DEVELOPMENT OF POLYETHERSULFONE (PES) MEMBRANE FOR THE TREATMENT OF AQUACULTURE WASTEWATER

NURUL SYAZANA BINTI ABDUL HALIM

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PERPUSTAKAAN SULTANAH NUR ZAHIRAH
UNIVERSITI MALAYSIA TERENGGANU (UMT)
21030 KUALA TERENGGANU.

1100077385

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HAK MILIK
PERPUSTAKAAN SULTANAH NUR ZAHIRAH UMT

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Universiti Malaysia Terengganu

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NURUL SYAZANA BINTI ABDUL HALIM

Thesis Submitted in Fulfilment of the Requirement for the
Degree of Master Science in the Faculty of Science and Technology
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Special dedication to:

My beloved papa and mama,

Dr Abdul Halim Mohd Aminullah and Wan Chak Pa'wan Chik

Who always pray the best for me, loves and believes in me.

For my late grandma,

Fatimah Sham Mohamed

Who had taken care of me since the day I was born.

My siblings,

Dr. Nurul Shakirah, Nurul Syazwani and Abdul Basith

Who had always gives me moral support.

My '*Sigaraning*'

Mohd Zain Hasan

For his loves, courage, patient and support.

And

For all the students and researchers,

Who appreciate the hard work!

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DEVELOPMENT OF POLYETHERSULFONE (PES) MEMBRANE FOR THE TREATMENT OF AQUACULTURE WASTEWATER

NURUL SYAZANA ABDUL HALIM

SEPTEMBER 2009

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

Member : **Associate Professor Ir. Ahmad Jusoh, Ph.D.**

Faculty : **Science and Technology**

Ammonia nitrogen and orthophosphate are the primary by product in aquaculture production. If both concentrations exceeded the control limit, the aquatic life and the ecosystem will be affected. Therefore, the aim of this study is to develop the polyethersulfone (PES) membranes with different preparation parameters in treating aquaculture wastewater and in order to produce the PES membranes with high selectivity as well as productivity. The effects of different PES concentration ranging from 18% to 23% and the influence of non-solvent additive, particularly water and polyvinylpyrrolidone (PVP) on the PES dope solution was first investigated. PES membrane with the best combination of polymer concentration and non-solvent additive was further studied by altering the shear rate from 80 s^{-1} to 400 s^{-1} in order to improve the fluxes and rejection rate. Lastly, membrane with the best shear rate was transformed into thin film composite (TFC) membrane via interfacial polymerization process by immersing the PES support in 2% m-phenylenediamine (MPD) followed by another dip into n-hexane solution of 0.1% trimesoyl chloride (TMC) to enhance the separation performance. All the PES membranes developed were subjected to pure water permeation and 0.01 M sodium chloride rejection. Besides, the morphology of the membrane was viewed using scanning electron microscopy (SEM) and the structural details such as pore radius, membrane thickness and effective charged density was obtained by employing the steric hindrance pore (SHP) model and Teorell-Meyer-Siever (TMS) model. Based on the results, 18% of PES membrane without any non-solvent additive (PES18) showed 57% of salt rejection even though the permeability is slightly lower than those with PVP (PES18PVP). The pore size and the membrane thickness obtained was 0.33 nm and 5.67 x 10^{-3} m respectively. Besides, the optimum shear rate was found to be around 200 s^{-1} with average of 93% and 64% of orthophosphate and ammonia removal respectively. After the transformation to the TFC membrane, the rejection of orthophosphate and ammonia was improved with

more than 99% and 93% respectively and the pore size was smaller with average at 0.15 nm. These findings revealed that polymer concentration, non-solvent additive and shear rate have significant role on the morphology and structural details of the membrane. By changing one or more of these parameters the membrane separation performance varied. Besides, this study indicates that the membrane technology showed a great potential in treating aquaculture wastewater as well as water management.

