Appendix A

Analysis of viscosity average molecular weight of chitosan

Average molecular weight of chitosan was obtained by viscosity measurement. Solvent used in this work was mixing solution of 10 mL of 0.1M acetic acid and 20 mL of 0.2M sodium chloride. The temperature was controlled at 25 °C using thermostat bath. The result was shown in Table A1 and Figure A1.

Table A1 Result from viscosity measurement of chitosan solution at 25 °C.

Solution	Concentration(C) ($\times 10^{-4}$ g/mL)	Time (s)	η_r	η_{sp}	η_{sp}/C (mL/g)
C_0	0.00	94.14	1.000	0.000	0
C_1	7.60	176.71	1.877	0.877	1154
C_2	6.71	164.64	1.749	0.749	1116
C_3	6.00	155.53	1.652	0.652	1087
C_4	2.17	114.69	1.218	0.218	1005
C_5	1.92	111.81	1.188	0.188	979
C_6	1.72	109.74	1.166	0.166	965

Where,

relative viscosity (η_r) ; $\eta_r = t_{solution} / t_{solvent}$

specific viscosity (η_{sp}) ; $\eta_{sp} = \eta_r - 1$

intrinsic viscosity ([η]) ; [η] = η_{sp} at C = 0

$t_{solution}$: flow time of solution

$t_{solvent}$: flow time of solvent

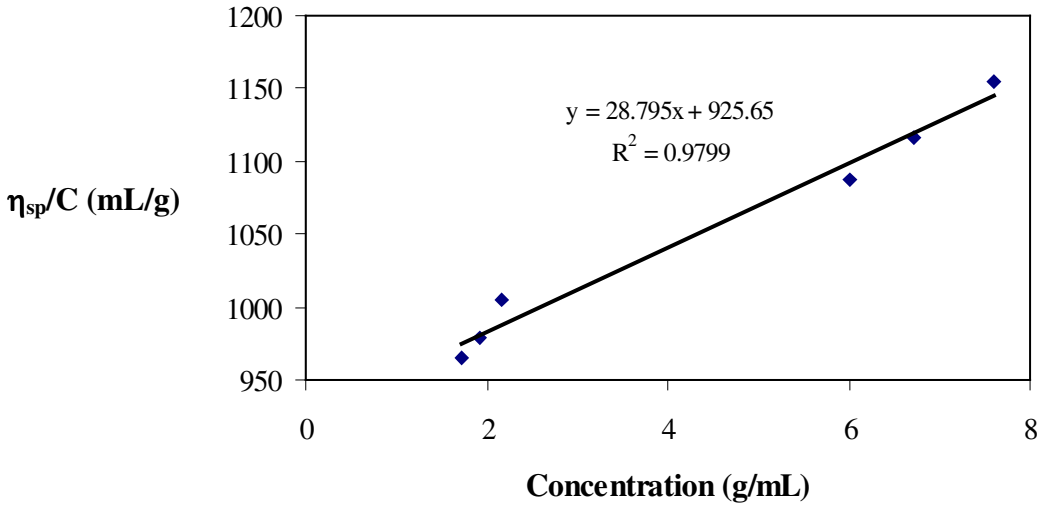


Figure A1 Relation between η_{sp}/C and concentration of chitosan solution.

Viscosity average molecular weight ($\overline{M}_v$) was calculated from standinger equation as follows:

$$\log [\eta] = \log K + a \log \overline{M}_v$$

where, K and a are the constant values; 1.8×10^{-3} and 0.93, respectively.

$$\log 925.65 = \log 0.0018 + 0.93 \log \overline{M}_v$$

$$2.966 = -2.745 + 0.93 \log \overline{M}_v$$

$$\log \overline{M}_v = 5.711 / 0.93$$

$$\overline{M}_v = 1{,}383{,}566$$

Appendix B

Analysis of %DD (degree of deacetylation) of chitosan using IR spectrometer

Chitosan membrane preparation

Chitosan membrane was prepared by dissolving 1%w/v chitosan in 1 %v/v acetic acid aqueous solution. After stiring at room temperature for 48 hour, the solution was filtered. The solution was poured on watch glass with diameter of 2.5 cm and dried. The dried membrane was neutralized in 1 M NaOH solution for 1 min, washed and rinsed, respectively with water and then dried at room temperature.

Infrared spectroscopic analysis

The films are analysed by IR spectroscopy, each spectrum being recorded immediately upon removal the film from the desiccator. The degree of *N*-acetylation of chitosan obtained by IR analysis depends on which ratio between peak area at wavenumber 1655 and 2867 cm^{-1}.

From Figure B1,

Area of peak at 1655 cm^{-1} = 3459

Area of peak at 2867 cm^{-1} = 19274

A_{1655}/A_{2867} = 1655 / 2867 cm^{-1}

= 3459 / 19274

= 0.18

Thus, from calibration curve of Figure B2, % DD was 94%.

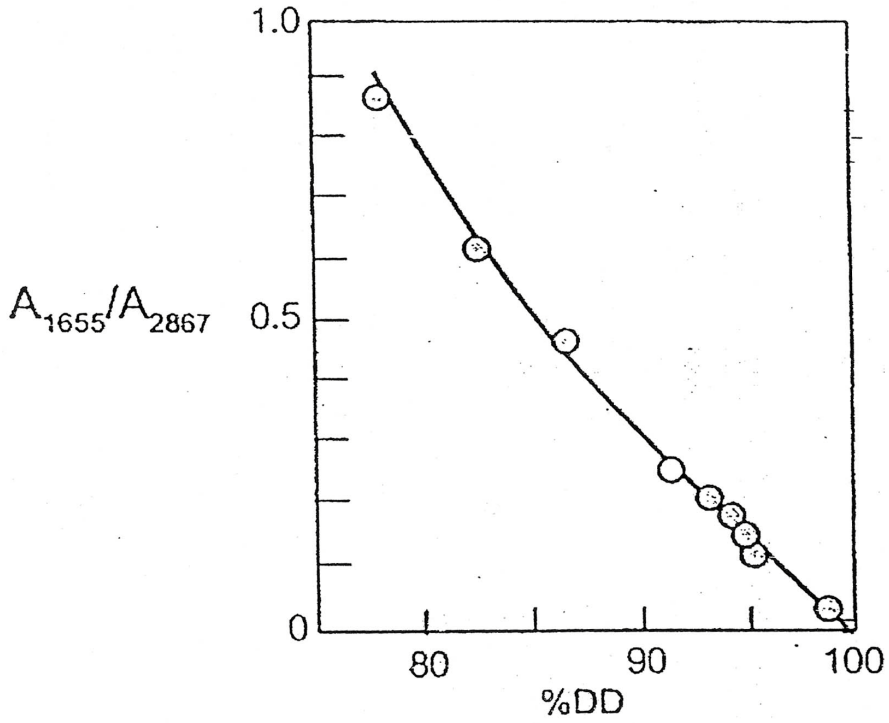


Figure B2 Calibration curve of Degree of Deacetylation.

Appendix C

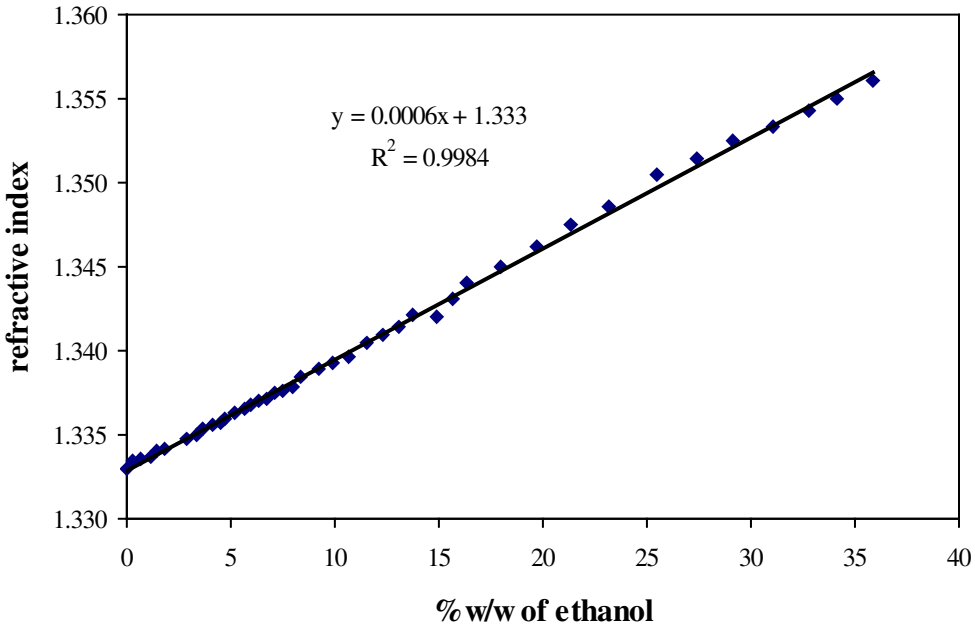
Refractive index of water-ethanol mixtures were measured using refractometer and shown in Table C1 and Figure C1.

Table C1 Refractive index of water-ethanol mixtures at 20 °C

%w/w of ethanol	Refractive index
0.00	1.3330
0.33	1.33342
0.70	1.33360
1.19	1.33375
1.42	1.33401
1.78	1.33420
2.86	1.33480
3.40	1.33502
3.66	1.33540
4.09	1.33561
4.50	1.33572
4.70	1.33599
5.21	1.33630
5.65	1.33652
5.99	1.33680
6.36	1.33701
6.70	1.33719
7.10	1.33746
7.52	1.33760
8.00	1.33790
8.37	1.33840
9.19	1.33898
9.92	1.33929
10.70	1.33968
11.51	1.34044
12.34	1.34092
13.07	1.34148
13.76	1.34212
14.89	1.34204
15.65	1.34315
16.39	1.34400

Table C1 Refractive index of water-ethanol mixtures at 20 °C (continued)

% w/w of ethanol	Refractive index
17.98	1.34505
19.72	1.34622
21.38	1.34749
23.22	1.34855
25.46	1.35044
27.39	1.35142
29.14	1.35250
31.05	1.35328
32.81	1.35430
34.17	1.35500
35.88	1.35610
38.44	1.35700
41.46	1.35840
42.14	1.35860
43.95	1.35940
46.49	1.36000
47.57	1.36041
49.82	1.36090
52.07	1.36156
53.74	1.36204
55.61	1.36241
58.07	1.36280
60.12	1.36322
62.28	1.36360
64.27	1.36378
67.78	1.36430
69.09	1.36443
71.31	1.36479
73.52	1.36500
75.60	1.36500
77.99	1.36500
80.27	1.36513
82.42	1.36513
84.98	1.36500
86.99	1.36480
89.48	1.36449
91.97	1.36405
94.15	1.36395
98.13	1.36300
99.80	1.36142



