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APPENDICES

Appendix A Extraction of chitin and chitosan from black tiger shrimp

Table A-1 Exaction chitin from black tiger shrimp

Times	Black tiger shrimp (g)	Chitin (g)	% Chitin
1	20.00	5.26	26.30
2	20.00	5.41	27.05
3	35.00	13.70	38.91
4	39.10	11.06	28.27
5	60.00	16.32	27.19
6	50.00	14.06	28.12
7	50.00	14.08	28.16
8	50.00	14.80	29.60
9	50.00	14.71	29.42
10	50.00	14.13	28.26
11	50.00	13.55	27.10
12	45.00	12.37	27.49
13	45.00	12.25	27.22
14	50.00	12.50	25.00
15	50.00	12.85	25.70
16	50.00	13.01	26.02
17	50.00	12.53	25.06
18	50.00	12.55	25.10
19	50.00	12.21	24.42
Total	864.10	237.35	
Average		12.49 ± 2.87	27.60 ± 3.04

Table A-2 Extraction chitosan from chitin

Times	Chitin (g)	Chitosan (g)	% Chitosan
1	20.00	15.96	79.80
2	10.10	7.42	73.47
3	12.36	9.67	78.24
4	35.00	30.40	86.86
5	35.00	31.17	89.06
6	45.00	36.81	81.80
7	45.00	36.82	81.82
Total	202.46	168.25	
Average			81.58 ± 4.84

Appendix B Resin and acitivated carbon adsorbents

Table B-1 Solubility effect of chitin, chitosan, crosslinking chitosan with GLA, blended chitosan/PVA resins and activated carbon

Solubility effect	Resins				
	Chitin	Chitosan	Crosslinking chitosan with GLA	Blended chitosan/PVA	Activated carbon
0.1% acetic acid	Insoluble	**Soluble**	Insoluble	**Soluble**	Insoluble
0.1 % HCl	Insoluble	**Soluble**	Insoluble	**Soluble**	Insoluble
DI water	Insoluble	Insoluble	Insoluble	Insoluble	Insoluble
0.1 % NaOH	Insoluble	Insoluble	Insoluble	Insoluble	Insoluble
Buffer pH3	Insoluble	Insoluble	Insoluble	Insoluble	Insoluble
Buffer pH5	Insoluble	Insoluble	Insoluble	Insoluble	Insoluble
Buffer pH7	Insoluble	Insoluble	Insoluble	Insoluble	Insoluble
Buffer pH9	Insoluble	Insoluble	Insoluble	Insoluble	Insoluble

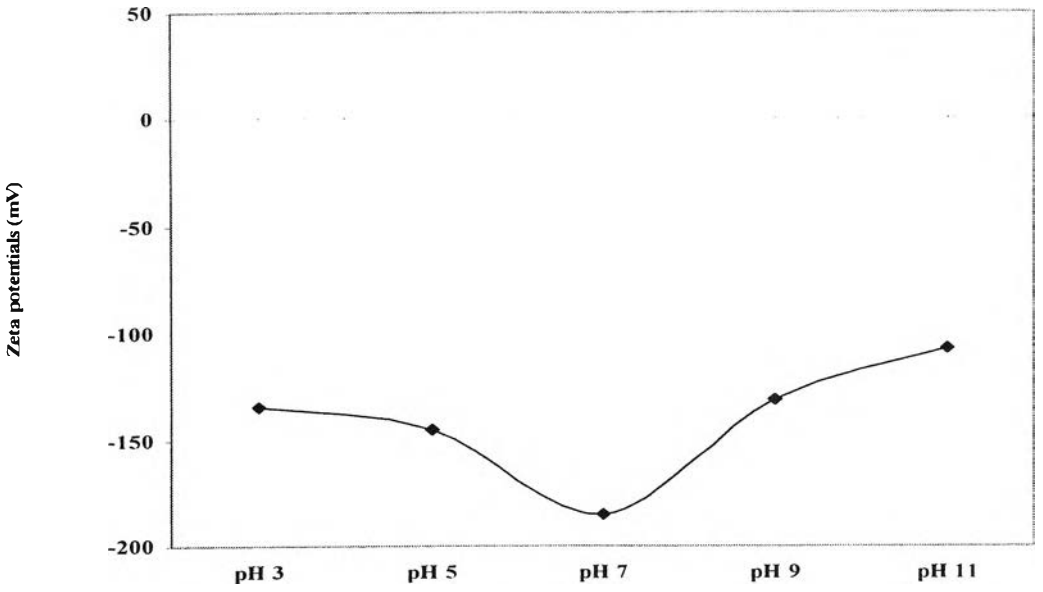

Figure B-1 Variation of Zeta potentials on pH of cutting fluids emulsion

Table B-2 Absorbent of cutting fluid

Concentration (% w/v)	Abs
0.000	0.000
0.025	0.012
0.050	0.029
0.100	0.054
0.200	0.106
0.500	0.262
1.000	0.515
2.000	0.938
3.000	1.313

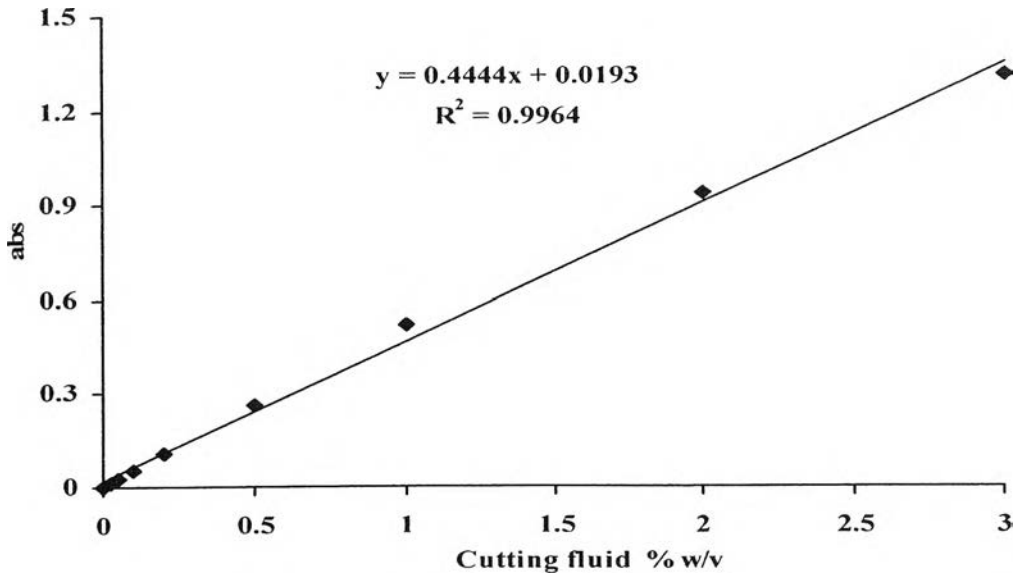

Figure B-2 Standard curve of cutting fluids

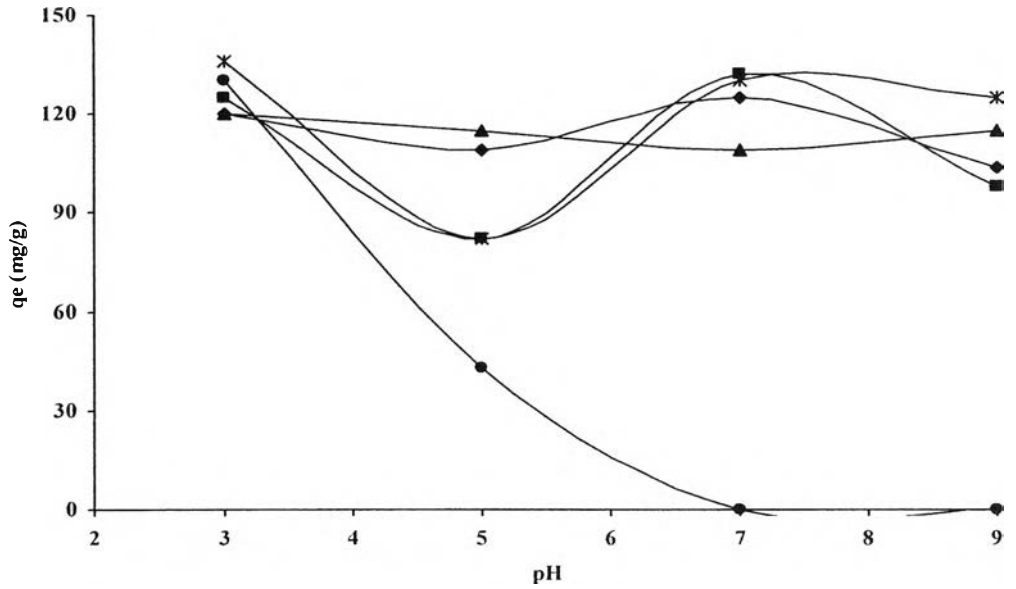

Figure B-3 Adsorption capacity cutting fluid of adsorbents at 250 rpm with swing shaker and cutting fluids concentration 0.5 % w/v of ♦ Chitin, ■ Chitosan, ▲ Crosslinking chitosan with GLA, ● Blended chitosan/PVA and × activated carbon

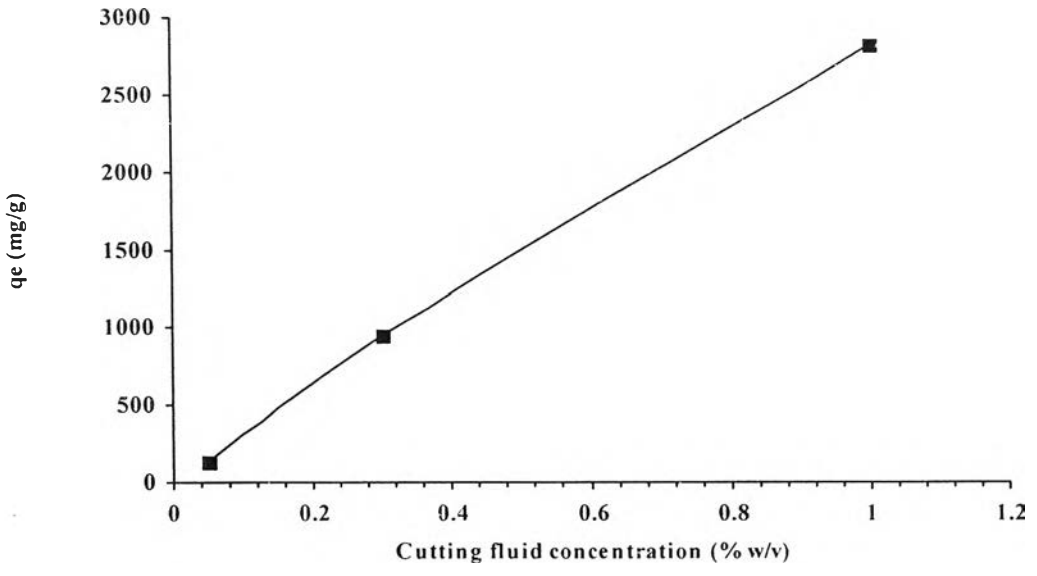

Figure B-4 Adsorption capacity of cutting fluids by blended chitosan/PVA at pH 3

Appendix C Chitin, chitosan, Crosslinking chitosan with GLA and blended chitosan/PVA

Table C-1 Solubility of bead adsorbents in acid, base and deionized water

Solubility	0.1 %Acetic acid	0.1 % HCl	Deionized water	0.1 % NaOH
Chitin	Insoluble	Insoluble	Insoluble	Insoluble
Chitosan	**Soluble**	**Soluble**	Insoluble	Insoluble
Crosslinking chitosan with GLA	Insoluble	Insoluble	Insoluble	Insoluble
Blended chitosan/PVA	**Soluble**	**Soluble**	Insoluble	Insoluble

