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FAKULTI SAINS DAN TEKNOLOGI

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EFFECT OF SHEAR RATE ON THE PERFORMANCE OF NANOFILTRATION MEMBRANE IN THE REMOVAL OF AMMONIUM ION

By

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JABATAN SAINS KEJURUTERAAN
FAKULTI SAINS DAN TEKNOLOGI
UNIVERSITI MALAYSIA TERENGGANU

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Adalah ini diakui dan disahkan bahawa laporan penyelidikan bertajuk:

Effect of Shear Rate on the Performance of Nanofiltration Membrane in the Removal of Ammonium Ion oleh NORHAFIZAH BINTI MAT JUNUS No. Matrik UK7804 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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LIST OF ABBREVIATIONS

Abbreviations

APHA	American Public Health Association
AWWA	American Water Works Association
EKA	Electro Kinetics Analyzer
INOS	Institute Oceanography
MF	Microfiltration
MW	Molecular Weight
NF	Nanofiltration
NMP	N-methyl-2-pyrrolidone
PES	Polyethersulfone
RO	Reverse Osmosis
SEM	Scanning Electron Microscopy
SHP	Steric Hindrance Pore model
UF	Ultrafiltration

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ABSTRACT

Excessive ammonia in aquaculture wastewater may cause many environmental problems to the receiving water. Such adverse effects of ammonium have promoted developing various techniques for its removal. Membrane separation processes are largely developed as an alternative to conventional wastewater treatment. In order to fabricate a high performance of nanofiltration membrane, the effect of shear rate on the membrane performance for aquaculture wastewater treatment has been studied. Membrane casting solution was prepared in binary system which consists of Polyethersulfone (PES) as polymer and N-methyl-2-pyrrolidone (NMP) as solvent with formulation 16/84 (PES/NMP). The flat sheet membranes were produced by a dry/wet phase inversion technique using a semi-automated electrically controlled casting machine varying casting speed 10s, 15s, 20s, 25s and 30s. Varying the casting speed has produced membranes with shear rate 278.88s^{-1}, 185.92s^{-1}, 139.44 s^{-1}, 111.55s^{-1}, and 96.92s^{-1}. The pore radius and charge of the membrane were predicted using SHP model and EKA. It was found that the pore size was decreased and the membrane charge implied the highest ξ-potentials (most negative) with increasing shear rate. The membranes performances were study based on percentage of rejection and flux of sodium chloride (NaCl) solution and ammonium solution. The highest rejection and flux for NaCl was found to be about 57% and 0.150 L/m^2.h respectively at shear rate 278.88s^{-1}. The same trend was also observed for ammonium ion removal where the membrane at shear rate 278.88s^{-1} removes greater than 70% of ammonium ion with 324.44 L/m^2.h flux. Due to the smallest pore radius, most negative surface charge and long finger-like structure, membrane with shear rate 278.88s^{-1} produced the highest rejection rate and flux rate. These findings suggest that the best shear rate is 278.88s^{-1}.

ABSTRAK

Pelbagai masalah alam sekitar boleh terjadi akibat kandungan ammonia yang berlebihan dalam air sisa akuakultur. Untuk mengatasi masalah tersebut, pelbagai teknik telah dibangunkan. Proses pemisahan menggunakan membran telah berkembang secara meluas sebagai alternatif baru dalam rawatan air sisa. Kesan kadar ricih ke atas prestasi membran telah dikaji dalam proses untuk menghasilkan membran penuras nano berprestasi tinggi. Larutan membran sistem binari yang terdiri daripada polietersulfon (PES) sebagai polimer dan n-metil-2-pirrolidon (NMP) sebagai pelarut dengan formulasi 16/84 (PES/NMP) telah dihasilkan. Kepingan nipis membran dihasilkan melalui kaedah pembalikan fasa kering/basah dengan menggunakan mesin acuan elektrik separa automatik dengan kelajuan 10s, 15s, 20s, 25s, dan 30s. Kelajuan mesin acuan tersebut menghasilkan membran berkadar ricih 278.88s^{-1}, 185.92s^{-1}, 139.44s^{-1}, 111.55s^{-1}, dan 96.92s^{-1}. Jejari liang dan cas pada permukaan membran telah ditentukan menggunakan model SHP dan EKA. Telah dikenalpasti bahawa saiz liang semakin mengecil dan membran semakin bercas negatif dengan pertambahan kadar ricih. Prestasi membran dikaji berdasarkan peratus penyingkiran dan fluk larutan NaCl dan larutan ammonia. Pada kadar ricih 278.88s^{-1}, peratus penyingkiran tertinggi NaCl adalah sebanyak 57% dengan fluk 0.150 L/m^2.h. Paten yang sama didapati pada penyingkiran ion ammonia dimana lebih 70% ion ammonia disingkirkan dengan fluk 324.44 L/m^2.h pada kadar ricih 278.88s^{-1}. Disebabkan saiz liang paling kecil, permukaan membran yang semakin bercas dan struktur seakan jejari yang panjang pada lapisan aktif membran telah menghasilkan peratuskan penyingkiran dan flux yang tinggi pada kadar ricih 278.88s^{-1}. Hasil kajian tersebut menunjukkan kadar ricih terbaik adalah 278.88s^{-1}.