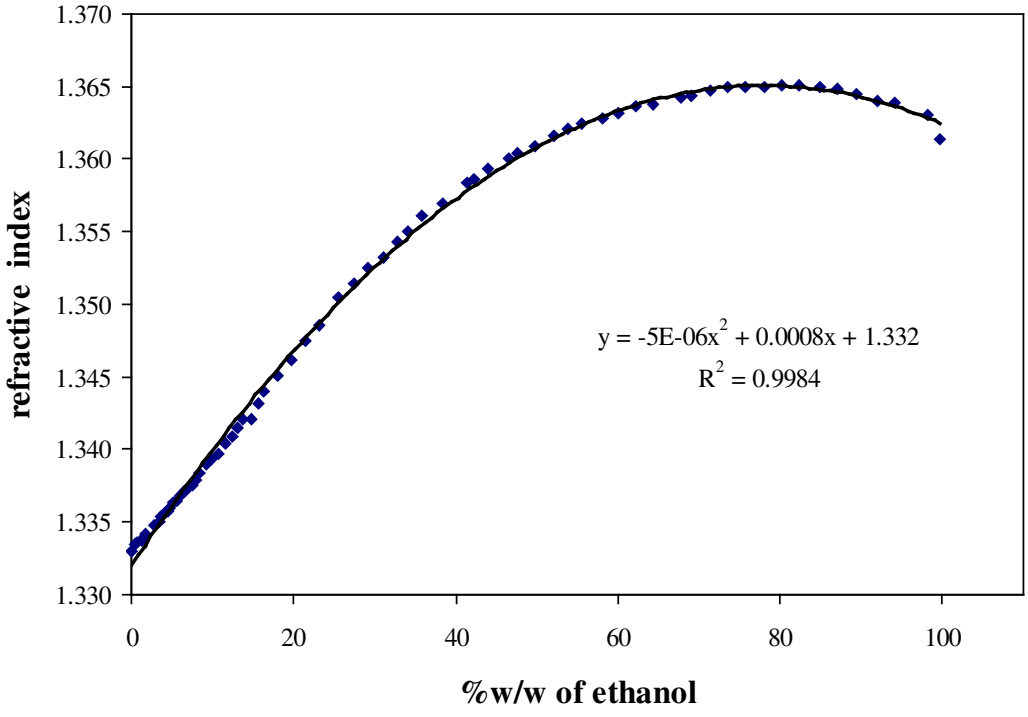


Figure C1 Refractive index of water-ethanol mixtures.

Appendix D

Results of experimental

Table D1 Swelling ratio of each experiment

Concentration of Average±SD)	Crosslinking time (min)	Temperature (° C)	Swelling ratio							
			1	2	3	4	5	6	7	
0.28	48	54	0.2281	0.2069	0.2174	0.2174	0.2174	0.2174	0.2174	0.2174±0.0061
0.82	48	54	0.2281	0.2281	0.2281	0.2174	0.2174	0.2174	0.2281	0.2257±0.0052
0.28	102	54	0.2111	0.2111	0.2174	0.2174	0.2174	0.2174	0.2174	0.2156±0.0031
0.82	102	54	0.2174	0.2174	0.2174	0.2111	0.2281	0.2281	0.2281	0.2212±0.0060
0.28	48	66	0.2174	0.2174	0.2174	0.2174	0.2111	0.2111	0.2281	0.2172±0.0057
0.82	48	66	0.2281	0.2281	0.2281	0.2281	0.2174	0.2174	0.2174	0.2235±0.0052
0.28	102	66	0.2111	0.2111	0.2111	0.2174	0.2174	0.2174	0.2174	0.2147±0.0034
0.82	102	66	0.2174	0.2174	0.2174	0.2174	0.2174	0.2281	0.2281	0.2205±0.0050
0.10	75	60	0.2174	0.2174	0.2174	0.2174	0.2174	0.2174	0.2174	0.2174±0.0000
1.00	75	60	0.2281	0.2281	0.2281	0.2281	0.2281	0.2281	0.2281	0.2281±0.0000
0.55	30	60	0.2281	0.2281	0.2281	0.2281	0.2281	0.2281	0.2281	0.2281±0.0000
0.55	120	60	0.1966	0.1966	0.2069	0.2069	0.2069	0.2069	0.2069	0.2040±0.0050
0.55	75	50	0.2281	0.2281	0.2281	0.2281	0.2281	0.2281	0.2281	0.2281±0.0000
0.55	75	70	0.2174	0.2174	0.2174	0.2174	0.2174	0.2174	0.2174	0.2174±0.0000
0.55	75	60	0.2174	0.2174	0.2281	0.2281	0.2281	0.2281	0.2281	0.2250±0.0052
0.55	75	60	0.2174	0.2174	0.2281	0.2281	0.2281	0.2281	0.2281	0.2250±0.0052
0.55	75	60	0.2174	0.2281	0.2281	0.2281	0.2281	0.2281	0.2281	0.2266±0.0040
0.55	75	60	0.2174	0.2281	0.2281	0.2281	0.2281	0.2281	0.2281	0.2266±0.0040
0.55	75	60	0.2174	0.2174	0.2281	0.2281	0.2281	0.2281	0.2281	0.2250±0.0052
0.55	75	60	0.2174	0.2174	0.2281	0.2281	0.2281	0.2281	0.2281	0.2250±0.0052

Table D2 Sorption selectivity of each experiment

Concentration of (M)	Crosslinking time (min)	Temperature (°C)	Ethanol in feed (%w/w)		Ethanol in product (%w/w)		Sorption selectivity		Average±SD
			1	2	1	2	1	2	
0.28	48	54	50.33	50.33	1.33	1.33	74.98	74.98	74.98±0.00
0.82	48	54	50.33	50.33	3.33	3.50	29.39	27.94	28.66±1.02
0.28	102	54	50.67	50.67	1.17	1.17	87.02	87.02	87.02±0.00
0.82	102	54	50.67	50.67	3.00	1.67	33.21	37.49	35.35±3.03
0.28	48	66	49.33	49.33	0.75	0.83	128.83	115.85	122.34±9.81
0.82	48	66	49.33	49.33	1.08	1.00	88.89	96.38	92.64±5.30
0.28	102	66	50.33	50.33	0.58	0.67	172.69	150.98	161.84±15.35
0.82	102	66	50.33	50.33	0.83	0.92	120.58	109.53	115.05±7.80
0.10	75	60	50.33	50.33	0.87	0.87	115.90	115.90	115.90±70.00
1.00	75	60	50.33	50.33	1.17	1.33	85.84	74.98	80.41±7.68
0.55	30	60	50.67	50.67	2.00	2.17	50.33	46.38	48.36±2.79
0.55	120	60	50.67	50.67	0.75	0.83	135.92	122.23	129.08±9.68
0.55	75	50	50.33	50.33	1.00	1.00	96.38	96.38	96.38±0.00
0.55	75	70	50.33	50.33	0.75	0.83	134.09	120.58	127.34±9.55
0.55	75	60	50.33	50.33	0.92	1.00	109.53	100.32	104.92±6.51
0.55	75	60	50.33	50.33	1.08	1.00	92.52	100.32	96.42±5.50
0.55	75	60	50.33	50.33	0.92	0.97	109.53	103.81	106.67±4.04
0.55	75	60	50.33	50.33	0.92	0.92	109.53	109.53	109.53±0.00
0.55	75	60	50.67	50.67	0.92	0.92	111.00	111.00	111.00±0.00
0.55	75	60	50.67	50.67	0.97	0.92	105.23	111.03	108.13±4.10

Table D3 The efficiency of chitosan membrane for dehydration of ethanol using pervaporation process (Flux)

Feed concentration : 87 %w/w ethanol
Feed temperature : 60 °C
Downstream pressure : 2.54 mm of Hg
Operating time : 2 hour
Effective membrane area : 13.35 cm^2

Concentration of s (M)	Crosslinking time (min)	Temperature (°C)	Weight of permeate (g)		Flux (g/m^2h)		Average±SD
			1	2	1	2	
0.28	48	54	0.4056	0.4123	459.86	467.46	463.66±5.37
0.82	48	54	0.4963	0.4756	562.70	539.23	550.96±16.60
0.28	102	54	0.3921	0.3900	444.56	442.18	443.37±1.68
0.82	102	54	0.4586	0.4487	519.96	508.73	514.34±7.94
0.28	48	66	0.3699	0.3726	419.39	422.45	420.92±2.16
0.82	48	66	0.4395	0.4356	498.30	493.88	496.09±3.13
0.28	102	66	0.3623	0.3693	410.77	418.71	414.74±5.61
0.82	102	66	0.3695	0.3700	418.93	419.50	419.22±0.40
0.10	75	60	0.3356	0.3399	380.50	385.37	382.94±3.44
1.00	75	60	0.3956	0.400	448.53	453.52	451.02±3.53
0.55	30	60	0.4231	0.4268	479.71	483.90	481.80±2.97
0.55	120	60	0.3300	0.3264	374.15	370.07	372.12±2.89
0.55	75	50	0.3980	0.3855	451.25	437.08	441.55±0.88
0.55	75	70	0.3214	0.3165	364.40	358.84	386.68±1.68
0.55	75	60	0.3741	0.3756	424.15	425.85	425.00±1.20
0.55	75	60	0.3691	0.3652	418.48	414.06	416.27±3.13
0.55	75	60	0.4123	0.4235	467.46	480.16	473.81±8.98
0.55	75	60	0.3956	0.3900	448.53	442.18	445.35±4.49
0.55	75	60	0.3874	0.3796	439.23	430.39	434.81±6.25
0.55	75	60	0.3560	0.3614	403.63	409.75	406.69±4.33

Table D4 The efficiency of chitosan membrane for dehydration of ethanol using pervaporation process (Seperaton factor)

Feed concentration : 87 %w/w ethanol
Feed temperature : 60 °C
Downstream pressure : 2.54 mm of Hg
Operating time : 2 hour
Effective membrane area : 13.35 cm^2