Table C-2 Size of adsorbents

Adsorbents	Size (mm)
Chitin	0.64
Chitosan	1.92
Crosslinking chitosan with GLA	2.18
Blended chitosan/PVA	1.70

Table C-3 Swelling of bead adsorbents

Adsorbents	Swelling (percent)
Chitin	3.35
Chitosan	14.83
Crosslinking chitosan with GLA	4.02
Blended chitosan/PVA	9.12

Table C-4 Moisture of bead adsorbents

Adsorbents	Moisture (percent)
Chitin	57.10 ± 1.42
Chitosan	95.86 ± 2.39
Crosslinking chitosan with GLA	93.79 ± 2.16
Blended chitosan/PVA	98.19 ± 0.76

Table C-6 Viscosity of chitosan solution

Times	Chitosan solution (% w/v) (cP)			
	1.2 % w/v	1.7 % w/v	2.0 % w/v	2.2 % w/v ($x10^3$)
1	476	925	2571	356
2	499	1028	2577	367
3	479	943	2588	368
4	479	942	2554	370
5	479	1045	2573	377
6	479	945	2576	379
7	497	935	2541	391
8	485	966	2573	398
9	493	943	2564	399
10	477	957	2577	398
Average	486.1	962.9	2571.4	380.3

Table C-7 Adsorption capacity (mg/g) of cutting fluids by chitosan and blended chitosan/PVA at cutting fluids concentration 0.1 % w/v and pH 3 of motor stirrer

Time	chitosan				Blended chitosan/PVA			
(min)	600 rpm	1200 rpm	2000 rpm	Blender	600 rpm	1200 rpm	2000 rpm	Blender
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	22.52	25.90	26.46	20.83	5.63	21.96	21.96	18.02
20	20.83	27.59	25.90	21.40	6.19	21.96	21.96	19.71
30	22.52	27.03	26.46	19.71	6.19	21.96	21.96	20.83
60	22.52	25.34	28.15	21.40	7.32	21.96	21.96	21.96
90	23.09	27.03	27.59	23.09	7.88	21.96	21.96	21.96
180	23.09	28.15	26.46	27.03	6.76	21.96	21.96	21.96
360	22.52	28.15	28.15	28.72	8.45	21.96	21.96	21.96
720	22.52	28.15	28.15	28.15	19.71	21.96	21.96	21.96
1440	21.96	28.15	28.15	28.15	21.96	21.96	21.96	21.96
2880	21.96	28.15	28.15	28.15	33.78	21.96	21.96	21.96

Table C-8 Adsorption capacity (mg/g) of cutting fluids effect of chitosan concentration 1.2 – 2.2 % w/v

Time (min)	Chitosan concentration 1.2 % (w/v)				Chitosan concentration 1.7 % (w/v)				Chitosan concentration 2.0 % (w/v)				Chitosan concentration 2.2 % (w/v)			
	Cutting fluids concentration % (w/v)				Cutting fluids concentration % (w/v)				Cutting fluids concentration % (w/v)				Cutting fluids concentration % (w/v)			
	0.10%	0.50%	1.00%	3.00%	0.10%	0.50%	1.00%	3.00%	0.10%	0.50%	1.00%	3.00%	0.10%	0.50%	1.00%	3.00%
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	10.14	3.94	50.11	73.20	6.19	18.02	101.91	26.46	7.88	1.13	80.52	28.72	9.01	12.39	73.20	19.71
30	10.14	4.50	53.49	73.20	9.01	24.77	105.29	29.28	7.88	2.25	119.37	33.78	9.01	8.45	78.27	21.96
45	10.14	5.07	60.25	76.58	9.57	25.90	109.23	29.84	8.45	2.25	125.00	34.35	10.14	11.82	83.33	19.71
60	10.70	5.07	65.32	79.95	10.14	29.28	109.80	28.72	9.57	3.38	126.69	39.41	11.26	16.89	86.15	16.33
90	10.70	7.32	73.20	79.95	10.70	30.97	116.55	28.72	9.57	2.82	129.50	33.78	11.26	19.14	91.22	23.65
120	10.70	10.70	76.01	77.70	11.82	32.66	118.24	28.15	9.57	3.38	136.26	39.41	11.82	21.40	95.72	29.28
180	14.08	20.27	82.77	75.45	12.39	34.91	121.06	28.15	10.14	10.14	133.45	36.60	11.82	21.40	101.35	29.84
240	17.45	40.54	88.96	72.64	13.51	43.36	124.44	27.59	10.14	10.70	135.14	31.53	11.82	27.03	104.17	29.28
300	18.02	46.73	93.47	73.20	13.51	46.73	125.00	27.03	10.14	28.15	136.26	30.41	12.39	30.97	108.11	30.41
360	18.58	51.80	95.72	72.64	14.64	51.80	125.00	28.15	14.08	31.53	137.39	27.03	14.64	33.22	110.36	29.84

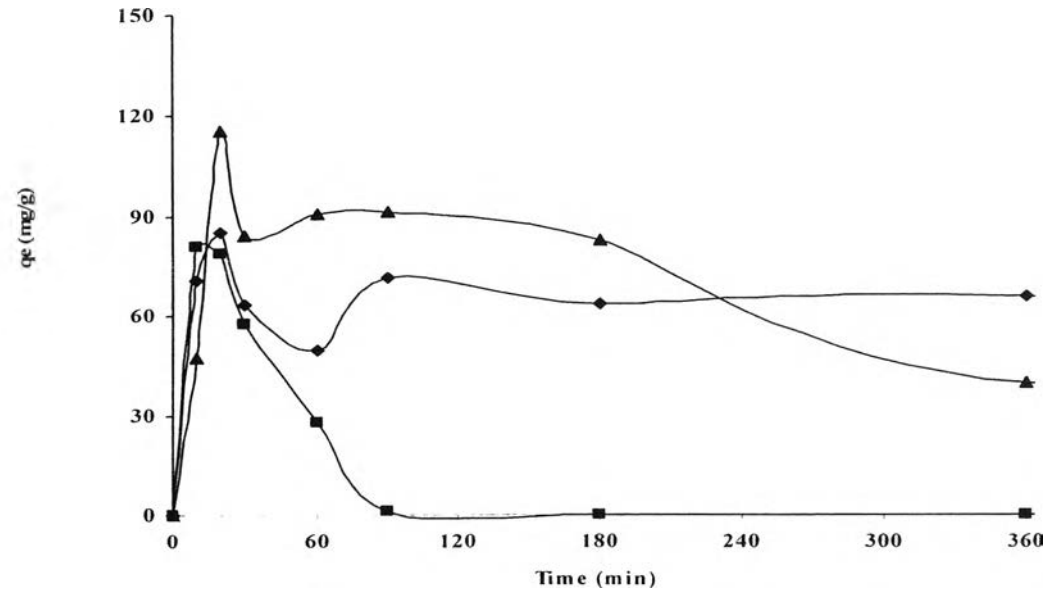

Figure C-1 Adsorption capacity of cutting fluids at concentration 0.1 % w/v and pH of ♦ chitosan, ■ crosslinking chitosan with GLA and ▲ blended chitosan PVA

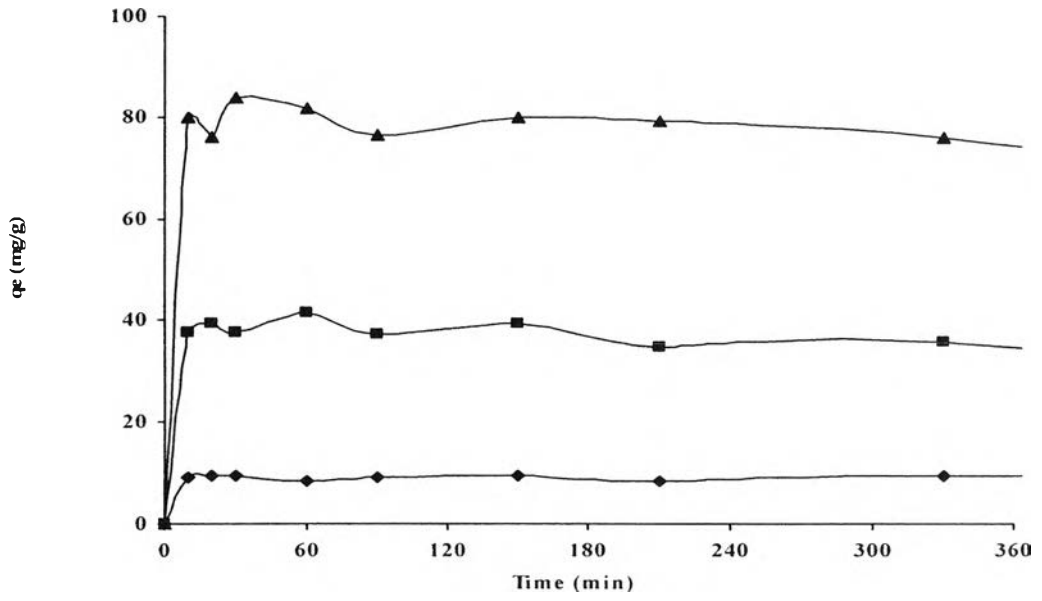

Figure C-2 Adsorption capacity of cutting fluids by chitin at pH 3 and cutting fluid concentration ♦ 0.05 % w/v, ■ 0.30 % w/v and ▲ 1.00 % w/v

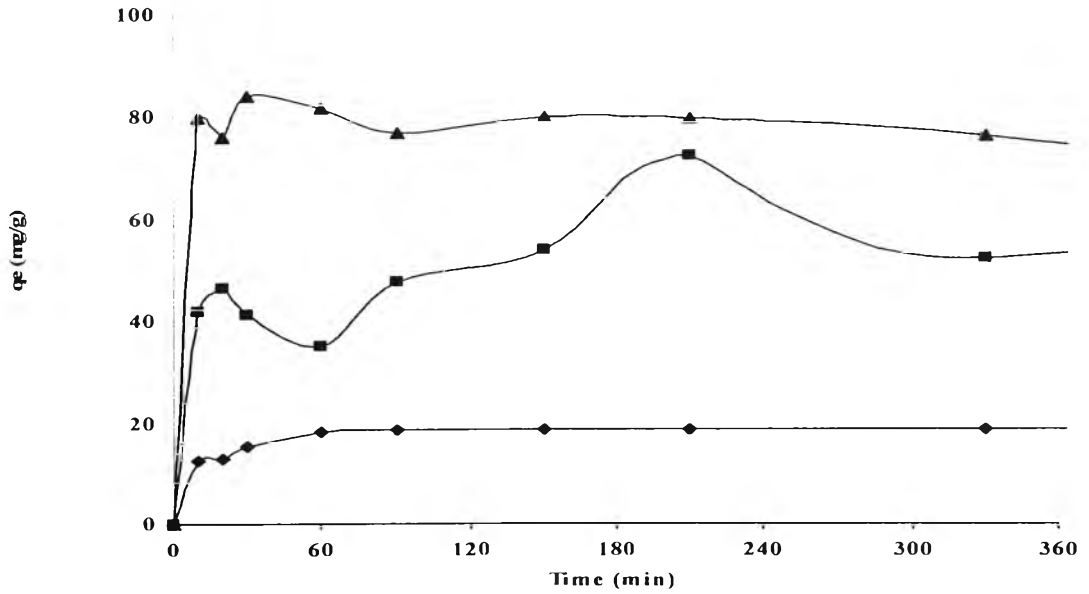

Figure C-3 Adsorption capacity of cutting fluids by chitosan at pH 3 and cutting fluids concentration ♦ 0.10 % w/v, ■ 0.60 % w/v and ▲ 1.00 % w/v

