THE EFFECTS OF SHEAR FORCE INDUCED DURING DRY/WET PHASE INVERSION PROCESS ON PROPERTIES AND PERFORMANCE OF ASYMMETRIC MEMBRANE

By

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BORANG PENGAKUAN DAN PENGESAHAN LAPORAN PROJEK PENYELIDIKAN I DAN II

Adalah ini diakui dan disahkan bahawa laporan penyelidikan bertajuk:

THE EFFECTS OF SHEAR FORCE INDUCED DURING DRY/WET PHASE INVERSION PROCESS ON PROPERTIES AND PERFORMANCE OF ASYMMETRIC MEMBRANE oleh JULIDAWATI BINTI AWANG No. Matrik UK8195 telah diperiksa dan semua pembetulan yang disarankan telah dilakukan. Laporan ini dikemukakan kepada Jabatan Sains Kejuruteraan sebagai memenuhi sebahagian daripada keperluan memperolehi Ijazah SARJANA MUDA TEKNOLOGI (ALAM SEKITAR), Fakulti Sains dan Teknologi, Universiti Malaysia Terengganu.

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TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURE

LIST OF SYMBOLS

GS	-	Gas Separation
MW	-	Molecular Weight
MWCO	-	Molecular Weight Cut Off
NaCl	-	Sodium Chloride
NF	-	Nanofiltration
NMP	-	N-methyl-2-pyrrolidone
PES	-	Polyethersulfone
R_{obs}	-	Observed rejection
R_{relal}	-	Real rejection
RO	-	Reverse Osmosis
SEM	-	Scanning Electron Microscope
SHP	-	Steric-Hindrance Pore
TMS	-	Teorell Meyers-Sievers
UF	-	Ultrafiltration
A_k	-	Membrane porosity
c	-	Concentration, mol/m^3
c_i	-	Concentration of component i , mol/m^3
C_f	-	Concentration of feed solution
C_p	-	Concentration of permeate solution

D_i	-	Diffusivity of ion *i* in free solution, m^2/s
D_s	-	Solute diffusivity for neutral molecule, or generalized diffusivity for 1-1 typr of electrolyte defined as $D_s = 2(D1D2)/(D1 + D2)\,(m^2/s)$
F	-	Faraday constant (=96487) C/mol
H_F, H_D	-	Streic parameters related to wall correction factoers under diffusion and convection conditions, respectively
J_S	-	Averaged solute flux over membrane surface, $mol/m^2.s$
J_V	-	Averaged volume flux over membrane surface, m/s
k_i	-	Averaged distribution coefficients of ion *i* by the electrostatic effects
P	-	Permeability, m/s
P_S	-	Solute permeability, m/s
r	-	Pore size, nm
r_p	-	Pore radius, nm
r_s	-	Solute radius, nm
R_{ri}	-	Rejection of component i (%)
R	-	Rejection, or gas constnt (8.314) $J/mol^3.K$
$S_F S_D$	-	Distribution coefficients of solute by steric-hindrance effect under diffusion and convection condition, respectively
u_x	-	Velocity in the axial direction to the membrane, m/s
X_d	-	Effective membrane charge density ($mol\ m^{-3}$)
z_i	-	Valence of ion

ΔP	-	Applied pressure (Pa)
Δx	-	Effective membrane thickness, nm
$\Delta x / A_k$	-	The ratio of effective membrane thickness to membrane porosity

Greek

ε	-	Membrane porosity (dimensionless)
η	-	Viscocity of solution (Pa s)
λ	-	Ratio of solute radius to membrane pore radius
σ	-	Refflection coefficient (%)
τ	-	Tortuosity (dimensionless)
ξ	-	Ratio of fixed charge density to salt concentration, mV

LIST OF APPENDIX

ABSTRACT

Asymmetric PSf UF membranes were prepared at different shear rates which were $103.5s^{-1}$, $129.3s^{-1}$, $172.5s^{-1}$ and $258.7s^{-1}$ to investigate the influence of different shear rate on the membrane structure and performance of asymmetric membrane by using sodium chloride solution. The experimental data was modeled based on the pore flow, solution-diffusion mechanisms and the extended Nernst-Plank equation. The Spiegler –Kedem membrane transport model was used to evaluate the membrane parameters such as reflection coefficient and solute permeability, P_s. The fine structural details of the ultrafiltration membrane were evaluated in terms of effective pore radius r_p and ratio of effective membrane thickness to membrane porosity. The measurement was conducted using steric-hindrance pore (SHP) model. The zeta potential ξ was measured using Electrokinetic Analyzer (EKA). The morphology of each membrane was characterized using Scanning Electron Microscope (SEM). The optimum shear rate is found to be 258.7 s^{-1}. This study also indicated that shear rate was found to affect performance and structural properties by providing, to a certain extent, an oriented membrane skin layer which in turn exhibiting an improvement in membrane separation ability.

ABSTRAK

Penuras ultra asimetrik PSf telah disediakan dengan perbezaan kadar ricih iaitu $103.5s^{-1}$, $129.3s^{-1}$, $172.5s^{-1}$ and $258.7s^{-1}$ untuk mengkaji kesan kadar ricih yang berbeza ke atas prestasi dan struktur membran dengan menggunakan larutan natrium klorida. Data eksperimen telah dimodelkan berdasarkan aliran liang, mekanisma penyebaran larutan dan kesinambungan persamaan Nernst-Plank. Model pemindahan membran Spiegler-Kedem telah digunakan untuk menilai parameter membran seperti pekali pantulan dan ketelapan bahan yang terlarut, P_s. Struktur halus terperinci penapis ultra membran telah dinilai berdasarkan keberkesanan jejari liang r_p dan nisbah keberkesanan ketebalan membran kepada keadaan rongga membran. Pengukuran telah dijalankan menggunakan model penapisan liang (SHP). Potensi zeta, ξ telah diukur menggunakan Penganalisa Elektrokinetik (EKA). Morfologi setiap membran telah dipercirikan menggunakan Mikroskop Pengimbas Electron (SEM). Optimum kadar ricih yang diperolehi adalah 258.7 s^{-1}. Kajian ini juga menunjukkan bahawa kadar ricih memberi kesan terhadap prestasi dan ciri-ciri struktur dengan menghasilkan satu lapisan membran yang padat yang mana menunjukkan satu kemajuan dalam proses pemisahan membran.