Concentration of (M)	Crosslinking time (min)	Temperature (°C)	Ethanol in feed (%w/w)		Ethanol in permeate (%w/w)		Separation factor		Average±SD
			1	2	1	2	1	2	
0.28	48	54	87.00	87.00	1.42	1.50	503.06	469.05	486.06±24.05
0.82	48	54	87.00	87.00	3.33	3.17	207.36	218.18	212.77±7.65
0.28	102	54	87.00	87.00	1.17	1.17	603.36	603.36	603.36±0.00
0.82	102	54	87.00	87.00	2.33	2.67	299.42	260.38	279.9±27.60
0.28	48	66	87.00	87.00	0.83	0.83	853.44	853.44	853.44±0.00
0.82	48	66	87.00	87.00	1.08	1.00	654.23	603.35	628.79±35.98
0.28	102	66	87.00	87.00	0.69	0.69	963.21	963.21	963.21±0.00
0.82	102	66	87.00	87.00	0.92	0.83	769.25	853.44	811.35±59.53
0.10	75	60	87.00	87.00	0.83	0.87	853.44	813.87	833.66±27.98
1.00	75	60	87.00	87.00	1.17	1.17	603.36	603.36	603.36±0.00
0.55	30	60	87.00	87.00	2.00	1.83	350.00	383.18	366.59±23.46
0.55	120	60	87.00	87.00	0.87	0.83	813.87	853.44	833.66±27.98
0.55	75	50	87.00	87.00	1.08	1.00	654.23	707.14	680.69±37.41
0.55	75	70	87.00	87.00	1.00	1.08	707.14	654.23	813.87±0.00
0.55	75	60	87.00	87.00	0.92	0.92	769.25	769.25	769.25±0.00
0.55	75	60	87.00	87.00	1.08	1.00	654.23	707.14	680.69±37.41
0.55	75	60	87.00	87.00	1.00	0.97	707.14	707.36	707.25±0.16
0.55	75	60	87.00	87.00	1.00	1.00	707.14	707.14	707.14±0.00
0.55	75	60	87.00	87.00	0.92	0.92	769.25	769.25	769.25±0.00
0.55	75	60	87.00	87.00	1.00	1.00	707.14	707.14	707.14±0.00

Table D5 Effect of feed concentrations (ethanol) and feed temperature on flux using pervaporation process

chitosan membrane were prepared, concentration of sulfuric acid : 0.28 M, crosslinking time : 102 minute and membrane formation temperature : 66 °C
Downstream pressure : 2.54 mm of Hg
Operating time : 2 hour
Effective membrane area : 13.35 cm^2

Ethanol in feed (%w/w)	Feed temperature (°C)	Weight of permeate (g)	Flux (g/m^2h)
74.00	53	0.5428	615.42
74.00	67	0.5826	660.54
91.00	53	0.3248	368.25
91.00	67	0.3629	411.45
70.00	60	0.5686	644.67
95.00	60	0.3366	381.63
83.00	50	0.4200	476.19
83.00	70	0.4954	561.68
83.00	60	0.4376	496.15
83.00	60	0.4413	500.34
83.00	60	0.4358	490.10
83.00	60	0.4400	498.87
83.00	60	0.4355	493.76

Table D6 Effect of feed concentrations (ethanol) and feed temperature on separation factor using pervaporation process

chitosan membrane were prepared, concentration of sulfuric acid : 0.28 M, crosslinking time : 102 minute and membrane formation temperature : 66 °C
Downstream pressure : 2.54 mm of Hg
Operating time : 2 hour
Effective membrane area : 13.35 cm^2

Ethanol in feed (%w/w)	Feed temperature (°C)	Ethanol in permeate (%w/w)	Separation factor
74.00	53	1.33	211.15
74.00	67	1.67	167.58
91.00	53	0.67	1499.07
91.00	67	0.83	1208.01
70.00	60	1.50	153.22
95.00	60	0.83	2270.16
83.00	50	1.00	483.35
83.00	70	2.00	239.24
83.00	60	1.50	320.61
83.00	60	1.67	287.47
83.00	60	1.50	320.61
83.00	60	1.67	287.47
83.00	60	1.50	320.61

Table D7a, b and c Computer output from essential linear regression for fitting a model of swelling ratio

Summary	
|R|	0.909955
R2	0.828018
R2 adjusted	0.748642
Standard Error	0.471447
# Points	20
PRESS	12.20996
R2 for Prediction	0.273247
Durbin-Watson d	2.016596
First Order Autocorrelation	-0.11984
Collinearity	5.08E-06
Coefficient of Variation	2.124545
Precision Index	36.02214

(a)

ANOVA						
Source	SS	SS%	MS	F	F Signif	df
Regression	13.91128	83	2.318547	10.43157	0.000248	6
Residual	2.889412	17	0.222262			13
LOF Error	2.799412	17 (97)	0.349927	19.44036	0.002311	8
Pure Error	0.09	1 (3)	0.018			5
Total	16.8007	100				19

(b)

		P value	Std Error	-0.95	0.95	t Stat	VIF
b_0	-5.11662	0.696031	12.80848	-32.7877	22.55441	-0.39947	
b_1	4.91655	0.026243	1.961174	0.679693	9.153407	2.506943	16.96721
b_2	0.058548	0.045394	0.026456	0.001394	0.115702	2.213067	30.77955
b_3	0.872047	0.059368	0.422115	-0.03988	1.78397	2.0659	386.9846
b_4	-3.35019	0.074911	1.730431	-7.08856	0.388178	-1.93604	16.98515
b_5	-0.00058	0.005133	0.000173	-0.00096	-0.00021	-3.35881	30.79776
b_6	-0.00755	0.050977	0.003513	-0.01514	3.72E-05	-2.14978	387.0028

(c)

Model

Swelling ratio = b_0 + b_1×concentration of sulfuric acid + b_2×crosslinking time + b_3×membrane formation temperature + b_4×concentration of sulfuric acid×concentration of sulfuric acid + b_5×crosslinking time×crosslinking time + b_6×membrane formation temperature×membrane formation temperature

Table D8 Effect of crosslinking time and membrane formation temperature on swelling ratio

C..T / M.T	50.0	52.2	54.4	56.7	58.9	61.1	63.3	65.6	67.8	70.0
30.0	22.5	22.7	22.9	23.0	23.0	22.9	22.7	22.5	22.2	21.8
40.0	22.7	22.9	23.1	23.1	23.1	23.1	22.9	22.7	22.4	22.0
50.0	22.8	23.0	23.1	23.2	23.2	23.1	23.0	22.8	22.5	22.1
60.0	22.7	22.9	23.1	23.2	23.2	23.1	22.9	22.7	22.4	22.0
70.0	22.5	22.8	22.9	23.0	23.0	22.9	22.8	22.5	22.2	21.9
80.0	22.3	22.5	22.6	22.7	22.7	22.6	22.5	22.2	21.9	21.6
90.0	21.8	22.1	22.2	22.3	22.3	22.2	22.1	21.8	21.5	21.2
100.0	21.3	21.5	21.7	21.8	21.8	21.7	21.5	21.3	21.0	20.6
110.0	20.7	20.9	21.1	21.1	21.1	21.1	20.9	20.7	20.4	20.0
120.0	19.9	20.2	20.3	20.4	20.4	20.3	20.1	19.9	19.6	19.2

* * C.T ; Crosslinking time and M.T : Membrane formation temperature

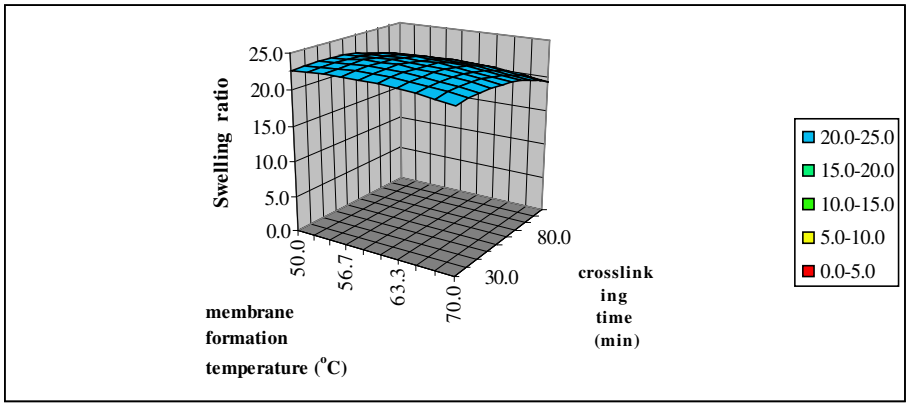


Figure D1 Effect of crosslinking time and membrane formation temperature on swelling ratio.

Table D9 Effect of crosslinking time and concentration of sulfuric acid on swelling ratio

C.S \ C.T	29.999	39.99911	49.99922	59.99933	69.99944	79.99956	89.99967	99.99978	109.9999	120
0.099	21.70357	21.8812	21.94228	21.88683	21.71485	21.42632	21.02126	20.49966	19.86152	19.10685
0.199111	22.09579	22.27342	22.3345	22.27905	22.10706	21.81854	21.41348	20.89188	20.25374	19.49906
0.299222	22.42086	22.59848	22.65957	22.60412	22.43213	22.1436	21.73854	21.21694	20.5788	19.82413
0.399333	22.67877	22.85639	22.91748	22.86203	22.69004	22.40151	21.99645	21.47485	20.83671	20.08204
0.499444	22.86953	23.04715	23.10824	23.05279	22.8808	22.59227	22.18721	21.66561	21.02747	20.2728
0.599556	22.99313	23.17076	23.23184	23.17639	23.00441	22.71588	22.31082	21.78922	21.15108	20.39641
0.699667	23.04959	23.22721	23.2883	23.23285	23.06086	22.77233	22.36727	21.84567	21.20753	20.45286
0.799778	23.03889	23.21651	23.2776	23.22215	23.05016	22.76163	22.35657	21.83497	21.19683	20.44216
0.899889	22.96104	23.13866	23.19975	23.1443	22.97231	22.68378	22.27872	21.75712	21.11898	20.36431
1	22.81603	22.99366	23.05474	22.99929	22.8273	22.53878	22.13372	21.61212	20.97398	20.2193

** C.T : Crosslinking time and C.S : Concentration of sulfuric acid

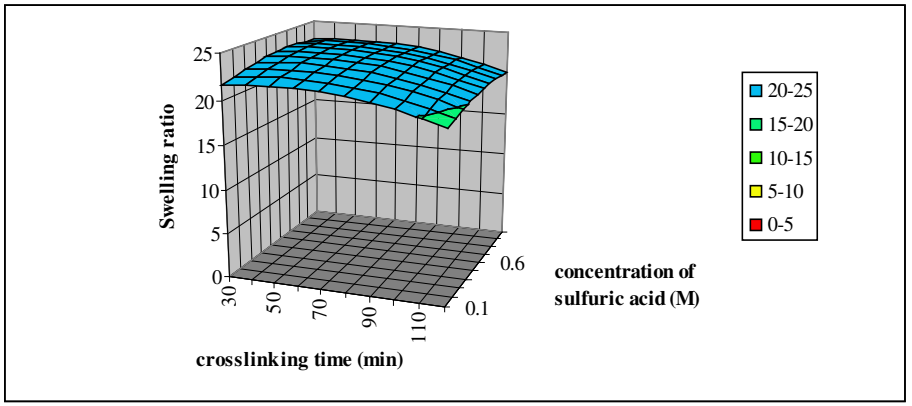


Figure D2 Effect of crosslinking time and concentration of sulfuric acid on swelling ratio.