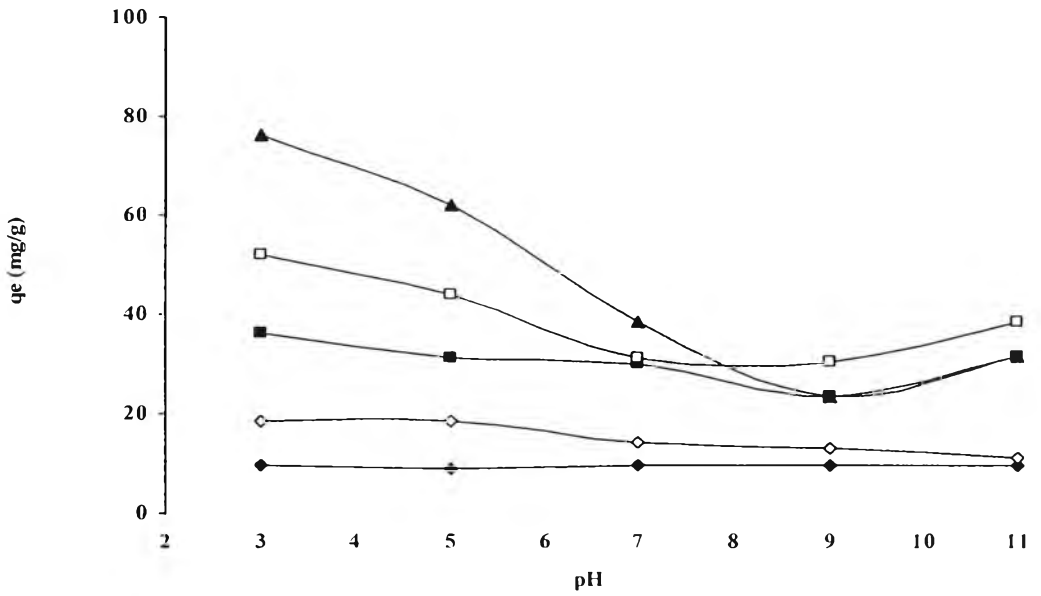

Figure C-4 Adsorption capacity of cutting fluids by chitin at cutting fluids concentration ♦ 0.10 % w/v, ■ 0.60 % w/v and ▲ 1.00 % w/v;

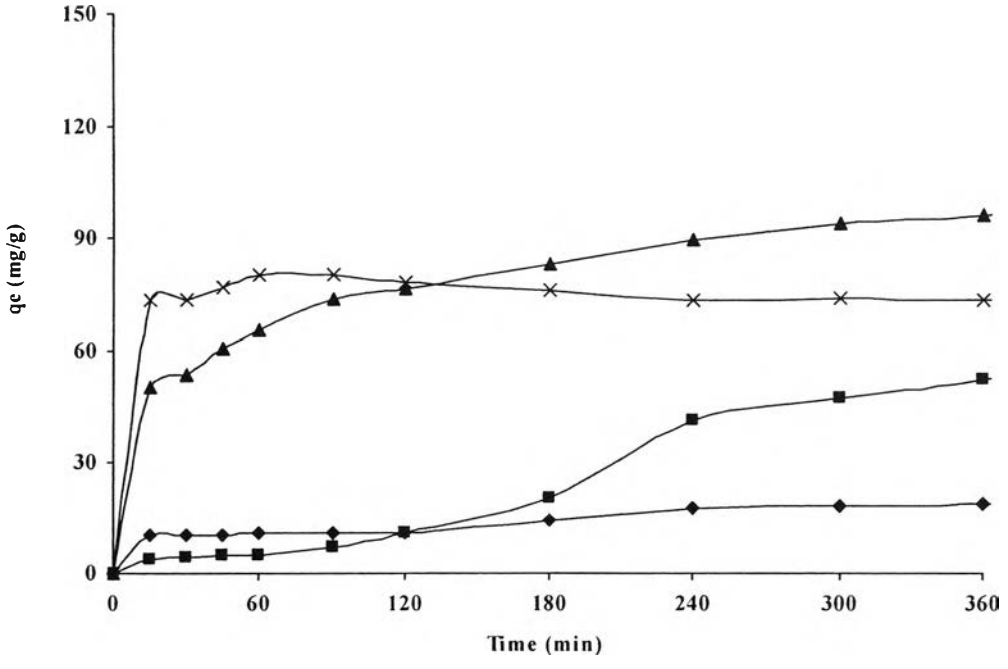

Figure C-5 Adsorption capacity of cutting fluids of chitosan concentration 1.20 % w/v, pH 3 at cutting fluids concentration ♦ 0.10 % w/v, ■ 0.50 % w/v, ▲ 1.00 % w/v and × 3.00 % w/v

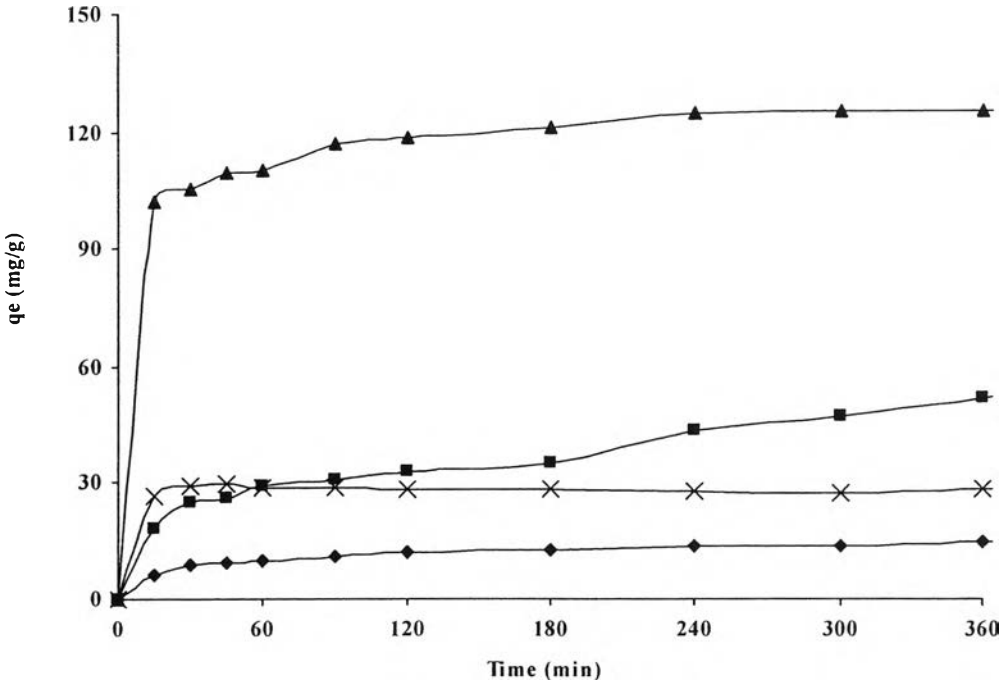

Figure C-6 Adsorption capacity of cutting fluids of chitosan concentration 1.70 % w/v, pH 3 At cutting fluids concentration ♦ 0.10 % w/v, ■ 0.50 % w/v, ▲ 1.00 % w/v and × 3.00 % w/v

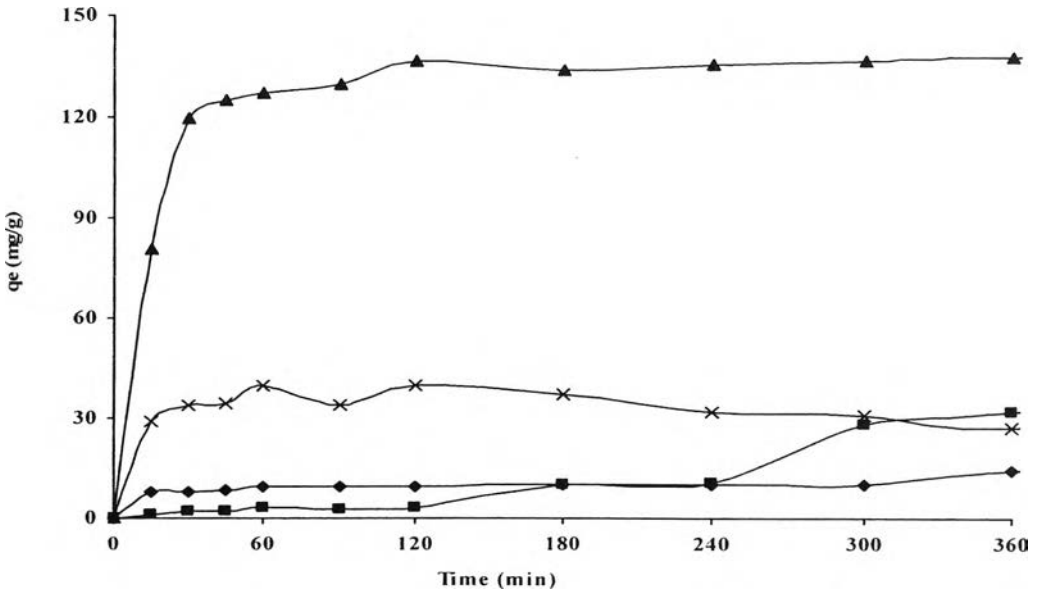

Figure C-7 Adsorption capacity of cutting fluids of chitosan concentration 2.00 % w/v, pH 3 At cutting fluids concentration ♦ 0.10 % w/v, ■ 0.50 % w/v, ▲ 1.00 % w/v and × 3.00 % w/v

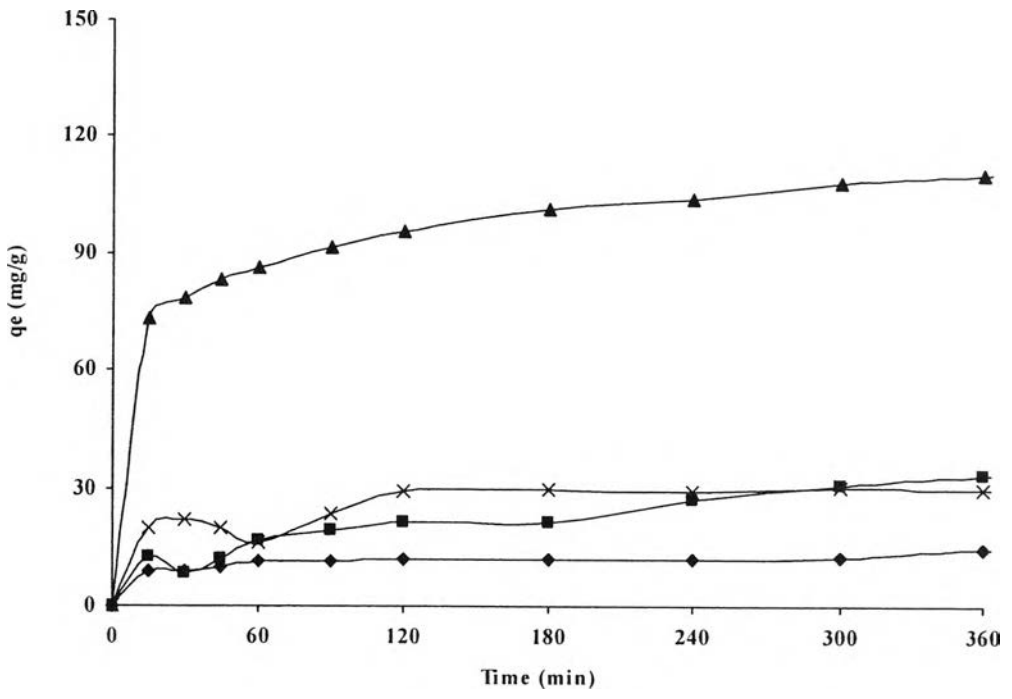

Figure C-8 Adsorption capacity of cutting fluids of chitosan concentration 2.20 % w/v, pH 3 at cutting fluids concentration ♦ 0.10 % w/v, ■ 0.50 % w/v, ▲ 1.0 % w/v and × 3.00 % w/v

