DEVELOPMENT OF POLYMERIC THIN FILM COMPOSITE NANOFILTRATION (TFC-NF) MEMBRANE FOR MONO AND DIVALENT SALTS REMOVAL

KHADIJAH BINTI YAHAYA

MASTER OF SCIENCE

UNIVERSITI MALAYSIA TERENGGANU
MALAYSIA

2010

DEVELOPMENT OF POLYMERIC THIN FILM COMPOSITE NANOFILTRATION (TFC-NF) MEMBRANE FOR MONO AND DIVALENT SALTS REMOVAL

KHADIJAH BINTI YAHAYA

Thesis Submitted in Fulfillment of the Requirement for the
Degree of Master of Science in the Faculty of Science and Technology
Universiti Malaysia Terengganu

June, 2010

Abstract of thesis presented to the Senate of Universiti Malaysia Terengganu in fulfillment of the requirement for the degree of Master of Science

DEVELOPMENT OF POLYMERIC THIN FILM COMPOSITE NANOFILTRATION (TFC-NF) MEMBRANE FOR MONO AND DIVALENT SALTS REMOVAL

KHADIJAH BINTI YAHAYA

June 2010

Chairperson : **Associate Professor Nora'aini binti Ali, Ph.D.**

Member : **Mohamad bin Awang, Ph.D.**

Faculty : **Science and Technology**

In the last few decades, considerable efforts have been invested into the development of membranes that combine the high retention of reverse osmosis with the lower pressure of ultrafiltration which resulted in the development of nanofiltration (NF) membranes. They potentially offered nanometer ranges of pore radius, high retention of charged particles, inherent charges and lower operating pressure which its applications are tremendously expanding especially in the field of processed water, drinking water and wastewater treatment.

In this study, high performance polymeric thin film composite (TFC) membrane was successfully developed for mono and divalent salts removal. The TFC membrane was fabricated from polyethersulfone (PES) support porous membrane via interfacial polymerization (IP) process based on dip-coating technique. In general, experimental results showed that polymer concentration and shear rates effects lead to the optimization of separation performance. Meanwhile, consideration on the key parameters during IP process which are contact time and reaction time are also found to be beneficial towards separation improvement and characteristic enhancement.

At low operating pressures of 300 kPa to 900 kPa, the membranes performances in terms of pure water permeability, salt permeation and rejection efficiency were evaluated using mono and divalent salts. In order to improve the separation characteristics of porous support, the rheological factor which is shear rates between 116.67 s^{-1} to 233.33 s^{-1} were deduced during the casting process. Towards producing high performance composite membranes, optimum conditions of polymer concentration, shear rate, contact time and reaction time were identified. From this study, the best PES concentration and shear rate were found to be about 13 wt% and 155.55 s^{-1}, respectively. The achievement of high water permeation approximately 2.20 x 10^{-6} $m^3/m^2.s$ and 31.85% of NaCl rejection indicated that a good porous support membrane was developed.

Furthermore, the studies of contact time and reaction time with different combination of reactants led to the fabrication of selective thinner skin layer and narrow pore sizes of thin film composite membranes. The NaCl rejection profile of TFC membranes follows such sequence: MPD > MPD/PIP > PIP. MPD-based TFC-NF membranes which acquired of about 0.13 nm to 0.28 nm in pore radius and -54.51 to -11.43 in charge density, were also found to be comparable to the available commercial membranes with the salts separation up to 99.36%. In combination with the separation properties, TFC-NF membranes also provides an excellent technical potentials towards the locally production of high performances TFC-NF membranes for various applications in the future.

Abstrak tesis yang dikemukakan kepada Senat Universiti Malaysia Terengganu sebagai memenuhi keperluan untuk ijazah Sarjana Sains

PEMBANGUNAN MEMBRAN POLIMERIK NANOTURASAN KOMPOSIT LAPISAN NIPIS UNTUK PENYINGKIRAN GARAM-GARAM MONO DAN DWIVALEN

KHADIJAH BINTI YAHAYA

Jun 2010

Pengerusi : **Profesor Madya Nora'aini binti Ali, Ph.D.**

Ahli : **Mohamad bin Awang, Ph.D.**

Fakulti : **Sains and Teknologi**

Dalam tempoh beberapa dekad kebelakangan ini, banyak usaha telah dilakukan dalam pembangunan membran yang menggabungkan osmosis balikan berintangan tinggi dengan ultraturasan bertekanan rendah yang seterusnya menjurus ke arah pembangunan membran nanoturasan. Ia berpotensi dalam menawarkan jejari liang berjulat nano, kadar penyingkiran partikel-partikel bercas yang tinggi dan cas-cas tersedia serta menawarkan tekanan operasi yang rendah di mana aplikasi-aplikasi nanoturasan sedang berkembang pesat terutama dalam bidang pemprosesan air, air untuk diminum dan rawatan air sisa.

Dalam kajian ini, membran polimerik komposit lapisan nipis berprestasi tinggi telah berjaya dibangunkan untuk aplikasi penyingkiran garam-garam mono dan dwivalen. Membran komposit lapisan nipis telah dihasilkan daripada membran sokongan berliang polietersulfona melalui proses pempolimeran antaramuka (IP) dengan menggunakan teknik penyalutan celup. Hasil kajian mendapati kesan kepekatan polimer dan kadar ricih telah mempengaruhi keseimbangan optimum prestasi penyingkiran membran. Malah, penekanan terhadap masa sentuh dan masa tindak

balas yang merupakan parameter penting dalam proses IP juga telah dikenalpasti bermanfaat dalam meningkatkan penyingkiran dan perkembangan ciri-ciri membran.

Pada tekanan operasi serendah 300 kPa hingga 900 kPa, prestasi membran dari segi penelapan air tulen, kebolehtelapan garam dan keberkesanan penyingkiran telah dinilai menggunakan garam-garam mono dan dwivalen. Untuk peningkatan dalam ciri-ciri pemisahan sokongan berliang, faktor reologi iaitu kadar ricihan di antara 116.67 s^{-1} hingga 233.33 s^{-1} telah dikenakan semasa proses penuangan. Bagi menghasilkan membran komposit berprestasi tinggi, keadaan-keadaan optimum bagi kepekatan polimer, kadar ricih, masa sentuh dan masa tindak balas telah dikenalpasti. Dalam kajian ini, kepekatan polimer dan kadar ricih terbaik telah didapati pada anggaran 13 wt% dan 155.55 s^{-1}. Kebolehtelapan air yang tinggi kira-kira 2.20 x 10^{-6} $m^3/m^2.s$ and 31.85% penyingkiran garam telah menunjukkan membran sokongan berliang yang baik telah dibangunkan.

Kajian masa sentuh dan masa tindak balas menggunakan kombinasi reaktan yang berbeza juga telah menghasilkan lapisan kulit pemisah yang lebih nipis dan saiz liang yang kecil pada membran komposit lapisan nipis. Butiran pemisahan garam membran-membran komposit lapisan nipis adalah mengikut urutan MPD > MPD/PIP > PIP. Membran nanoturasan komposit lapisan nipis (TFC-NF) MPD yang dihasilkan sekitar jejari berliang 0.13 nm hingga 0.28 nm, ketumpatan cas -54.51 ke -11.43 dengan penyingkiran garam sehingga 99.36% pula telah didapati setanding dengan membran-membran komersial sedia ada. Melalui kombinasi sifat-sifat pemisah, membran TFC-NF juga menyediakan potensi teknikal yang baik ke arah penghasilan membran TFC-NF berprestasi tinggi untuk pelbagai kegunaan pada masa akan datang.