Table D10 Effect of membrane formation temperature and concentration of sulfuric acid on swelling ratio

M.T / C.S	50.00	52.22	54.44	56.67	58.89	61.11	63.33	65.55	67.78	70.00
0.10	21.17	21.39	21.54	21.62	21.61	21.54	21.39	21.16	20.86	20.49
0.20	21.56	21.79	21.93	22.01	22.01	21.93	21.78	21.55	21.25	20.88
0.30	21.89	22.11	22.26	22.33	22.33	22.26	22.10	21.88	21.58	21.20
0.40	22.15	22.37	22.52	22.59	22.59	22.51	22.36	22.14	21.84	21.46
0.50	22.34	22.56	22.71	22.78	22.78	22.70	22.55	22.33	22.03	21.65
0.60	22.46	22.68	22.83	22.90	22.90	22.83	22.68	22.45	22.15	21.78
0.70	22.52	22.74	22.89	22.96	22.96	22.88	22.73	22.51	22.21	21.83
0.80	22.51	22.73	22.88	22.95	22.95	22.87	22.72	22.50	22.20	21.82
0.90	22.43	22.65	22.80	22.87	22.87	22.80	22.64	22.42	22.12	21.75
1.00	22.28	22.51	22.65	22.73	22.73	22.65	22.50	22.27	21.97	21.60

**M.T : Membrane formation temperature and C.S : Concentration of sulfuric acid

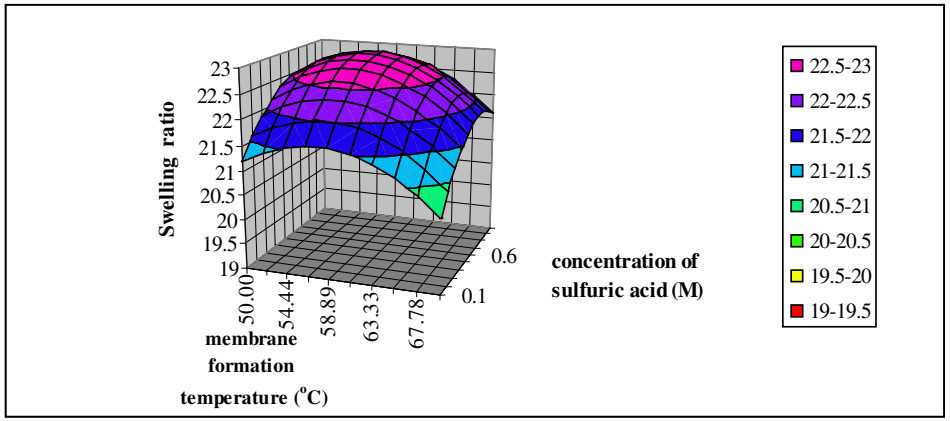


Figure D3 Effect of membrane formation temperature and concentration of sulfuric acid on swelling ratio.

Table D11a, b and c Computer output from essential linear regression for fitting a model of tensile strength

Summary	
|R|	0.849
R^2	0.721
R^2 adjusted	0.668
Standard Error	6.07E+15
# Points	20
PRESS	-
R^2 for Prediction	0.339
Durbin-Watson d	2.348
First Order Autocorrelation	-0.217
Collinearity	0.003
Coefficient of Variation	65.323
Precision Index	15.109

(a)

ANOVA						
Source	SS	SS%	MS	F	F Signif	df
Regression	1.52E+33	72	5.06E+32	13.76	0.000107	3
Residual	5.89E+32	28	3.68E+31			16
LOF Error	4.69E+32	22 (80)	4.26E+31	1.7759	0.273	11
Pure Error	1.2E+32	6 (20)	2.4E+31			5
Total	2.11E+33	100				19

(b)

		P value	Std Error	-95%	95%	t Stat	VIF
b_0	4.51E+17	0.01289	1.61E+17	1.09E+17	7.92E+17	2.798	
b_1	-1.6E+16	0.00878	5.38E+15	-2.7E+16	-4.6E+15	-2.983	380.06
b_2	3.08E+14	0.000204	6.44E+13	1.71E+14	4.44E+14	4.781	1.000
b_3	1.41E+14	0.00636	4.48E+13	4.56E+13	2.35E+14	3.138	380.06

(c)

Model

Tensile strength = b_0 + b_1×membrane formation temperature + b_2×concentration of sulfuric acid×crosslinking time + b_3×membrane formation temperature×membrane formation temperature

Table D12 Effect of membrane formation temperature and concentration of sulfuric acid on tensile strength

C..S / M.T	0.099	0.199111	0.299222	0.399333	0.499444	0.599556	0.699667	0.799778	0.899889	1.000000
50	1.458898	3.768952	6.079005	8.389058	10.69911	13.00916	15.31922	17.62927	19.93932	22.24938
52.22211	-2.29701	0.013046	2.323099	4.633152	6.943205	9.253259	11.56331	13.87337	16.18342	18.49347
54.44422	-4.66501	-2.35496	-0.04491	2.265147	4.5752	6.885253	9.195307	11.50536	13.81541	16.12547
56.66633	-5.64512	-3.33506	-1.02501	1.285042	3.595095	5.905149	8.215202	10.52526	12.83531	15.14536
58.88844	-5.23732	-2.92727	-0.61722	1.692838	4.002891	6.312945	8.622998	10.93305	13.2431	15.55316
61.11056	-3.44163	-1.13157	1.178481	3.488535	5.798588	8.108641	10.41869	12.72875	15.0388	17.34885
63.33267	-0.25803	2.052025	4.362079	6.672132	8.982185	11.29224	13.60229	15.91234	18.2224	20.53245
65.55478	4.31347	6.623523	8.933576	11.24363	13.55368	15.86374	18.17379	20.48384	22.7939	25.10395
67.77689	10.27287	12.58292	14.89297	17.20303	19.51308	21.82313	24.13319	26.44324	28.75329	31.06335
69.999	17.62017	19.93022	22.24027	24.55033	26.86038	29.17043	31.48049	33.79054	36.10059	38.41065

**M.T : Membrane formation temperature and C.S : Concentration of sulfuric acid

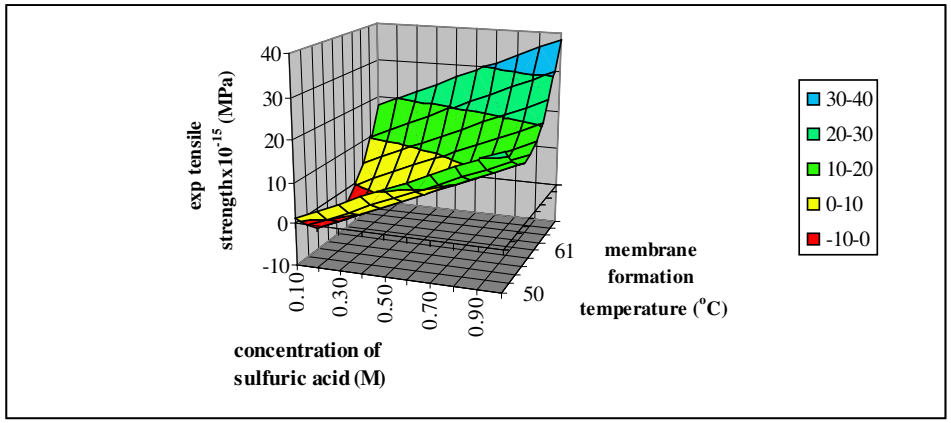


Figure D4 Effect of membrane formation temperature and concentration of sulfuric acid on tensile strength.

Table D13 Effect of membrane formation temperature and crosslinking time on tensile strength

C.T \ M.T	50	52.22211	54.44422	56.66633	58.88844	61.11056	63.33267	65.55478	67.77689	69.999
29.999	4.250211	0.494305	-1.8737	-2.8538	-2.44601	-0.65031	2.533285	7.104783	13.06418	20.41148
39.99911	5.942196	2.18629	-0.18172	-1.16182	-0.75402	1.041672	4.225269	8.796767	14.75617	22.10346
49.99922	7.63418	3.878274	1.510269	0.530164	0.93796	2.733657	5.917254	10.48875	16.44815	23.79545
59.99933	9.326165	5.570259	3.202253	2.222148	2.629944	4.425641	7.609238	12.18074	18.14013	25.48743
69.99944	11.01815	7.262243	4.894238	3.914133	4.321929	6.117625	9.301223	13.87272	19.83212	27.17942
79.99956	12.71013	8.954227	6.586222	5.606117	6.013913	7.80961	10.99321	15.5647	21.5241	28.8714
89.99967	14.40212	10.64621	8.278206	7.298102	7.705898	9.501594	12.68519	17.25669	23.21609	30.56339
99.99978	16.0941	12.3382	9.970191	8.990086	9.397882	11.19358	14.37718	18.94867	24.90807	32.25537
109.9999	17.78609	14.03018	11.66218	10.68207	11.08987	12.88556	16.06916	20.64066	26.60006	33.94736
120	19.47807	15.72216	13.35416	12.37405	12.78185	14.57755	17.76114	22.33264	28.29204	35.63934

* * C.T ; Crosslinking time and M.T : Membrane formation temperature

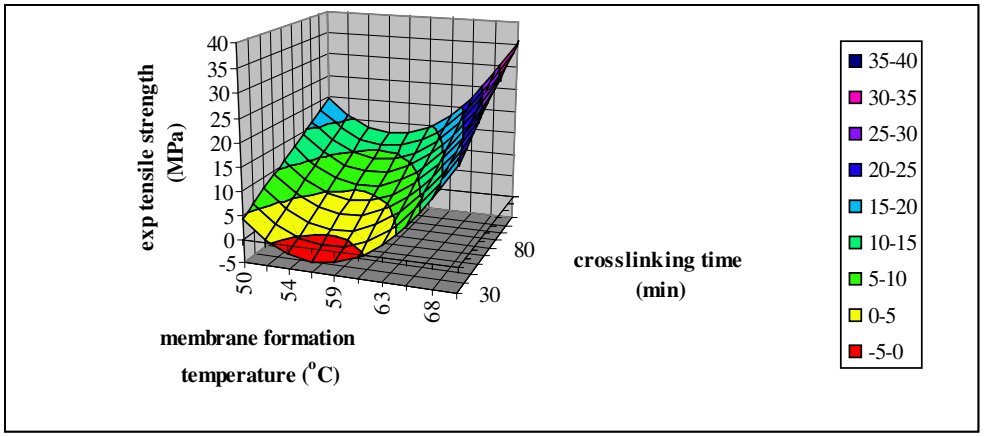


Figure D5 Effect of membrane formation temperature and crosslinking time on tensile strength.