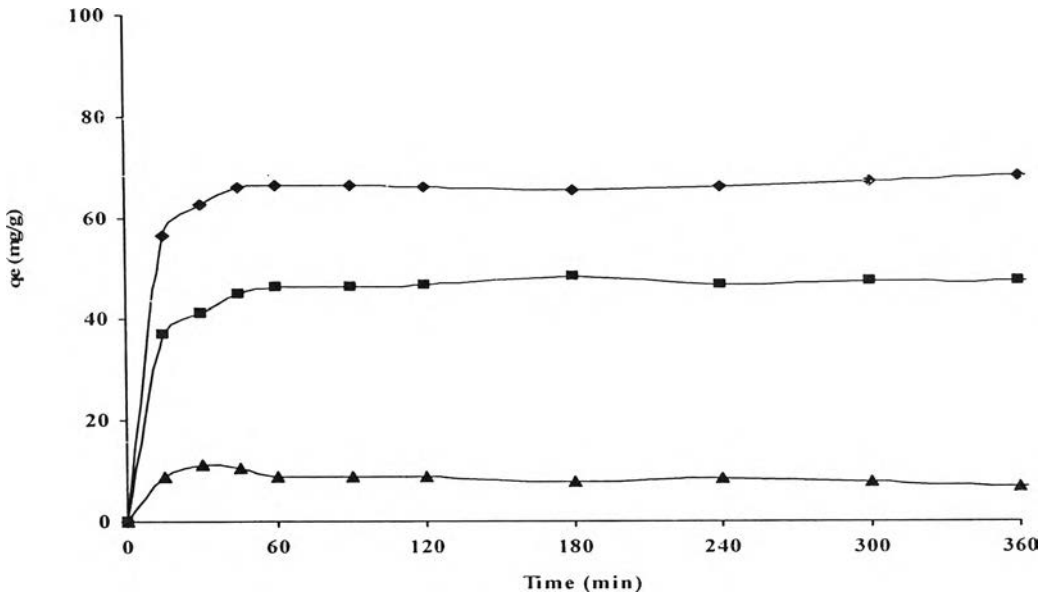

Figure C-9 Comparing adsorption capacity of cutting fluids concentration 1.00 % w/v ♦ blended chitosan/PVA 1:1, ■ blended chitosan/PVA 1:2 and ▲ blended chitosan/PVA 1:3

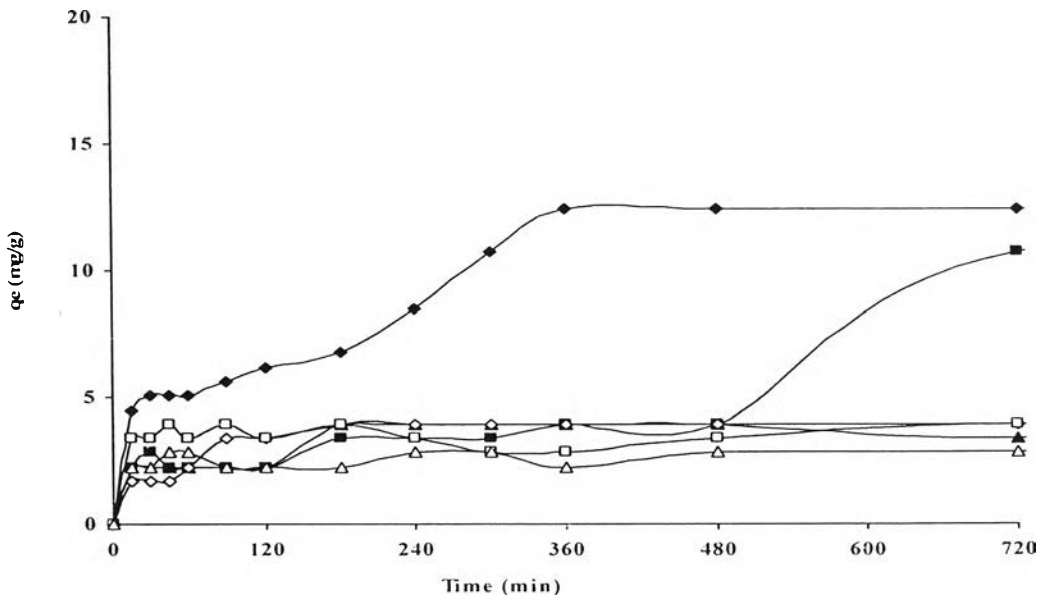

Figure C-10 Adsorption capacity of cutting fluids concentration 0.10 % w/v by variation crosslinking chitosan with GLA ♦ 0.1 %, ■ 0.5 %, ▲ 1.0 %, ◊ 1.5 %, □ 2.0 % and Δ 2.5 % v/v

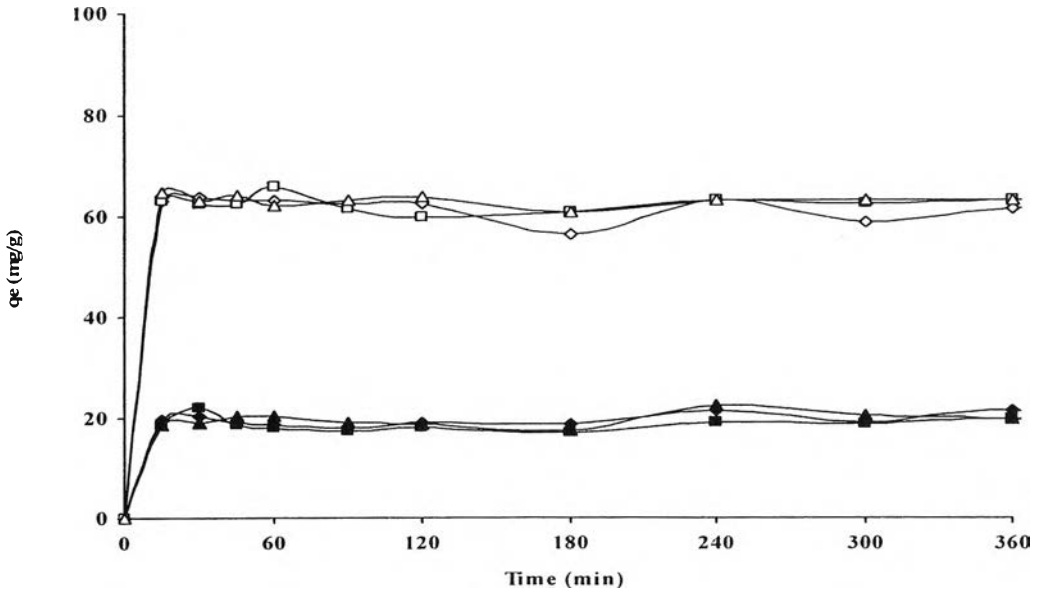

Figure C-11 Adsorption capacity of cutting fluids concentration 0.10 % w/v by blended crosslinking chitosan/PVA with GLA ratio ♦ 1:1, ■ 1:2 and ▲1:3; and cutting fluids concentration 0.50 % w/v by blended crosslinking chitosan/PVA with GLA ratio ◊1:1, □ 1:2 and Δ1:3

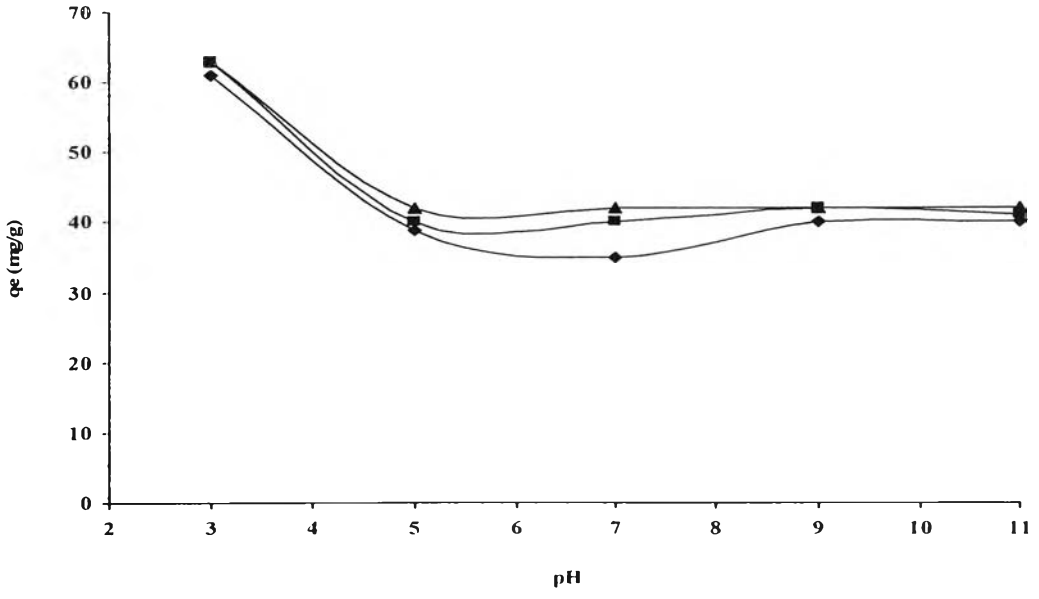

Figure C-12 Adsorption capacity of variation pH cutting fluids concentration 0.50 % w/v by ♦ crosslinking chitosan with GLA, ■ blended crosslinking chitosan/PVA with GLA 1:1 and ▲ blended crosslinking chitosan/PVA with GLA 1:2

Appendix D Physical properties of bead adsorbents from batch mode

Table D-1 Solubility of bead adsorbents

Solubility	0.1 % Acetic acid	0.1 % HCl	0.1 % NaOH	Deionized water
Chitosan	**Soluble**	**Soluble**	Insoluble	Insoluble
Blended chitosan/PVA 1:1	**Soluble**	**Soluble**	Insoluble	Insoluble
Blended chitosan/PVA 1:2	**Soluble**	**Soluble**	Insoluble	Insoluble
Benzoyl chitosan	Insoluble	Insoluble	Insoluble	Insoluble
Quateraminated chitosan	Insoluble	Insoluble	Insoluble	Insoluble
CH-SDS	Insoluble	Insoluble	Insoluble	Insoluble
CH-C-Tab	**Soluble**	**Soluble**	Insoluble	Insoluble
CH-Tween 80	**Soluble**	**Soluble**	Insoluble	Insoluble
BCH-SDS	Insoluble	Insoluble	Insoluble	Insoluble
BCH-C-Tab	**Soluble**	**Soluble**	Insoluble	Insoluble
BCH-Tween 80	**Soluble**	**Soluble**	Insoluble	Insoluble

Table D-2 Size of bead adsorbents

Adsorbents	Size (mm)
Chitosan	3.1
Blended chitosan/PVA 1:1	2.5
Blended chitosan/PVA 1:2	2.7
Benzoyl chitosan	2.4
Quateraminated chitosan	3.5
CH-SDS	-
CH-C-Tab	2.3
CH-Tween 80	3.1
BCH-SDS	-
BCH-C-Tab	2.0
BCH-Tween 80	2.0

Table D-3 Swelling of bead adsorbents

Adsorbents	Swelling (percent)
Chitosan	28.33
Blended chitosan/PVA 1:1	29.38
Blended chitosan/PVA 1:2	27.13
Benzoyl chitosan	25.06
Quateraminated chitosan	27.47
CH-SDS	24.52
CH-C-Tab	19.77
CH-Tween 80	6.77
BCH-SDS	30.58
BCH-C-Tab	15.80
BCH-Tween 80	2.08

Table D-4 Moisture content of bead adsorbents

Adsorbents	Moisture content (percent)
Chitosan	95.86
Blended chitosan/PVA 1:1	98.19
Blended chitosan/PVA 1:2	96.21
Benzoyl chitosan	93.22
Quateraminated chitosan	94.89
CH-SDS	72.28
CH-C-Tab	94.84
CH-Tween 80	96.09
CH-SDS	69.62
CH-C-Tab	95.49
CH-Tween 80	95.65