Perpustakaan Sultanah Nur Zahirah (UMT)
Universiti Malaysia Terengganu

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

PENGHASILAN POLYETHERSULFONE (PES) MEMBRAN BAGI RAWATAN TERHADAP PENYINGKIRAN AIR SISA AKUAKULTUR

NURUL SYAZANA ABDUL HALIM

SEPTEMBER 2009

Pengerusi : Professor Madya Nora'aini Ali, Ph.D.

Ahli : Professor Madya Ir. Ahmad Jusoh, Ph.D.

Fakulti : Sains dan Teknologi

Amonia nitrogen dan orthofosfat adalah sisa utama dalam produksi akuakultur. Seandainya kandungan sisa ini melebihi had yang dibenarkan, ia boleh mendatangkan masalah kepada ikan dan gangguan terhadap ekosistem air semulajadi. Oleh sebab itu, kajian ini dijalankan untuk menghasilkan membran polyethersulfon (PES) dengan pelbagai parameter pembuatan untuk menyingkirkan sisa buangan ini dan sekaligus menghasilkan PES membran yang mempunyai penyingkiran dan produktiviti yang tinggi. Kesan kepekatan PES yang berbeza iaitu dari 18% hingga 23% serta kesan penambahan bahan bukan pelarut iaitu air dan polyvinylpyrrolidon (PVP) ke atas larutan polimer PES dijalankan. Kemudian, ujian yang lebih terperinci dijalankan ke atas membran PES yang mempunyai kombinasi kepekatan polimer dan gabungan bukan pelarut yang terbaik untuk menentukan kadar ricihan terbaik bagi membran tersebut. Kadar ricihan yang dikaji adalah antara 80 s^{-1} hingga 400 s^{-1}. Akhir sekali, membran dengan kadar ricihan yang terbaik ditransformasikan kepada komposit membran lapisan tipis, menggunakan kaedah pempolimeran antara muka; iaitu dengan mencelup PES membran tadi ke dalam 2% larutan yang mengandungi m-phenylenediamine (MPD) dan diikuti pula dengan 0.1% trimesoyl chloride (TMC) dalam larutan n-hexane. Kesemua membran PES yang dihasilkan, diuji dengan ujian ketelapan terhadap air dan ujian penyingkiran terhadap 0.01 M natrium klorida. Selain itu, struktur morfologi membran diimbas menggunakan pengimbas electron mikroskopik (SEM) dan pencirian struktur membran seperti saiz liang, ketebalan membran dan kepadatan cas dikira menggunakan 2 model iaitu *'steric hindrance pore'* (SHP) dan *Teorell-Meyer-Siever* (TMS). Berdasarkan keputusan yang diperolehi, membran PES tanpa banah bukan pelarut (PES18) menunjukkan penyingkiran sebanyak 57% terhadap kandungan garam walaupun ketelapan terhadap air sedikit berkurang dari membran yang menggunakan PVP sebagai bahan bukan pelarut (PES18PVP). Manakala saiz liang dan ketebalan yang

diperoleh adalah sebanyak 0.31 nm dan 5.67 x 10^{-3} m setiap satu. Selain itu, kadar ricih yang optimum didapati terletak sekitar 200 s^{-1} dengan purata penyingkiran sebanyak 93% untuk orthofosfat dan 64% untuk amonia. Selepas ditransformasikan kepada komposit membran, data penyingkiran terhadap orthofosfat dan ammonia meningkat melebihi 99% dan 93% masing-masingnya. Malah saiz liang yang diperolehi adalah lebih kecil dengan hanya 0.15 nm. Hasil daripada penemuan ini membuktikan bahan bukan pelarut dan kadar ricih membran memberi kesan terhadap pembentukan struktur dan morfologi ke atas membran. Dengan mengubah salah satu daripada kesan tersebut, prestasi membran turut berubah. Selain itu, kajian ini menunjukkan potensi teknologi membran terhadap pengurusan air dan sisa akuakultur.