Table D14 Effect of crosslinking time and concentration of sulfuric acid on tensile strength

C.T / C.S	29.999	39.99911	49.99922	59.99933	69.99944	79.99956	89.99967	99.99978	109.9999	120
0.099	-5.8833	-5.57871	-5.27413	-4.96954	-4.66496	-4.36037	-4.05579	-3.7512	-3.44662	-3.14203
0.199111	-4.95933	-4.34674	-3.73415	-3.12156	-2.50898	-1.89639	-1.2838	-0.67121	-0.05862	0.553965
0.299222	-4.03536	-3.11477	-2.19418	-1.27359	-0.35299	0.567598	1.488189	2.408781	3.329372	4.249964
0.399333	-3.11139	-1.8828	-0.6542	0.574394	1.802989	3.031583	4.260178	5.488773	6.717368	7.945963
0.499444	-2.18742	-0.65082	0.885774	2.422373	3.958971	5.495569	7.032167	8.568766	10.10536	11.64196
0.599556	-1.26345	0.581148	2.42575	4.270352	6.114953	7.959555	9.804156	11.64876	13.49336	15.33796
0.699667	-0.33948	1.813121	3.965726	6.118331	8.270936	10.42354	12.57615	14.72875	16.88136	19.03396
0.799778	0.584485	3.045093	5.505701	7.96631	10.42692	12.88753	15.34813	17.80874	20.26935	22.72996
0.899889	1.508454	4.277065	7.045677	9.814289	12.5829	15.35151	18.12012	20.88873	23.65735	26.42596
1	2.432423	5.509038	8.585653	11.66227	14.73888	17.8155	20.89211	23.96873	27.04534	30.12196

** C.T : Crosslinking time and C.S : Concentration of sulfuric acid

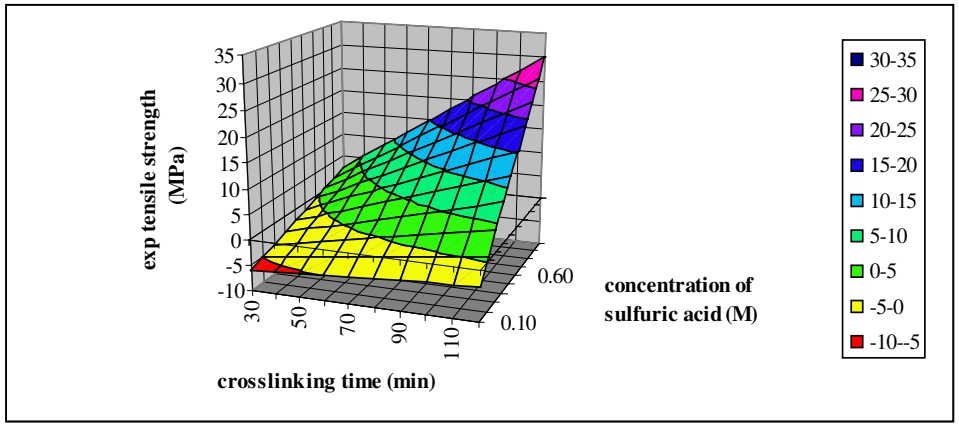


Figure D6 Effect of crosslinking time and concentration of sulfuric acid on tensile strength.

Table D15a, b and c Computer output from essential linear regression for fitting a model of sorption selectivity

Summary	
|R|	0.885
R^2	0.783
R^2 adjusted	0.742
Standard Error	16.44
# Points	20
PRESS	8002.60
R^2 for Prediction	0.598
Durbin-Watson d	1.611
First Order Autocorrelation	0.189
Collinearity	0.107
Coefficient of Variation	16.755
Precision Index	46.462

(a)

ANOVA						
Source	SS	SS%	MS	F	F Signif	df
Regression	15573.3	78	5191.1	19.21	1.49E-05	3
Residual	4324.2	22	270.26			16
LOF Error	4188.6	21 (97)	380.78	14.0398	0.00456	11
Pure Error	135.61	1 (3)	27.12			5
Total	19897.5	100				19

(b)

		P value	Std Error	-95%	95%	t Stat	VIF
b_0	0.07475	0.997	19.61	-41.50	41.65	0.00381	
b_1	-59.31	0.000928	14.64	-90.35	-28.27	-4.051	1.000
b_2	-0.01432	0.000551	0.00333	-0.02138	-0.00726	-4.299	9.338
b_3	0.04588	3.71E-05	0.00814	0.02862	0.06313	5.637	9.338

(c)

Model

Sorption selectivity = b_0 + b_1×concentration of sulfuric acid×concentration of sulfuric acid + b_2×crosslinking time×crosslinking time + b_3×crosslinking time×membrane formation temperature

Table D16 Effect of crosslinking time and concentration of sulfuric acid on sorption selectivity

C.T / C.S	30.0	40.0	50.0	60.0	70.0	80.0	90.0	100.0	110.0	120.0
0.1	69.2	86.7	101.3	113.1	122.0	128.0	131.2	131.5	129.0	123.6
0.2	67.4	84.9	99.5	111.3	120.2	126.3	129.5	129.8	127.2	121.8
0.3	64.5	82.0	96.6	108.4	117.3	123.3	126.5	126.8	124.3	118.8
0.4	60.3	77.8	92.4	104.2	113.1	119.2	122.3	122.7	120.1	114.7
0.5	55.0	72.5	87.1	98.9	107.8	113.8	117.0	117.3	114.8	109.4
0.6	48.4	65.9	80.6	92.4	101.3	107.3	110.5	110.8	108.3	102.8
0.7	40.7	58.2	72.9	84.6	93.5	99.6	102.8	103.1	100.5	95.1
0.8	31.8	49.3	64.0	75.7	84.6	90.7	93.9	94.2	91.6	86.2
0.9	21.7	39.2	53.9	65.6	74.6	80.6	83.8	84.1	81.5	76.1
1.0	10.4	28.0	42.6	54.4	63.3	69.3	72.5	72.8	70.3	64.8

** C.T : Crosslinking time and C.S : Concentration of sulfuric acid

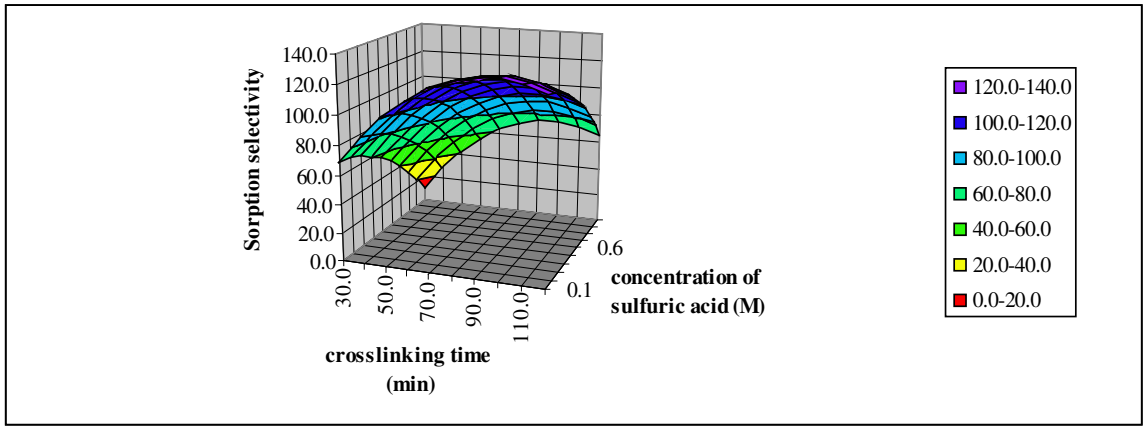


Figure D7 Effect of crosslinking time and concentration of sulfuric acid on sorption selectivity.

Table D17 Effect of crosslinking time and membrane formation temperature on sorption selectivity

C.T \ M.T	50	52.22211	54.44422	56.66633	58.88844	61.11056	63.33267	65.55478	67.77689	69.999
29.999	38.06017	41.11833	44.17648	47.23464	50.29279	53.35094	56.4091	59.46725	62.5254	65.58356
39.99911	50.97388	55.05147	59.12905	63.20663	67.28422	71.3618	75.43938	79.51697	83.59455	87.67213
49.99922	61.02331	66.12032	71.21734	76.31435	81.41136	86.50838	91.60539	96.7024	101.7994	106.8964
59.99933	68.20846	74.3249	80.44134	86.55778	92.67423	98.79067	104.9071	111.0236	117.14	123.2564
69.99944	72.52932	79.66519	86.80106	93.93693	101.0728	108.2087	115.3446	122.4804	129.6163	136.7522
79.99956	73.98589	82.1412	90.2965	98.4518	106.6071	114.7624	122.9177	131.073	139.2283	147.3836
89.99967	72.57819	81.75292	90.92765	100.1024	109.2771	118.4519	127.6266	136.8013	145.976	155.1508
99.99978	68.3062	78.50036	88.69453	98.88869	109.0829	119.277	129.4712	139.6653	149.8595	160.0537
109.9999	61.16993	72.38352	83.59712	94.81071	106.0243	117.2379	128.4515	139.6651	150.8787	162.0923
120	51.16938	63.4024	75.63542	87.86845	100.1015	112.3345	124.5675	136.8005	149.0336	161.2666

* * C.T ; Crosslinking time and M.T : Membrane formation temperature

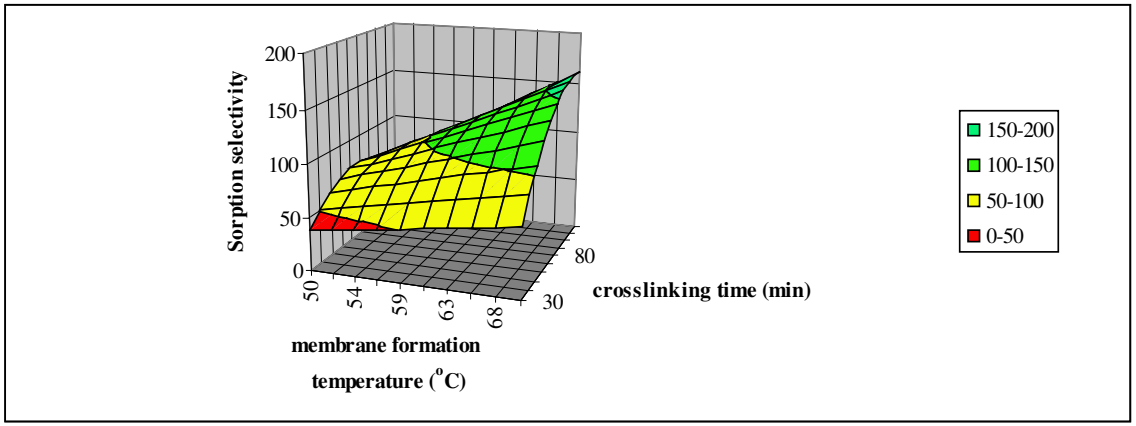


Figure D8 Effect of crosslinking time and membrane formation temperature on sorption selectivity.