Table D-5 Pore diameter and surface area of bead adsorbents

Adsorbents	Pore diameter (nm)	Surface area (m^2/g)
Chitosan	6.12	1.67
Blended chitosan/PVA 1:1	6.68	1.87
Blended chitosan/PVA 1:2	17.10	2.10
Benzoyl chitosan	53.01	1.94
Quateraminated chitosan	50.28	1.96
CH-SDS	1.49	0.67
CH-C-Tab	8.25	0.13
CH-Tween 80	0.03	56.61
BCH-SDS	1.81	0.99
BCH-C-Tab	2.06	20.85
BCH-Tween 80	2.10	3.59

Table D-6 Contact angle of bead adsorbents

Adsorbents	Contact angle (^{o})
Chitosan	24.99
Blended chitosan/PVA 1:1	19.71
Blended chitosan/PVA 1:2	24.98
Benzoyl chitosan	7.66
Quateraminated chitosan	23.93
CH-SDS	12.88
CH-C-Tab	23.68
CH-Tween 80	22.26
BCH-SDS	13.51
BCH-C-Tab	30.41
BCH-Tween 80	26.88

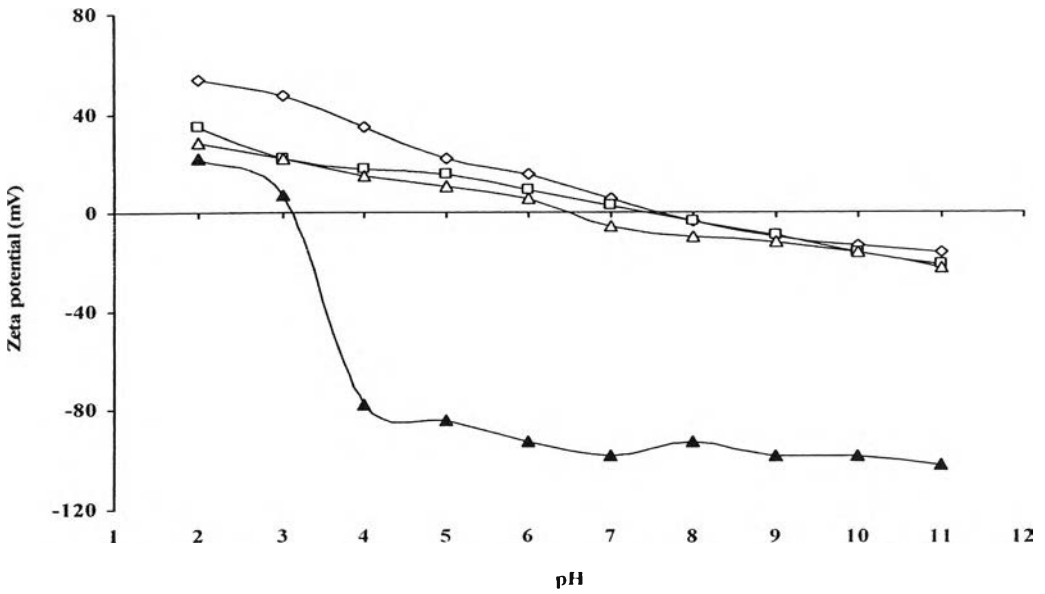

Figure D-1 Zeta potential of ▲ cutting fluids, ◊ chitosan □ blended chitosan/PVA 1:1 and Δ blended chitosan/PVA 1:2

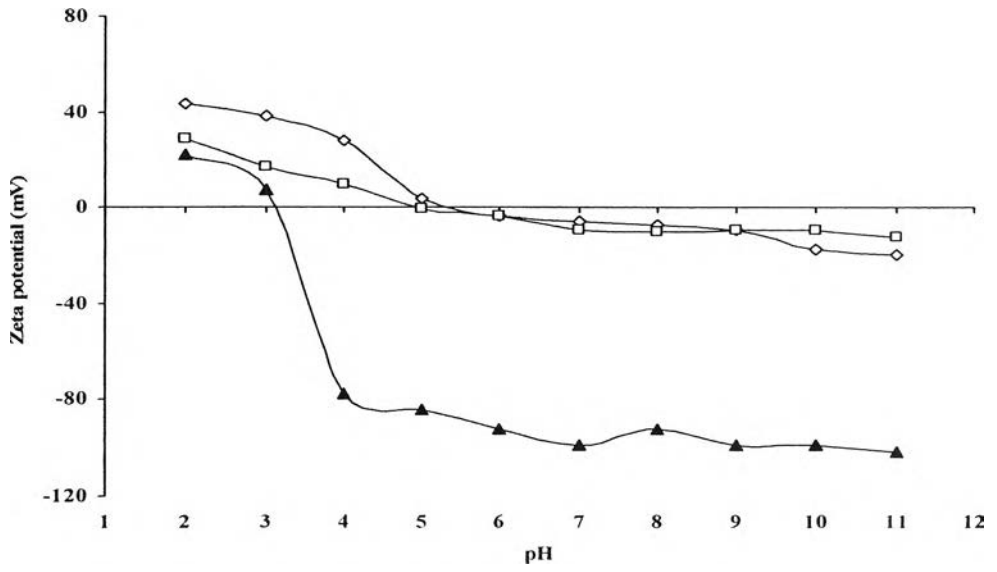

Figure D-2 Zeta potential of ▲ cutting fluids, ◊ benzoyl chitosan and □ quateraminated chitosan chitosan

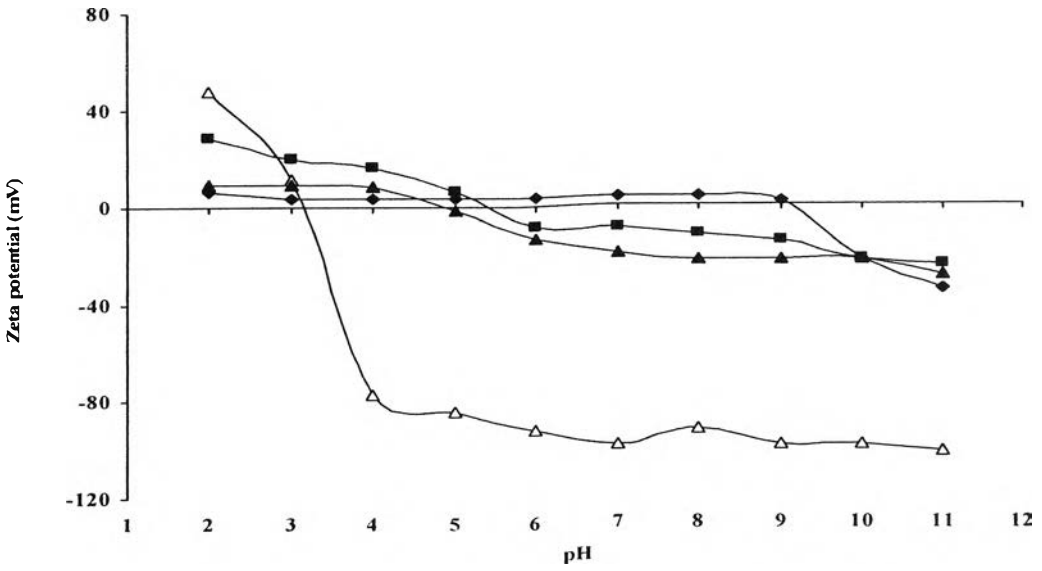

Figure D-3 Zeta potential of Δ cutting fluids, ♦ CH-SDS, ■ CH-C-Tab and ▲ CH Tween 80

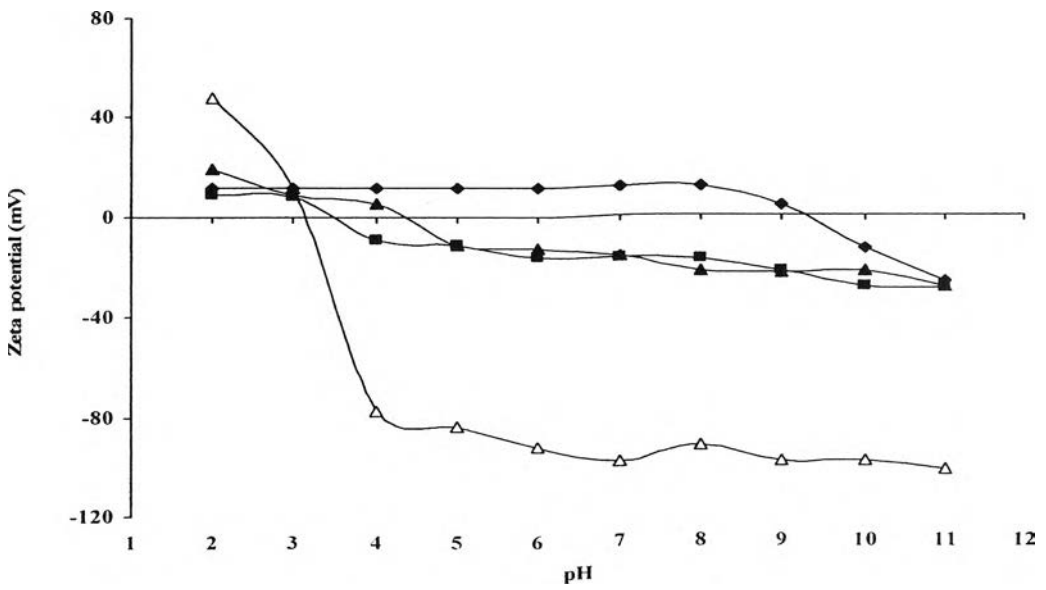

Figure D-4 Zeta potential of Δ cutting fluids, ♦ BCH-SDS, ■ BCH-C-Tab and ▲ BCH-Tween 80

Table D-7 Zeta potential (mV) of cutting fluids, chitosan, blended chitosan/PVA 1:1

pH	cutting fluids	Chitosan	Blended chitosan/ PVA 1:1	Blended chitosan/ PVA 1:2
2	22.2	54.0	35.0	28.6
3	7.5	47.6	22.2	22.2
4	-77.5	34.9	17.7	15.0
5	-84.1	22.2	15.9	11.0
6	-92.1	15.9	9.5	5.7
7	-98.4	6.0	3.2	-5.5
8	-92.1	-3.2	-3.2	-9.5
9	-98.4	-9.5	-9.3	-12.1
10	-98.4	-13.3	-15.9	-15.9
11	-101.6	-15.9	-21.4	-22.2

Table D-8 Adsorption capacity (mg/g) of cutting fluids concentration 0.10 – 3.00 % w/v by chitosan, blended chitosan/PVA 1:1 and blended chitosan/PVA 1:2

Time (min)	Chitosan				Blended chitosan/PVA 1:1				Blended chitosan/PVA 1:2			
	Cutting fluids concentration % w/v				Cutting fluids concentration % w/v				Cutting fluids concentration % w/v			
	0.10 %	0.50 %	1.00 %	3.00 %	0.10 %	0.50 %	1.00 %	3.00 %	0.10 %	0.50 %	1.00 %	3.00 %
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	13.51	81.08	121.62	65.32	32.66	110.36	118.24	140.77	22.52	95.72	144.14	172.30
10	15.77	172.30	163.29	77.70	34.91	185.81	264.64	234.23	25.90	99.10	149.77	181.31
15	16.89	174.55	212.84	91.22	39.41	186.94	368.24	236.49	28.15	97.97	174.55	210.59
20	16.89	177.93	216.22	102.48	39.41	189.19	395.27	224.10	30.41	113.74	230.86	213.96
30	18.02	179.05	221.85	115.99	42.79	190.32	390.77	230.86	32.66	123.87	238.74	216.22
45	19.14	185.81	227.48	141.89	42.79	191.44	391.89	235.36	32.66	129.50	245.50	215.09
60	21.40	183.56	225.23	154.28	42.79	190.32	400.90	237.61	33.78	132.88	262.39	208.33
90	21.40	199.32	233.11	153.15	43.92	192.57	407.66	245.50	33.78	139.64	284.91	212.84
120	21.40	197.07	236.49	149.77	48.42	188.06	420.05	251.13	34.91	145.27	281.53	217.34
180	20.27	193.69	235.36	127.25	47.30	198.20	402.03	251.13	34.91	140.77	282.66	212.84
240	20.27	192.57	237.61	127.25	46.17	191.44	384.01	247.75	37.16	137.39	279.28	218.47
300	20.27	185.81	239.86	137.39	43.92	192.57	388.51	242.12	36.04	135.14	278.15	212.84
360	20.27	183.56	237.61	130.63	43.92	194.82	382.88	242.12	33.78	136.26	277.03	210.59

