable flux of this membrane showed a good promise in developing durable NF membranes in water oil separation.

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