Table D18 Effect of concentration of sulfuric acid and membrane formation temperature on sorption selectivity

C.S \ M.T	50	52.22211	54.44422	56.66633	58.88844	61.11056	63.33267	65.55478	67.77689	69.999
0.099	90.973	98.61882	106.2646	113.9105	121.5563	129.2021	136.8479	144.4937	152.1395	159.7854
0.199111	89.20291	96.84872	104.4945	112.1404	119.7862	127.432	135.0778	142.7236	150.3694	158.0153
0.299222	86.24395	93.88977	101.5356	109.1814	116.8272	124.473	132.1189	139.7647	147.4105	155.0563
0.399333	82.09614	89.74196	97.38778	105.0336	112.6794	120.3252	127.971	135.6169	143.2627	150.9085
0.499444	76.75947	84.40529	92.0511	99.69692	107.3427	114.9886	122.6344	130.2802	137.926	145.5718
0.599556	70.23394	77.87976	85.52557	93.17139	100.8172	108.463	116.1088	123.7547	131.4005	139.0463
0.699667	62.51955	70.16537	77.81119	85.457	93.10282	100.7486	108.3945	116.0403	123.6861	131.3319
0.799778	53.6163	61.26212	68.90794	76.55375	84.19957	91.84539	99.49121	107.137	114.7828	122.4287
0.899889	43.5242	51.17001	58.81583	66.46165	74.10746	81.75328	89.3991	97.04492	104.6907	112.3366
1	32.24323	39.88905	47.53486	55.18068	62.8265	70.47232	78.11813	85.76395	93.40977	101.0556

**M.T : Membrane formation temperature and C.S : Concentration of sulfuric acid

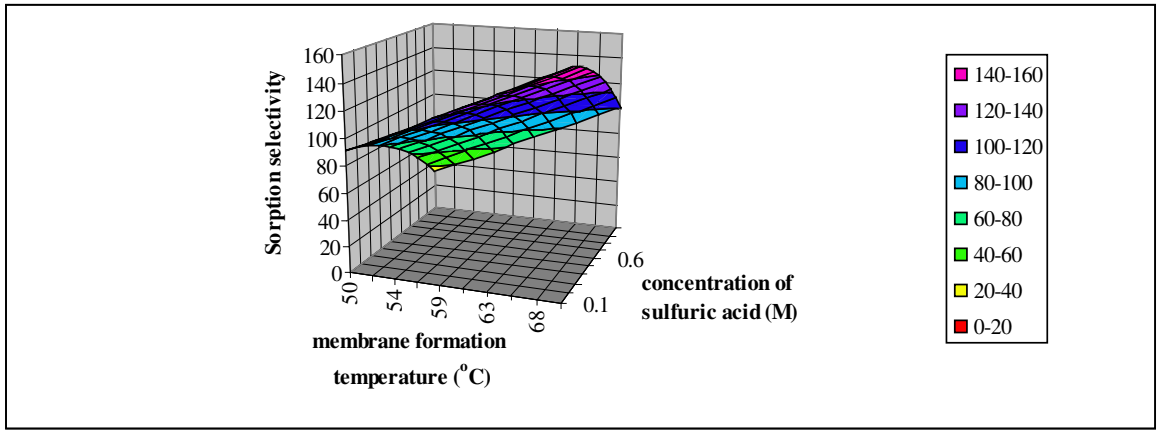


Figure D9 Effect of concentration of sulfuric acid and membrane formation temperature on sorption selectivity.

Table D19a, b and c Computer output from essential linear regression for fitting a model of separation factor

Summary	
|R|	0.883
R^2	0.781
R^2 adjusted	0.739
Standard Error	104.81
# Points	20
PRESS	-
R^2 for Prediction	0.603
Durbin-Watson d	1.734
First Order Autocorrelation	0.113
Collinearity	0.107
Coefficient of Variation	15.635
Precision Index	41.426

(a)

ANOVA						
Source	SS	SS%	MS	F	F Signif	df
Regression	625209	78	208403	18.97	1.61E-05	3
Residual	175761	22	10985.1			16
LOF Error	168943	21 (96)	15358.4	11.2629	0.00757	11
Pure Error	6818.2	1 (4)	1363.6			5
Total	800970	100				19

(b)

		P value	Std Error	-95%	95%	t Stat	VIF
b_0	119.10	0.388	134.23	-165.46	403.66	0.887	
b_1	-398.01	0.00171	105.85	-622.40	-173.62	-3.760	1.000
b_2	-0.09447	0.000404	0.02123	-0.139	-0.04945	-4.449	9.337
b_3	0.299	2.86E-05	0.05188	0.190	0.409	5.773	9.337

(c)

Model

Separation factor = b_0 + b_1×concentration of sulfuric acid + b_2×crosslinking time×crosslinking time + b_3×crosslinking time×membrane formation temperature

Table D20 Effect of crosslinking time and concentration of sulfuric acid on separation factor

C.S \ C.T	29.999	39.99911	49.99922	59.99933	69.99944	79.99956	89.99967	99.99978	109.9999	120
0.099	533.7375	647.3045	741.9778	817.7573	874.6432	912.6353	931.7338	931.9385	913.2495	875.6668
0.199111	493.8922	607.4592	702.1325	777.912	834.7979	872.79	891.8885	892.0932	873.4042	835.8215
0.299222	454.0469	567.6139	662.2871	738.0667	794.9526	832.9447	852.0432	852.2479	833.5589	795.9762
0.399333	414.2016	527.7686	622.4418	698.2214	755.1073	793.0994	812.1978	812.4026	793.7136	756.1309
0.499444	374.3562	487.9232	582.5965	658.3761	715.262	753.2541	772.3525	772.5573	753.8683	716.2856
0.599556	334.5109	448.0779	542.7512	618.5308	675.4167	713.4088	732.5072	732.712	714.023	676.4402
0.699667	294.6656	408.2326	502.9059	578.6855	635.5714	673.5635	692.6619	692.8666	674.1776	636.5949
0.799778	254.8203	368.3873	463.0606	538.8402	595.726	633.7182	652.8166	653.0213	634.3323	596.7496
0.899889	214.975	328.542	423.2153	498.9949	555.8807	593.8729	612.9713	613.176	594.487	556.9043
1	175.1297	288.6967	383.37	459.1496	516.0354	554.0276	573.126	573.3307	554.6417	517.059

** C.T : Crosslinking time and C.S : Concentration of sulfuric acid

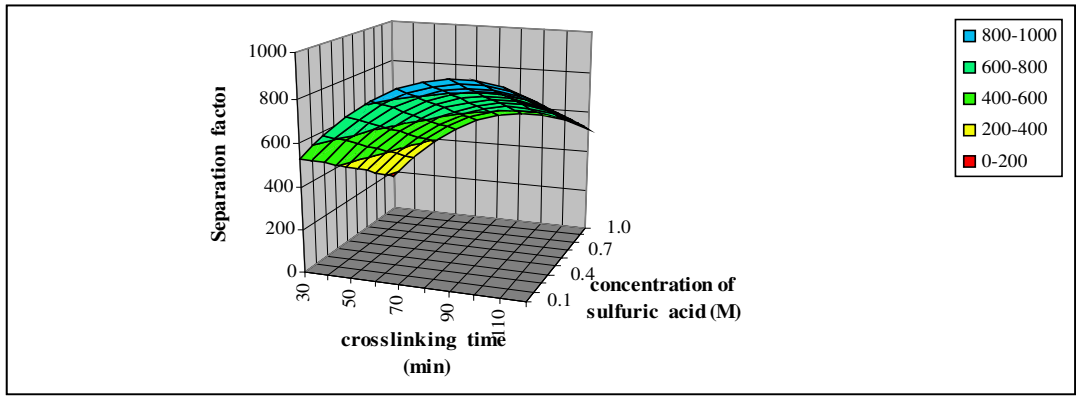


Figure D10 Effect of crosslinking time and concentration of sulfuric acid on separation factor.

Table D21 Effect of crosslinking time and membrane formation temperature on separation factor

M.T / C.T	50	52.22211	54.44422	56.66633	58.88844	61.11056	63.33267	65.55478	67.77689	69.999
29.999	264.4126	284.3766	304.3405	324.3045	344.2685	364.2324	384.1964	404.1603	424.1243	444.0883
39.99911	348.031	374.6499	401.2688	427.8877	454.5066	481.1256	507.7445	534.3634	560.9823	587.6012
49.99922	412.7557	446.0295	479.3034	512.5772	545.8511	579.125	612.3988	645.6727	678.9466	712.2204
59.99933	458.5866	498.5154	538.4442	578.373	618.3019	658.2307	698.1595	738.0883	778.0171	817.9459
69.99944	485.5238	532.1076	578.6914	625.2751	671.8589	718.4427	765.0264	811.6102	858.1939	904.7777
79.99956	493.5674	546.8061	600.0448	653.2835	706.5222	759.7609	812.9996	866.2383	919.4771	972.7158
89.99967	482.7172	542.6108	602.5045	662.3982	722.2918	782.1855	842.0791	901.9728	961.8665	1021.76
99.99978	452.9733	519.5219	586.0705	652.6191	719.1677	785.7163	852.2649	918.8136	985.3622	1051.911
109.9999	404.3357	477.5392	550.7428	623.9463	697.1499	770.3535	843.557	916.7606	989.9641	1063.168
120	336.8043	416.6628	496.5213	576.3799	656.2384	736.0969	815.9554	895.8139	975.6724	1055.531

* * C.T ; Crosslinking time and M.T : Membrane formation temperature

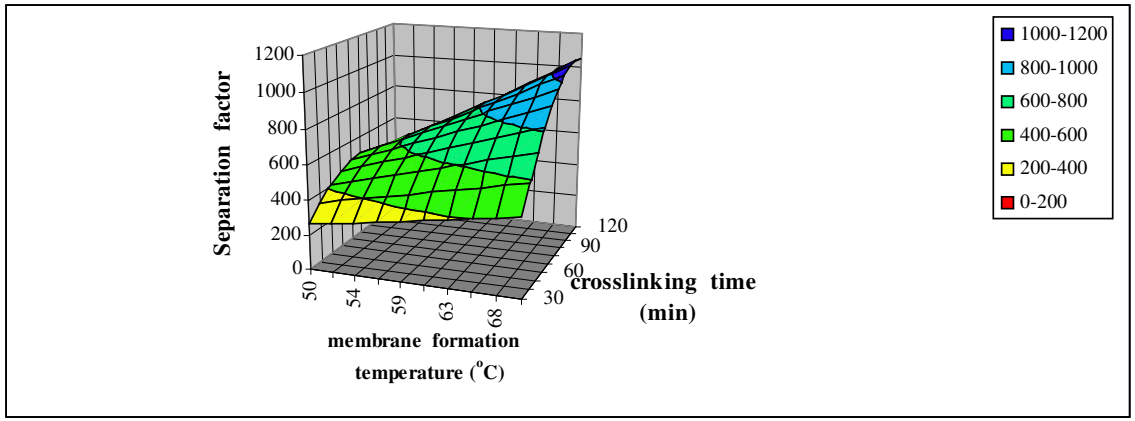


Figure D11 Effect of crosslinking time and membrane formation temperature on separation factor.