Table D-9 Comparing adsorption capacity (mg/g) of cutting fluids concentration 1.00 % w/v, pH 3 by chitosan and blended chitosan/PVA 1:1

Time (min)	Chitosan	Blended chitosan/PVA 1:1
0	0.00	0.00
5	121.62	118.24
10	163.29	264.64
15	212.84	368.24
20	216.22	395.27
30	221.85	390.77
45	227.48	391.89
60	225.23	400.90
90	233.11	407.66
120	236.49	420.05
180	235.36	402.03
240	237.61	384.01
300	239.86	388.51
360	237.61	382.88

Table D-10 Variation pH to adsorption capacity (mg/g) of cutting fluids concentration 1.00 % w/v by chitosan and blended chitosan/PVA 1:1

pH	Chitosan	Blended chitosan/PVA 1:1
3	45.0	55.0
5	9.0	12.0
7	7.0	9.0
9	10.0	11.0
11	9.0	8.0

Table D-11 Time profile adsorption capacity (mg/g) of cutting fluids effluent at pH 3 By chitosan and blended chitosan/PVA 1:1

Time (min)	Chitosan	Blended chitosan/PVA 1:1
0	0.00	0.00
5	534.91	613.74
10	652.03	674.55
15	655.41	677.93
20	649.77	674.55
30	650.90	673.42
45	647.52	676.80
60	657.66	680.18
90	657.66	665.54
120	652.03	682.43
180	661.04	683.56
240	663.29	683.56
300	667.79	686.94
360	668.92	684.68

Table D-12 Zeta potential (mV) of cutting fluids, benzoyl chitosan and quateraminated chitosan

pH	cutting fluids	Benzoyl chitosan	Quateraminated chitosan
2	22.2	43.7	28.6
3	7.5	38.1	16.9
4	-77.5	27.8	9.8
5	-84.1	4.0	-0.5
6	-92.1	-3.2	-3.2
7	-98.4	-5.5	-9.5
8	-92.1	-7.2	-10.3
9	-98.4	-9.5	-9.5
10	-98.4	-17.3	-9.5
11	-101.6	-19.9	-12.1

Table D-13 Adsorption capacity (mg/g) of cutting fluids concentration 0.20 – 3.00 % w/v by benzoyl chitosan and quateraminated chitosan

Time (min)	Benzoyl chitosan				Quateraminated			
	Cutting fluids concentration % w/v				Cutting fluids concentration % w/v			
	0.20 %	1.00 %	2.00 %	3.00 %	0.20 %	1.00 %	2.00 %	3.00 %
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	24.77	103.60	11.26	55.18	27.03	121.62	115.99	47.30
30	34.91	123.87	28.15	84.46	25.90	153.15	171.17	59.68
60	50.68	125.00	90.09	105.86	39.41	181.31	197.07	70.95
90	67.57	132.88	97.97	127.25	72.07	199.32	236.49	84.46
120	76.58	136.26	117.12	128.38	91.22	208.33	251.13	119.37
180	97.64	150.90	123.87	123.87	97.64	274.77	306.31	180.18
240	97.64	165.54	125.00	128.38	97.64	304.05	369.37	233.11
360	97.64	179.05	128.38	130.63	97.64	350.23	403.15	282.66

Table D-14 Comparing adsorption capacity (mg/g) of cutting fluids concentration 1.00 % w/v, pH 3 by benzoyl chitosan and quateraminated chitosan

Time (min)	Benzoyl chitosan	Quateraminated chitosan
0	0.00	0.00
15	103.60	121.62
30	123.87	153.15
60	125.00	181.31
90	132.88	199.32
120	136.26	208.33
180	150.90	274.77
240	165.54	304.05
360	179.05	350.23

Table D-15 Variation pH to adsorption capacity (mg/g) of cutting fluids concentration 1.00 % w/v by benzoyl chitosan and quateraminated chitosan

pH	Benzoyl chitosan	Quateraminated chitosan
3	91.0	91.0
5	13.0	20.0
7	41.0	36.0
9	24.0	44.0
11	28.0	24.0

Table D-16 Time profile adsorption capacity (mg/g) of effluent cutting fluids at pH 3 by benzoyl chitosan and quateraminated chitosan

Time (min)	Benzoyl chitosan	Quateraminated chitosan
0	0.00	0.00
5	250.00	168.92
10	417.79	322.07
15	530.41	404.28
20	615.99	487.61
30	734.23	590.09
45	731.98	708.33
60	736.49	731.98
90	735.36	735.36
120	738.74	735.36
180	735.36	735.36
240	729.73	735.36
300	733.11	735.36
360	735.36	735.36

Table D-17 Zeta potential (mV) of cutting fluids, CH-SDS, CH-C-Tab and CH-Tween 80

pH	cutting fluids	CH-SDS	CH-C-Tab	CH-Tween 80
2	22.2	6.5	28.6	9.5
3	7.5	3.6	20.2	9.5
4	-77.5	4.0	17.0	8.5
5	-84.1	4.0	6.4	-1.1
6	-92.1	4.0	-8.6	-13.1
7	-98.4	4.0	-9.0	-19.7
8	-92.1	4.0	-11.5	-22.6
9	-98.4	1.9	-14.9	-22.7
10	-98.4	-22.2	-22.2	-22.2
11	-101.6	-34.4	-24.4	-28.6

Table D-18 Comparing adsorption capacity (mg/g) of cutting fluids concentration 3.00 % w/v, pH 3 by CH-SDS, CH-C-Tab and CH-Tween 80

Time (min)	CH-SDS	CH-C-Tab	CH-Tween 80
0	0.00	0.00	0.00
5	819.82	1297.30	33.78
10	947.07	2382.88	176.80
15	1121.62	2325.45	2183.56
20	1591.22	2412.16	2340.09
30	1807.43	2439.19	2343.47
45	1962.84	2483.11	2343.47
60	2014.64	2454.95	2361.49
90	2182.43	2488.74	2359.23
120	2511.26	2462.84	2360.36
180	2512.39	2452.70	2393.02
240	2514.64	2476.35	2405.41
300	2515.77	2507.88	2422.30
360	2515.77	2514.64	2417.79

Table D-19 Adsorption capacity (mg/g) of cutting fluids concentration 0.10 – 3.00 % w/v by CH-SDS, CH-C-Tab and CH-Tween 80

Time (min)	CH-SDS					CH-C-Tab					CH-Tween 80				
	Cutting fluids concentration % w/v					Cutting fluids concentration % w/v					Cutting fluids concentration % w/v				
	0.10 %	0.50 %	1.00 %	2.00 %	3.00 %	0.10 %	0.50 %	1.00 %	2.00 %	3.00 %	0.10 %	0.50 %	1.00 %	2.00 %	3.00 %
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	1.13	55.18	126.13	193.69	819.82	5.63	139.64	182.43	1398.65	1297.30	38.29	91.22	385.14	1117.12	33.78
10	9.01	115.99	361.49	653.15	947.07	12.39	130.63	363.74	1341.22	2382.88	42.79	129.50	496.62	1192.57	176.80
15	2.25	352.48	568.69	813.06	1121.62	9.01	114.86	371.62	1389.64	2325.45	29.28	130.63	561.94	1270.27	2183.56
20	49.55	375.00	636.26	1049.55	1591.22	14.64	127.25	378.38	1403.15	2412.16	31.53	137.39	680.18	1313.06	2340.09
30	0.00	390.77	825.45	1168.92	1807.43	12.39	111.49	373.87	1412.16	2439.19	38.29	138.51	683.56	1318.69	2343.47
45	13.51	403.15	825.45	1514.64	1962.84	18.02	168.92	372.75	1540.54	2483.11	34.91	141.89	693.69	1420.05	2343.47
60	52.93	407.66	832.21	1574.32	2014.64	21.40	163.29	325.45	1534.91	2454.95	46.17	153.15	691.44	1328.83	2361.49
90	51.80	405.41	834.46	1725.23	2182.43	14.64	127.25	355.86	1515.77	2488.74	36.04	157.66	709.46	1337.84	2359.23
120	18.02	408.78	847.97	1725.23	2511.26	16.89	113.74	371.62	1638.51	2462.84	45.05	155.41	704.95	1350.23	2360.36
180	21.40	407.66	847.97	1725.23	2512.39	20.27	208.33	344.59	1674.55	2452.70	31.53	168.92	716.22	1420.05	2393.02
240	3.38	408.78	842.34	1725.23	2514.64	19.14	150.90	362.61	1674.55	2476.35	33.78	177.93	699.32	1454.95	2405.41
300	4.50	409.91	844.59	1725.23	2515.77	28.15	140.77	355.86	1703.83	2507.88	32.66	198.20	721.85	1510.14	2422.30
360	4.50	406.53	838.96	1725.23	2515.77	25.90	130.63	358.11	1722.97	2514.64	24.77	189.19	722.97	1503.38	2417.79

Table D-20 Variation pH to adsorption capacity (mg/g) of cutting fluids concentration 3.00 % w/v by CH-SDS, CH-C-Tab and CH-Tween 80

pH	CH-SDS	CH-C-Tab	CH-Tween 80
3	2516.0	2476.0	2417.0
5	849.0	203.0	241.0
7	747.0	88.0	180.0
9	333.0	42.0	195.0
11	309.0	97.0	146.0

Table D-21 Time profile for adsorption capacity (mg/g) of cutting fluids effluent at pH 3 by CH-SDS, CH-C-Tab and CH-Tween 80

Time (min)	CH-SDS	CH-C-Tab	CH-Tween 80
0	0.00	0.00	0.00
5	46.17	269.14	298.42
10	54.05	266.89	297.30
15	63.06	268.02	296.17
20	67.57	256.76	306.31
30	120.50	242.12	307.43
45	165.54	266.89	311.94
60	199.32	261.26	329.95
90	229.73	257.88	329.95
120	297.30	266.89	326.58
180	389.64	284.91	324.32
240	443.69	269.14	325.45
300	519.14	268.02	325.45
360	590.09	264.64	326.58

Table D-22 Zeta potential (mV) of cutting fluids, BCH-SDS, BCH-C-Tab and BCH-Tween 80

pH	cutting fluids	BCH-SDS	BCH-C-Tab	BCH-Tween 80
2	22.2	11.9	8.7	19.6
3	7.5	11.9	8.1	9.0
4	-77.5	11.9	-9.5	5.4
5	-84.1	11.9	-11.3	-11.6
6	-92.1	11.9	-15.9	-12.4
7	-98.4	11.9	-16.8	-15.9
8	-92.1	11.9	-17.3	-22.2
9	-98.4	4.2	-22.2	-23.0
10	-98.4	-13.4	-28.6	-22.2
11	-101.6	-26.5	-29.1	-28.6

Table D-23 Adsorption capacity (mg/g) of cutting fluids concentration 0.10 – 3.00 % w/v by CH-SDS

