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FOULING ANALYSIS OF PROTEIN ULTRAFILTRATION: EFFECTS OF TRANSMEMBRANE PRESSURE AND CROSSFLOW VELOCITY

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DEDICATION

For my parents and my husband

Abstract of the thesis presented to the Senate of University Malaysia Terengganu in fulfilment of the requirement for the degree of Master of Science

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Fouling is a major obstacle in membrane technology applications. A comprehensive understanding of fouling mechanisms throughout a separation system process is crucial in designing desired separation system. Fouling mechanisms can be identified by fouling stages, significantly help in determining favourable fouling control procedure to be implemented. Severe fouling occurrence during protein separation limits the potential offered by ultrafiltration for proteins recovery from washwater. In this research, a resistance-in-series model was adopted to determine magnitude of four major resistances that govern in fouling mechanisms namely membrane (R_m), adsorption (R_{ad}), pore plugging (R_{pp}) and cake formation (R_c) resistances. These resistances were evaluated to quantify fouling mechanism in order to further understand fouling behaviour. The experiments were conducted using commercial tubular ultrafiltration Polyvinylidenedifluoride (PVDF) membrane with surimi washwater as model-protein solution. Two main operating parameters of trans-membrane pressure (TMP) and cross-flow velocity (CFV) with the values of 0.2 to 0.4bar and 0.0014 to 0.0028m/s were chosen to study

the effects of operating conditions towards fouling mechanisms with respect to flux. Permeate obtained from the filtration process produced clarified washwater with satisfactory quality physically and physico-chemically based on national water quality standards. The ultrafiltered washwater in this study complied with Environmental Quality Act guidelines for industrial water effluent at standard A and B. During ultrafiltration, it was proposed that fouling phenomena was divided into four phases based on flux declination patern. The resistances' magnitudes were arranged in the following sequence: $R_{pp} > R_{ad} > R_c > R_m$. The optimized operating parameters obtained for TMP and CFV using response surface methodology (RSM) were combination of TMP 0.3bar and CFV 0.0021m/s produced the best flux performance which marked least fouling occurrence. Based on resistance-in-series model that have been developed for surimi washwater treatment by using PVDF ultrafiltration continuous system, it was proposed that the suitable operating clean in place procedure to be implemented to overcome fouling were backflusing and membrane surface modification.

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ANALISIS KOTORAN BAGI ULTRATURASAN PROTEIN: KESAN TEKANAN TRANS-MEMBRAN DAN HALAJU ALIRAN SILANG

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Pusat Pengajian : Pusat Pengajian Kejuruteraan Kelautan

Kotoran merupakan kekangan terbesar dalam aplikasi teknologi membran. Pemahaman komprehensif tentang mekanisma kotoran sepanjang proses pemisahan adalah amat penting dalam merekabentuk sistem pemisah yang diingini. Mekanisma kotoran boleh ditentukan dengan mengukur nilai rintangan kotoran, di mana ia adalah penting dalam menentukan kaedah pengawalan kotoran yang paling sesuai untuk dipraktikkan. Kotaran yang teruk berlaku ketika proses pemisahan protein mengehadkan potensi ultraturasan untuk pemulihan protein dari air basuhan. Dalam kajian ini, model rintangan sesiri telah digunakan untuk mengukur magnitud empat rintangan utama dalam mekanisma kotoran iaitu rintangan membran (R_m), penyerapan (R_{ad}), penutupan liang (R_{pp}) dan pembentukan kek (R_c). Rintangan-rintangan ini dinilai untuk mengukur mekanisma kotoran untuk memperolehi kefahaman yang lebih mendalam tentang pembentukan kotoran. Ujikaji dijalankan menggunakan tiub membran ultraturasan komersil polivinilidinaflorida (PVDF) dengan air basuhan surimi sebagai model larutan protein. Dua parameter operasi utama dipilih iaitu tekanan trans-membran (TMP) dan halaju aliran

silang (CFV) dengan julat nilai 0.2 hingga 0.4bar dan 0.0014 hingga 0.0028m/s digunakan untuk mengkaji kesan keadaan operasi terhadap mekanisma kotoran dengan mempertimbangkan nilai fluks. Penelapan yang diperoleh dari proses penurasan menghasilkan air basuhan yang lebih jernih dengan kualiti fizikal dan kimia-fizik yang mematuhi had piawaian kualiti air kebangsaan. Air basuhan yang telah melalui proses ultraturasan mematuhi garis panduan Akta Kualiti Alam Sekitar bagi air aliran keluar berdasarkan piawaian A dan B. Semasa proses ultraturasan, adalah disarankan fenomena kotoran dibahagikan kepada empat fasa. Magnitud bagi rintangan-rintangan yang diperoleh adalah dalam jujukan berikut: $R_{pp} > R_{ad} > R_c > R_m$. Dengan mengoptimumkan parameter operasi menggunakan kaedah respon permukaan (RSM), didapati kombinasi TMP 0.3bar dengan CFV 0.0021m/s menghasilkan prestasi fluks terbaik yang menandakan paling sedikit kotoran berlaku. Berdasarkan model rintangan sesiri yang telah diguna pakai untuk merawat air basuhan surimi menggunakan sistem ultraturasan PVDF berterusan, adalah disarankan prosedur pembersihan langsung yang sesuai untuk dipraktikkan bagi mengekang kotoran adalah simbahan songsang dan pengubahsuaian permukaan membran.