Table D22 Effect of concentration of sulfuric acid and membrane formation temperature on separation factor

C.S \ M.T	50	52.22211	54.44422	56.66633	58.88844	61.11056	63.33267	65.55478	67.77689	69.999
0.099	671.3921	721.3049	771.2176	821.1303	871.0431	920.9558	970.8685	1020.781	1070.694	1120.607
0.199111	631.5468	681.4595	731.3723	781.285	831.1977	881.1105	931.0232	980.9359	1030.849	1080.761
0.299222	591.7015	641.6142	691.527	741.4397	791.3524	841.2652	891.1779	941.0906	991.0034	1040.916
0.399333	551.8562	601.7689	651.6817	701.5944	751.5071	801.4199	851.3326	901.2453	951.1581	1001.071
0.499444	512.0109	561.9236	611.8364	661.7491	711.6618	761.5746	811.4873	861.4	911.3128	961.2255
0.599556	472.1656	522.0783	571.991	621.9038	671.8165	721.7293	771.642	821.5547	871.4675	921.3802
0.699667	432.3203	482.233	532.1457	582.0585	631.9712	681.8839	731.7967	781.7094	831.6221	881.5349
0.799778	392.475	442.3877	492.3004	542.2132	592.1259	642.0386	691.9514	741.8641	791.7768	841.6896
0.899889	352.6297	402.5424	452.4551	502.3679	552.2806	602.1933	652.1061	702.0188	751.9315	801.8443
1	312.7844	362.6971	412.6098	462.5226	512.4353	562.348	612.2608	662.1735	712.0862	761.999

**M.T : Membrane formation temperature and C.S : Concentration of sulfuric acid

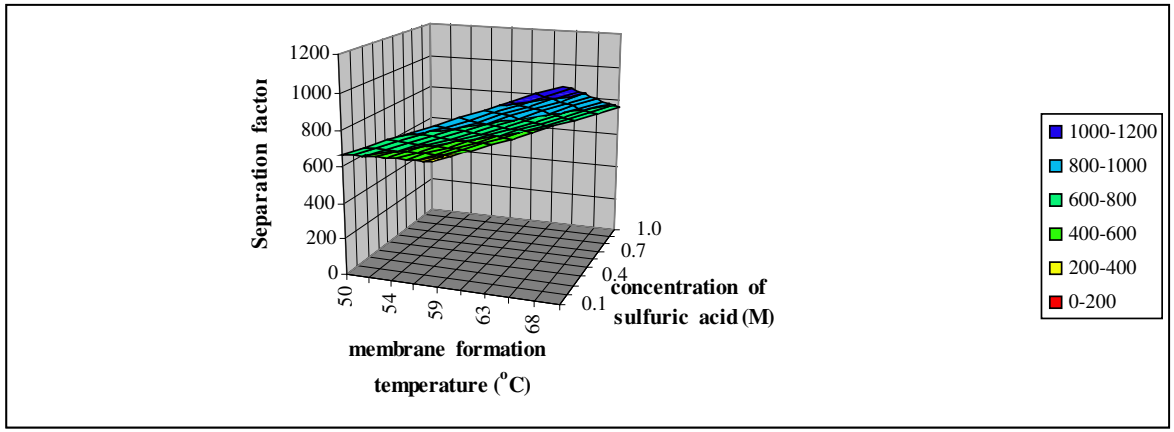


Figure D12 Effect of concentration of sulfuric acid and membrane formation temperature on separation factor.

Table D23a, b and c Computer output from essential linear regression for fitting a model of flux

Summary	
|R|	0.816
R^2	0.666
R^2 adjusted	0.604
Standard Error	29.59
# Points	20
PRESS	25866.51
R^2 for Prediction	0.384
Durbin-Watson d	0.897
First Order Autocorrelation	0.490
Collinearity	0.017
Coefficient of Variation	6.710
Precision Index	14.038

(a)

ANOVA						
Source	SS	SS%	MS	F	F Signif	df
Regression	27955.3	67	9318.4	10.65	0.000431	3
Residual	14005.8	33	875.36			16
LOF Error	11151.0	27 (80)	1013.7	1.7755	0.273	11
Pure Error	2854.8	7 (20)	570.96			5
Total	41961.2	100				19

(b)

		P value	Std Error	-95%	95%	t Stat	VIF
b_0	387.96	2.35E-13	17.71	350.41	425.52	21.90	
b_1	686.54	0.000239	145.95	377.15	995.94	4.704	23.86
b_2	-1.602	0.00628	0.510	-2.683	-0.522	-3.143	2.638
b_3	-7.834	0.00355	2.294	-12.70	-2.970	-3.415	22.22

(c)

Model

Flux = b_0 + b_1×concentration of sulfuric acid + b_2×concentration of sulfuric acid×crosslinking time + b_3×concentration of sulfuric acid×membrane formation temperature

Table D24 Effect of crosslinking time and concentration of sulfuric acid on flux

C.T / C.S	29.99	39.99911	49.99922	59.99933	69.99944	79.99956	89.99967	99.99978	109.9999	120
0.099	404.6406	403.0541	401.4676	399.8812	398.2947	396.7082	395.1217	393.5352	391.9487	390.3622
0.199111	421.5048	418.314	415.1232	411.9324	408.7416	405.5508	402.3601	399.1693	395.9785	392.7877
0.299222	438.3689	433.5739	428.7788	423.9837	419.1886	414.3935	409.5984	404.8034	400.0083	395.2132
0.399333	455.2331	448.8337	442.4343	436.035	429.6356	423.2362	416.8368	410.4374	404.0381	397.6387
0.499444	472.0973	464.0936	456.0899	448.0862	440.0826	432.0789	424.0752	416.0715	408.0678	400.0642
0.599556	488.9614	479.3535	469.7455	460.1375	450.5295	440.9216	431.3136	421.7056	412.0976	402.4897
0.699667	505.8256	494.6133	483.401	472.1888	460.9765	449.7642	438.552	427.3397	416.1274	404.9151
0.799778	522.6898	509.8732	497.0566	484.24	471.4235	458.6069	445.7903	432.9738	420.1572	407.3406
0.899889	539.5539	525.133	510.7122	496.2913	481.8705	467.4496	453.0287	438.6079	424.187	409.7661
1	556.4181	540.3929	524.3677	508.3426	492.3174	476.2923	460.2671	444.2419	428.2168	412.1916

** C.T : Crosslinking time and C.S : Concentration of sulfuric acid

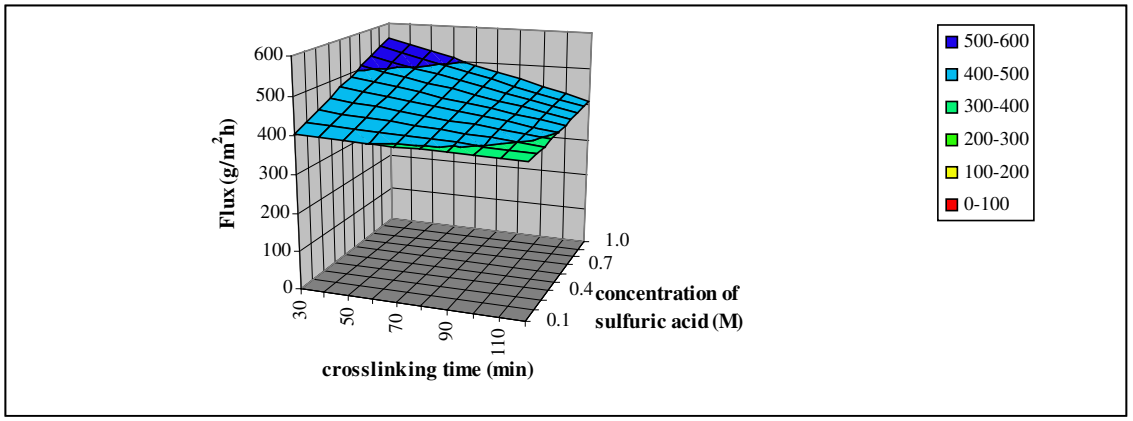


Figure D13 Effect of crosslinking time and concentration of sulfuric acid on flux.