Time (min)	CH-SDS				
	Cutting fluids concentration % w/v				
	0.10 %	0.50 %	1.00 %	2.00 %	3.00 %
0	0.00	0.00	0.00	0.00	0.00
5	1.13	216.22	336.71	206.08	1072.07
10	2.25	260.14	447.07	783.78	1140.77
15	15.77	308.56	459.46	868.24	1472.97
20	22.52	375.00	530.41	941.44	1496.62
30	24.77	400.90	593.47	1032.66	1506.76
45	28.15	405.41	708.33	1082.21	1747.75
60	30.41	400.90	734.23	1144.14	1865.99
90	33.78	404.28	747.75	1198.20	1932.43
120	38.29	411.04	784.91	1283.78	2064.19
180	37.16	413.29	816.44	1311.94	2161.04
240	32.66	413.29	837.84	1391.89	2202.70
300	33.78	413.29	842.34	1440.32	2248.87
360	36.04	413.29	846.85	1472.97	2310.81

Table D-24 Variation of pH to adsorption capacity (mg/g) of cutting fluids concentration 3.00 % w/v by BCH-SDS, BCH-C-Tab and BCH-Tween 80

pH	BCH-SDS	BCH-C-Tab	BCH-Tween 80
3	2310.0		
5	1360.0	416.0	420.0
7	1049.0	305.0	296.0
9	931.0	218.0	177.0
11	522.0	299.0	262.0

Table D-25 Time profile of adsorption capacity (mg/g) of effluent cutting fluids at pH 3 by BCH-SDS, BCH-C-Tab and BCH-Tween 80

Time (min)	BCH-SDS	BCH-C-Tab	BCH-Tween 80
0	0.00	0.00	0.00
5	42.79	278.15	313.06
10	46.17	279.28	323.20
15	79.95	279.28	335.59
20	48.42	280.41	332.21
30	87.84	277.03	349.10
45	135.14	284.91	350.23
60	227.48	299.55	344.59
90	393.02	284.91	345.72
120	505.63	290.54	346.85
180	564.19	287.16	329.95
240	610.36	289.41	341.22
300	662.16	291.67	351.35
360	692.57	290.54	332.21

Table D-26 Adsorption capacity (mg/g) of cutting fluids by chitosan and blended chitosan/PVA 1:1 adding salt 0.01 M

Salts	Adsorbents	
	Chitosan	Blended chitosan 1:1
Non-adding	69.82	77.80
NaCl	134.01	129.69
$CaCl_2$	134.57	133.82
$Fe(NO_3)_3$	79.77	62.12
Na_2SO_4	32.85	24.96
$CaSO_4$	36.60	39.98
$FeSO_4$	48.24	44.11

Table D-27 Adsorption capacity (mg/g) of cutting fluids by benzoyl chitosan and quateraminated chitosan adding salt 0.01 M

Salts	Adsorbents	
	Benzoyl chitosan	Quateraminated chitosan
Non-adding	90.47	90.84
NaCl	132.70	132.88
$CaCl_2$	134.57	134.57
$Fe(NO_3)_3$	83.15	92.34
Na_2SO_4	51.24	65.32
$CaSO_4$	117.30	118.06
$FeSO_4$	86.90	134.57

Table D-28 Adsorption capacity (mg/g) of cutting fluids by CH-SDS, CH-C-Tab and CH-Tween 80 adding salt 0.01 M

Salts	Adsorbents		
	CH-SDS	CH-C-Tab	CH-Tween 80
Non-adding	141.33	61.19	95.16
NaCl	134.57	133.07	134.57
$CaCl_2$	132.51	134.57	130.82
$Fe(NO_3)_3$	94.57	56.68	64.56
Na_2SO_4	118.06	75.83	74.32
$CaSO_4$	119.93	85.59	78.27
$FeSO_4$	134.38	132.32	134.57

Table D-29 Adsorption capacity (mg/g) of cutting fluids by BCH-SDS, BCH-C-Tab and BCH-Tween 80 adding salt 0.01 M

Salts	Adsorbents		
	BCH-SDS	BCH-C-Tab	BCH-Tween 80
Non-adding	132.88	133.45	134.01
NaCl	133.63	132.32	134.57
$CaCl_2$	94.97	52.93	48.80
$Fe(NO_3)_3$	116.93	40.92	61.75
Na_2SO_4	118.06	58.37	70.57
$CaSO_4$	134.57		
$FeSO_4$	141.33		

Table D-30 Adsorption capacity (mg/g) of cutting fluids adding salts NaCl and $CaCl_2$ concentration 0.01 – 0.05 M

Salts		NaCl		$CaCl_2$	
Adsorbents	non	0.01 M	0.05 M	0.01 M	0.05 M
Chitosan	69.82	134.01	138.14	134.57	138.95
Blended chitosan/PVA 1:1	77.80	129.69	138.14	133.82	138.14
Benzoyl chitosan	90.47	132.70	138.14	134.57	138.14
Quateraminated chitosan	90.84	132.88	138.14	134.57	136.64
CH-SDS	141.33	134.57	138.14	132.51	138.14
CH-C-Tab	61.19	133.07	42.42	134.57	138.14
CH-Tween 80	95.16	134.57	138.14	130.82	138.14
BCH-SDS	132.88	133.63	137.01	94.97	138.14
BCH-C-Tab	133.45	132.32	135.14	52.93	138.58
BCH-Tween 80	134.01	134.57	18.96	48.80	137.95

Appendix E Adsorption isotherms of adsorbents

Table E-1 Adsorption isotherms of chitosan

No	Weight of adsorbents (mg)	Volume (cm^3)	C (mg/l)	x (g)	(x/m) (mg/g)	Langmuir		Freundlich		BET		
						1/C	1/(x/m)	C	x/m	C_s-C	C/((C_s-C)(x/m))	C/C_s
1	8000	50	83	733.35	0.0917	0.01205	10.9	733.35	0.0917	14667.0	0.062	0.0056
2	6000	50	151	729.95	0.1217	0.00662	8.2	729.95	0.1217	14599.0	0.085	0.0102
3	4000	50	511	711.95	0.1780	0.00196	5.6	711.95	0.1780	14239.0	0.202	0.0346
4	2000	50	984	688.30	0.3442	0.00102	2.9	688.30	0.3442	13766.0	0.208	0.0667
5	0	50	14750	0				0		14750.0		

Table E-2 Adsorption isotherms of Blended chitosan/PVA 1:1

No	Weight of adsorbents (mg)	Volume (cm^3)	C (mg/l)	x (g)	(x/m) (mg/g)	Langmuir		Freundlich		BET		
						1/C	1/(x/m)	C	x/m	C_s-C	C/((C_s-C)(x/m))	C/C_s
1	8000	50	60	46.20	0.0058	0.0166667	173.2	60	0.0058	924	11.244	0.0610
2	6000	50	83	45.05	0.0075	0.0120482	133.2	83	0.0075	901	12.269	0.0843
3	4000	50	150	41.70	0.0104	0.0066667	95.9	150	0.0104	834	17.252	0.1524
4	2000	50	240	37.20	0.0186	0.0041667	53.8	240	0.0186	744	17.343	0.2439
5	1000	50	331	32.65	0.0327	0.0030211	30.6	331	0.0327	653	15.525	0.3364
6	0	50	984	0		0.0010163		984		0		

Table E-3 Adsorption isotherms of benzoyl chitosan

No	Weight of adsorbents (mg)	Volume (cm^3)	C (mg/l)	x (g)	(x/m) (mg/g)	Langmuir		Freundlich		BET		
						1/C	1/(x/m)	C	x/m	C_s-C	C/((C_s-C)(x/m))	C/C_s
1	6000	50	2493.0	420.05	0.0700	0.000401	14.3	2493.0	0.0700	8401.0	4.239	0.2288
2	4000	50	4768.0	306.30	0.0766	0.00021	13.1	4768.0	0.0766	7568.0	4.646	0.3053
3	2000	50	6074	241.00	0.1205	0.00016	8.3	6074	0.1205	4820	10.458	0.5576
4	1000	50	7313	179.05	0.1791	0.000137	5.6	7313	0.1791	3581	11.406	0.6713
5	500	50	9160	86.70	0.1734	0.000109	5.8	9160	0.1734	1734	-	-
6	0	50	10894	0				10894		10894		

Table E-4 Adsorption isotherms of quateraminated chitosan

No	Weight of adsorbents (mg)	Volume (cm^3)	C (mg/l)	x (g)	(x/m) (mg/g)	Langmuir		Freundlich		BET		
						1/C	1/(x/m)	C	x/m	C_s-C	C/((C_s-C)(x/m))	C/C_s
1	6000	50	128.0	91.20	0.0152	-	-	128.0	0.0152	1824.0	4.617	0.0656
2	4000	50	871.0	54.05	0.0135	0.001148	74.0	871.0	0.0135	1081.0	59.629	0.4462
3	2000	50	1121	41.55	0.0208	0.00089	48.1	1121	0.0208	831.0	64.933	0.5743
4	1000	50	1412	27.00	0.0270	0.000708	37.0	1412	0.0270	540.0	96.845	0.7234
5	500	50	1682	13.50	0.0270	0.000595	37.0	1682	0.0270	270.0	-	-
6	0	50	1952	0				1952		1952.0	-	-

Table E-5 Adsorption isotherms of CH-SDS

No	Weight of adsorbents (mg)	Volume (cm^3)	C (mg/l)	x (g)	(x/m) (mg/g)	Langmuir		Freundlich		BET		
						1/C	1/(x/m)	C	x/m	C_s-C	C/((C_s-C)(x/m))	C/C_s
1	6000	50	16	2515.70	0.4193	0.0625000	2.4	16	0.4193	50270	0.003	0.0012
2	4000	50	105	2511.25	0.6278	0.0095238	1.6	105	0.6278	50225	0.003	0.0021
3	2000	50	4385	2297.25	1.1486	0.0002281	0.9	4385	1.1486	45945	0.083	0.0871
4	1000	50	6682	2182.40	2.1824	0.0001497	0.5	6682	2.1824	43648	0.070	0.1328
5	500	50	27020	1165.50	2.3310	3.701E-05	0.4	27020	2.3310	23310	0.497	0.5369
6	0	50	50330	0				50330		50330		

Table E-6 Adsorption isotherm of CH-C-Tab

No	Weight of adsorbents (mg)	Volume (cm^3)	C (mg/l)	x (g)	(x/m) (mg/g)	Langmuir		Freundlich		BET		
						1/C	1/(x/m)	C	x/m	C_s-C	C/((C_s-C)(x/m))	C/C_s
1	6000	50	3551	1548.45	0.2581	0.0002816	3.9	3551	0.2581	30969	0.444	0.1029
2	4000	50	4970	1477.50	0.3694	0.0002012	2.7	4970	0.3694	29550	0.455	0.1440
3	2000	50	6502	1400.90	0.7005	-	-	6502	0.7005	28018	0.331	0.1884
4	1000	50	7695	1341.25	1.3413	-	-	7695	1.3413	26825	0.214	0.2229
5	500	50	27020	375.00	-	3.701E-05	1.3	27020	-	7500	4.804	0.7827
6	0	50	34520	0				34520		50330		

Table E-7 Adsorption isotherms of CH-Tween 80

No	Weight of adsorbents (mg)	Volume (cm^3)	C (mg/l)	x (g)	(x/m) (mg/g)	Langmuir		Freundlich		BET		
						1/C	1/(x/m)	C	x/m	C_s-C	C/((C_s-C)(x/m))	C/C_s
1	6000	50	556	57.40	0.0096	0.0017986	104.5	556	0.0096	1148	50.626	0.3263
2	4000	50	646	52.90	0.0132	0.001548	75.6	646	0.0132	1058	46.169	0.3791
3	2000	50	894	40.50	0.0203	0.0011186	49.4	894	0.0203	810	-	-
4	1000	50	1006	34.90	0.0349	0.0009940	28.7	1006	0.0349	698	41.297	0.5904
5	500	50	1186	25.90	0.0518	8.432E-04	19.3	1186	0.0518	518	44.200	0.6960
6	0	50	1704	0				1704		50330		