Table D25 Effect of crosslinking time and membrane formation temperature on flux

M.T / C.T	50	52.22211	54.44422	56.66633	58.88844	61.11056	63.33267	65.55478	67.77689	69.999
29.999	523.6859	514.1128	504.5398	494.9667	485.3936	475.8206	466.2475	456.6744	447.1013	437.5283
39.99911	514.8729	505.2998	495.7267	486.1537	476.5806	467.0075	457.4344	447.8614	438.2883	428.7152
49.99922	506.0598	496.4868	486.9137	477.3406	467.7676	458.1945	448.6214	439.0483	429.4753	419.9022
59.99933	497.2468	487.6737	478.1007	468.5276	458.9545	449.3814	439.8084	430.2353	420.6622	411.0892
69.99944	488.4338	478.8607	469.2876	459.7145	450.1415	440.5684	430.9953	421.4223	411.8492	402.2761
79.99956	479.6207	470.0477	460.4746	450.9015	441.3284	431.7554	422.1823	412.6092	403.0362	393.4631
89.99967	470.8077	461.2346	451.6615	442.0885	432.5154	422.9423	413.3693	403.7962	394.2231	384.65
99.99978	461.9947	452.4216	442.8485	433.2754	423.7024	414.1293	404.5562	394.9831	385.4101	375.837
109.9999	453.1816	443.6085	434.0355	424.4624	414.8893	405.3163	395.7432	386.1701	376.597	367.024
120	444.3686	434.7955	425.2224	415.6494	406.0763	396.5032	386.9301	377.3571	367.784	358.2109

* * C.T ; Crosslinking time and M.T : Membrane formation temperature

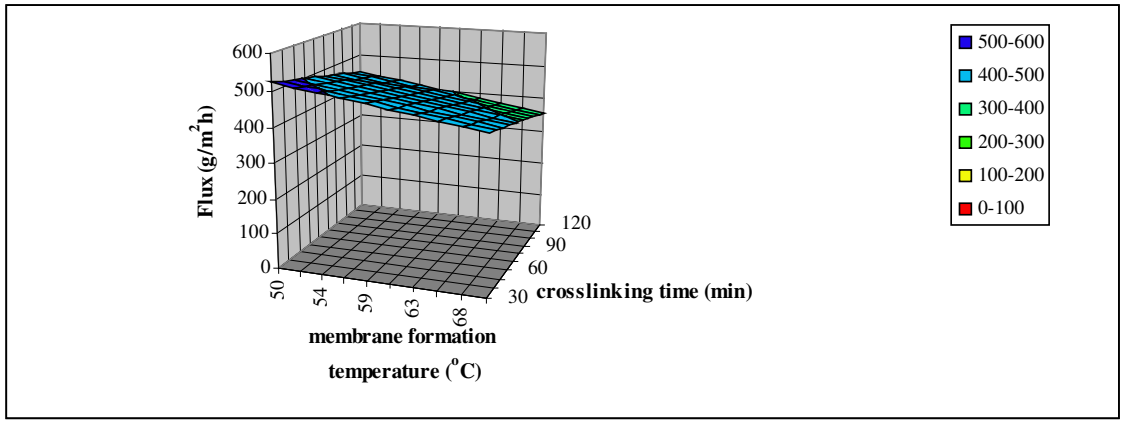


Figure D14 Effect of crosslinking time and membrane formation temperature on flux.

Table D26 Effect of concentration of sulfuric acid and membrane formation temperature on flux

M.T / C.S	50	52.22211	54.44422	56.66633	58.88844	61.11056	63.33267	65.55478	67.77689	69.999
0.099	405.2563	403.533	401.8097	400.0864	398.3631	396.6398	394.9164	393.1931	391.4698	389.7465
0.199111	422.743	419.2771	415.8111	412.3452	408.8792	405.4132	401.9473	398.4813	395.0154	391.5494
0.299222	440.2298	435.0212	429.8126	424.604	419.3953	414.1867	408.9781	403.7695	398.5609	393.3523
0.399333	457.7165	450.7653	443.814	436.8628	429.9115	422.9602	416.009	409.0577	402.1064	395.1552
0.499444	475.2033	466.5094	457.8155	449.1215	440.4276	431.7337	423.0398	414.3459	405.652	396.9581
0.599556	492.69	482.2535	471.8169	461.3803	450.9438	440.5072	430.0706	419.6341	409.1975	398.761
0.699667	510.1768	497.9976	485.8183	473.6391	461.4599	449.2807	437.1015	424.9223	412.7431	400.5638
0.799778	527.6635	513.7417	499.8198	485.8979	471.9761	458.0542	444.1323	430.2105	416.2886	402.3667
0.899889	545.1503	529.4858	513.8212	498.1567	482.4922	466.8277	451.1632	435.4987	419.8341	404.1696
1	562.637	545.2299	527.8227	510.4155	493.0083	475.6012	458.194	440.7868	423.3797	405.9725

**M.T : Membrane formation temperature and C.S : Concentration of sulfuric acid

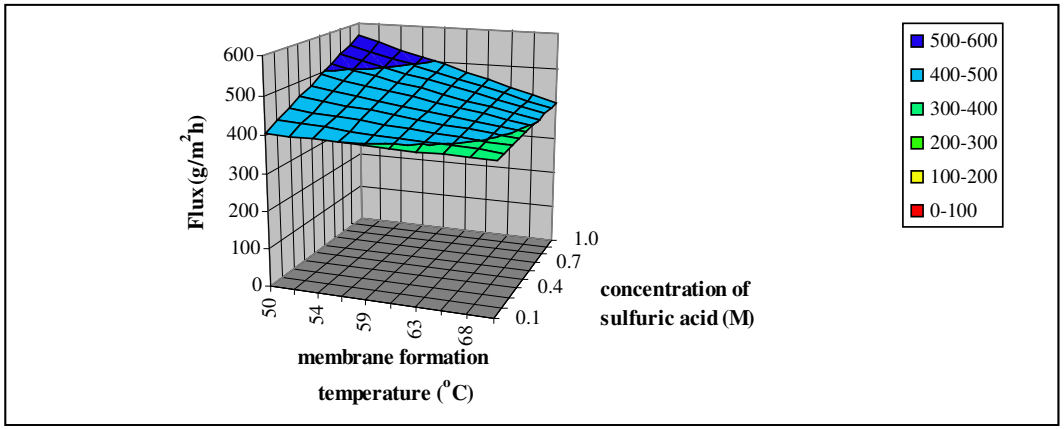


Figure D15 Effect of concentration of sulfuric acid and membrane formation temperature on flux.

Table D27 a, b and c Computer output from essential linear regression for fitting a model of separation factor

Summary	
|R|	0.993
R^2	0.986
R^2 adjusted	0.981
Standard Error	89.76
# Points	13
PRESS	275514.59
R^2 for Prediction	0.946
Durbin-Watson d	1.678
First Order Autocorrelation	0.155
Collinearity	0.001
Coefficient of Variation	15.021
Precision Index	211.427

(a)

ANOVA						
Source	SS	SS%	MS	F	F Signif	df
Regression	5005928.092	99	1668643	207.09	1.28E-08	3
Residual	72518.3	1	8057.6			9
LOF Error	71200.4	1 (98)	14240.1	43.2202	0.00142	5
Pure Error	1317.9	0 (2)	329.48			4
Total	5078446.431	100				12

(b)

		P value	Std Error	-95%	95%	t Stat	VIF
b_0	32942.9	1.36E-06	2935.4	26302.6	39583.3	11.22	
b_1	-857.05	7.74E-07	71.47	-1018.7	-695.38	-11.99	396.07
b_2	5.705	3.4E-07	0.432	4.728	6.683	13.20	395.24
b_3	-0.150	0.02160	0.05424	-0.273	-0.02778	-2.774	1.821

(c)

Model

Separation factor = $b_0 + b_1 \times$feed concentration + $b_2 \times$feed concentration$\times$feed concentration + $b_3 \times$feed concentration$\times$feed temperature

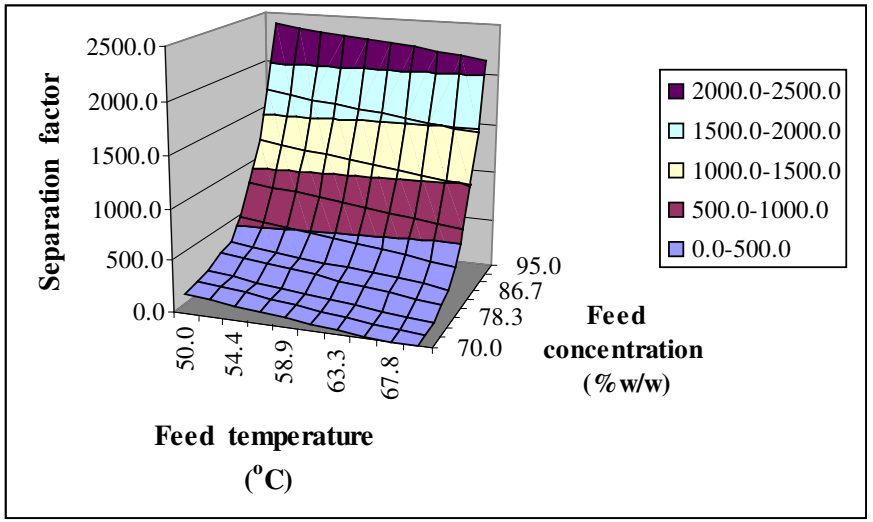


Figure D16 Effect of feed concentration and feed temperature on separation factor.

Table D28 a, b and c Computer output from essential linear regression for fitting a model of flux

Summary	
|R|	0.985
R^2	0.970
R^2 adjusted	0.964
Standard Error	17.58
# Points	13
PRESS	6178.64
R^2 for Prediction	0.940
Durbin-Watson d	1.331
First Order Autocorrelation	0.205
Collinearity	1.000
Coefficient of Variation	3.463
Precision Index	156.335

(a)

ANOVA						
Source	*SS*	*SS%*	*MS*	*F*	*F Signif*	*df*
Regression	99915.3	97	49957.7	161.71	2.43E-08	2
Residual	3089.4	3	308.94			10
LOF Error	3022.6	3 (98)	503.76	30.1650	0.00273	6
Pure Error	66.80	0 (2)	16.70			4
Total	103005	100				12

(b)

		P value	Std Error	-95%	95%	t Stat	VIF
b_0	1407.0	8.47E-10	63.98	1264.5	1549.6	21.99	
b_1	-12.28	8.04E-09	0.703	-13.85	-10.71	-17.47	1.000
b_2	0.03134	0.00160	0.00731	0.01504	0.04763	4.285	1.000

(c)

Model

Flux = $b_0 + b_1 \times$feed concentration + $b_2 \times$feed temperature$\times$feed temperature

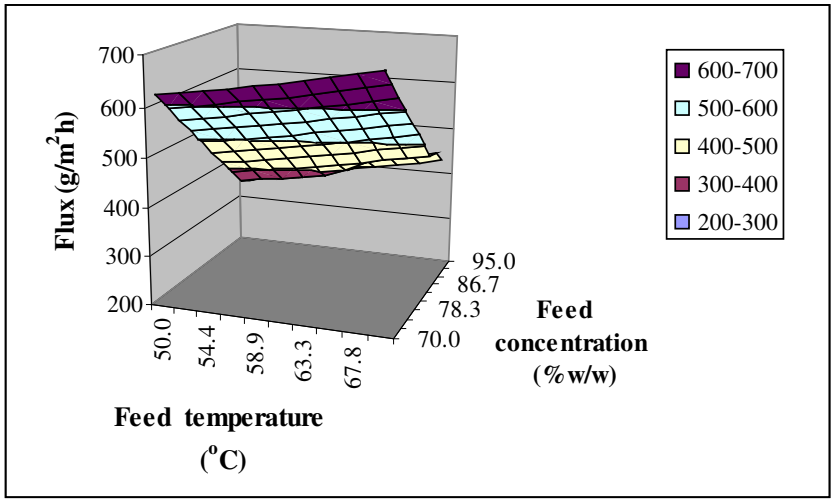


Figure D17 Effect of feed concentration and feed temperature on flux.