Table E-8 Adsorption isotherms of BCH-SDS

No	Weight of adsorbents (mg)	Volume (cm^3)	C (mg/l)	x (g)	(x/m) (mg/g)	Langmuir		Freundlich		BET		
						1/C	1/(x/m)	C	x/m	C_s-C	C/((C_s-C)(x/m))	C/C_s
1	4000	50	240	2504.50	0.6261	0.0041667	1.6	240	0.6261	50090	0.008	0.0048
2	2000	50	1210	2456.00	1.2280	0.0008264	0.8	1210	1.2280	49120	0.020	0.0240
3	1000	50	4115	2310.75	2.3108	0.0002430	0.4	4115	2.3108	46215	0.039	0.0818
4	500	50	15353	1748.85	3.4977	6.513E-05	0.3	15353	3.4977	34977	0.125	0.3050
5	0	50	50330	0				50330		50330		

Table E-9 Adsorption isotherms of BCH-C-Tab

No	Weight of adsorbents (mg)	Volume (cm^3)	C (mg/l)	x (g)	(x/m) (mg/g)	Langmuir		Freundlich		BET		
						1/C	1/(x/m)	C	x/m	C_s-C	C/((C_s-C)(x/m))	C/C_s
1	6000	50	33686	447.10	0.0745	2.969E-05	13.4	33686	0.0745	8942	50.555	0.7902
2	4000	50	33912	435.80	0.1090	2.949E-05	9.2	33912	0.1090	8716	35.712	0.7955
3	2000	50	34385	412.15	0.2061	2.908E-05	4.9	34385	0.2061	8243	20.242	0.8066
4	1000	50	34677	397.55	0.3976	0.0000288	2.5	34677	0.3976	7951	10.971	0.8135
5	500	50	35466	358.10	0.3581	-	-	35466	0.3581	7162	6.914	0.8320
6	0	50	42628	0				42628		50330		

Table E-10 Adsorption isotherms of BCH-Tween 80

No	Weight of adsorbents (mg)	Volume (cm^3)	C (mg/l)	x (g)	(x/m) (mg/g)	Langmuir		Freundlich		BET		
						1/C	1/(x/m)	C	x/m	C_s-C	C/((C_s-C)(x/m))	C/C_s
1	6000	50	33033	479.75	0.0800	3.027E-05	12.5	33033	0.0800	9595	43.057	0.7749
2	4000	50	34092	426.80	0.1067	2.933E-05	9.4	34092	0.1067	8536	37.431	0.7998
3	2000	50	34250	418.90	0.2095	2.92E-05	4.8	34250	0.2095	8378	19.518	0.8035
4	1000	50	34317	415.55	0.4156	0.0000291	2.4	34317	0.4156	8311	9.936	0.8050
5	500	50	35511	355.85	0.3559	0.0000282	2.8	35511	0.3559	7117	7.011	0.8330
6	0	50	42628	0				42628		50330		

Appendix F Kinetic and mechanism of adsorption

Table F-1 Pseudo-first-order of chitosan and blended chitosan/PVA 1:1

Time (min)	Pseudo-first-order					
	Chitosan			Blended chitosan/PVA 1:1		
	q_e (mg/g)	q_e-q_t	log(q_e-q_t)	q_e (mg/g)	q_e-q_t	log(q_e-q_t)
0	0.00	237.61	2.38	0.00	382.88	2.58
5	121.62	115.99	2.06	118.24	264.64	2.42
10	163.29	74.32	1.87	264.64	118.24	2.07
15	212.84	24.77	1.39	368.24	14.64	1.17
20	216.22	21.40	1.33	395.27	-12.39	#NUM!
30	221.85	15.77	1.20	390.77	-7.88	#NUM!
45	227.48	10.14	1.01	391.89	-9.01	#NUM!
60	225.23	12.39	1.09	400.90	-18.02	#NUM!
90	233.11	4.50	0.65	407.66	-24.77	#NUM!
120	236.49	1.13	0.05	420.05	-37.16	#NUM!
180	235.36	2.25	0.35	402.03	-19.14	#NUM!
240	237.61	0.00	#NUM!	384.01	-1.13	#NUM!
300	239.86	-2.25	#NUM!	388.51	-5.63	#NUM!
360	237.61	0.00		382.88	0.00	

Table F-2 Pseudo-second-order of chitosan and blended chitosan/PVA 1:1

Time (min)	Pseudo-second-order			
	Chitosan		Blended chitosan/PVA 1:1	
	q_e (mg/g)	t/q_t	q_e (mg/g)	t/q_t
0	0.00	0.0000	0.00	0.000
5	121.62	0.0411	118.24	0.042
10	163.29	0.0612	264.64	0.038
15	212.84	0.0705	368.24	0.041
20	216.22	0.0925	395.27	0.051
30	221.85	0.1352	390.77	0.077
45	227.48	0.1978	391.89	0.115
60	225.23	0.2664	400.90	0.150
90	233.11	0.3861	407.66	0.221
120	236.49	0.5074	420.05	0.286
180	235.36	0.7648	402.03	0.448
240	237.61	1.0100	384.01	0.625
300	239.86	1.2507	388.51	0.772
360	237.61	1.5151	382.88	0.940

Table F-3 Intraparticle diffusion of chitosan and blended chitosan/PVA 1:1

$t^{0.5}$	Chitosan	Blended chitosan/PVA 1:1
	q_t	q_t
0.00	0.00	0.00
2.24	121.62	118.24
3.16	163.29	264.64
3.87	212.84	368.24
4.47	216.22	395.27
5.48	221.85	390.77
6.71	227.48	391.89
7.75	225.23	400.90
9.49	233.11	407.66
10.95	236.49	420.05
13.42	235.36	402.03
15.49	237.61	384.01
17.32	239.86	388.51
18.97	237.61	382.88

Table F-4 Pseudo-first-order of benzoyl chitosan and quateraminated chitosan

Time (min)	Pseudo-first-order					
	Benzoyl chitosan			Quateraminated chitosan		
	q_e (mg/g)	q_e-q_t	log(q_e-q_t)	q_e (mg/g)	q_e-q_t	log(q_e-q_t)
0	0.00	0.00	#NUM!	0.00	0.00	#NUM!
15	33.22	57.56	1.76	51.05	39.73	1.60
30	54.05	36.73	1.57	61.00	29.79	1.47
60	70.01	20.78	1.32	82.77	8.01	0.90
90	89.71	1.07	0.03	85.96	4.82	0.68
120	89.90	0.88	-0.05	88.78	2.01	0.30
180	90.78	0.00	#NUM!	90.78	0.00	#NUM!
240	90.78	0.00	#NUM!	90.78	0.00	#NUM!
360	90.78	0.00	#NUM!	90.78	0.00	#NUM!

Table F-5 Pseudo-second-order of benzoyl chitosan and quateraminated chitosan

Time (min)	Pseudo-second-order			
	Benzoyl chitosan		Quateraminated chitosan	
	q_e	t/q_t	q_e	t/q_t
0	0.00	0.0000	0.00	0.000
15	33.22	0.4515	51.05	0.294
30	54.05	0.5550	61.00	0.492
60	70.01	0.8571	82.77	0.725
90	89.71	1.0032	85.96	1.047
120	89.90	1.3348	88.78	1.352
180	90.78	1.9827	90.78	1.983
240	90.78	2.6436	90.78	2.644
360	90.78	3.9654	90.78	3.965

Table F-6 Intraparticle diffusion of benzoyl chitosan and quateraminated chitosan

$t^{0.5}$	Intrapartical	
	Benzoyl chitosan	Quateraminated chitosan
	q_t	q_t
0.00	0.00	0.00
3.87	33.22	51.05
5.48	54.05	61.00
7.75	70.01	82.77
9.49	89.71	85.96
10.95	89.90	88.78
13.42	90.78	90.78
15.49	90.78	90.78
18.97	90.78	90.78

Table F-7 Pseudo-first-order of CH-SDS, CH-C-Tab and CH-Tween 80

Time (min)	Pseudo-first-order								
	CH-SDS			CH-C-Tab			CH-Tween 80		
	q_e (mg/g)	q_e-q_t	log(q_e-q_t)	q_e (mg/g)	q_e-q_t	log(q_e-q_t)	q_e (mg/g)	q_e-q_t	log(q_e-q_t)
0	0.00	2515.77	3.40	0.00	2514.64	3.40	0.00	2418	3.38
5	819.82	1695.95	3.23	1297.30	1217.34	3.09	146.40	2271	3.36
10	947.07	1568.69	3.20	2382.88	131.76	2.12	176.80	2241	3.35
15	1121.62	1394.14	3.14	2325.45	189.19	2.28	2183.56	234	2.37
20	1591.22	924.55	2.97	2412.16	102.48	2.01	2340.09	78	1.89
30	1807.43	708.33	2.85	2439.19	75.45	1.88	2343.47	74	1.87
45	1962.84	552.93	2.74	2483.11	31.53	1.50	2343.47	74	1.87
60	2014.64	501.13	2.70	2454.95	59.68	1.78	2361.49	56	1.75
90	2182.43	333.33	2.52	2488.74	25.90	1.41	2359.23	59	1.77
120	2511.26	4.50	0.65	2462.84	51.80	1.71	2360.36	57	1.76
180	2512.39	3.38	0.53	2452.70	61.94	1.79	2393.02	25	1.39
240	2514.64	1.13	0.05	2476.35	38.29	1.58	2405.41	12	1.09
300	2515.77	0.00	#NUM!	2507.88	6.76	0.83	2422.30	-5	#NUM!
360	2515.77	0.00		2514.64	0.00		2417.79	0	

Table F-8 Pseudo-second-order of CH-SDS, CH-C-Tab and CH-Tween 80

Time (min)	Pseudo-second-order					
	CH-SDS		CH-C-Tab		CH-Tween 80	
	q_e	t/q_t	q_e	t/q_t	q_e	t/q_t
0	0.00	0.0000	0.00	0.000	0.00	0.000
5	819.82	0.0061	1297.30	0.004	146.40	0.034
10	947.07	0.0106	2382.88	0.004	176.80	0.057
15	1121.62	0.0134	2325.45	0.006	2183.56	0.007
20	1591.22	0.0126	2412.16	0.008	2340.09	0.009
30	1807.43	0.0166	2439.19	0.012	2343.47	0.013
45	1962.84	0.0229	2483.11	0.018	2343.47	0.019
60	2014.64	0.0298	2454.95	0.024	2361.49	0.025
90	2182.43	0.0412	2488.74	0.036	2359.23	0.038
120	2511.26	0.0478	2462.84	0.049	2360.36	0.051
180	2512.39	0.0716	2452.70	0.073	2393.02	0.075
240	2514.64	0.0954	2476.35	0.097	2405.41	0.100
300	2515.77	0.1192	2507.88	0.120	2422.30	0.124
360	2515.77	0.1431	2514.64	0.143	2417.79	0.149

Table F-9 Intraparticle diffusion of CH-SDS, CH-C-Tab and CH-Tween 80

$t^{0.5}$	Intrapartical		
	CH-SDS	CH-C-Tab	CH-Tween 80
	q_t	q_t	q_t
0.00	0.00	0.00	0.00
2.24	819.82	1297.30	146.40
3.16	947.07	2382.88	176.80
3.87	1121.62	2325.45	2183.56
4.47	1591.22	2412.16	2340.09
5.48	1807.43	2439.19	2343.47
6.71	1962.84	2483.11	2343.47
7.75	2014.64	2454.95	2361.49
9.49	2182.43	2488.74	2359.23
10.95	2511.26	2462.84	2360.36
13.42	2512.39	2452.70	2393.02
15.49	2514.64	2476.35	2405.41
17.32	2515.77	2507.88	2422.30
18.97	2515.77	2514.64	2417.79

Table F-10 Pseudo-first-order of BCH-SDS

Time (min)	Pseudo-first-order		
	BCH-SDS		
	q_e (mg/g)	q_e-q_t	log(q_e- q_t)
0	0.00	2310.81	3.36
5	1072.07	1238.74	3.09
10	1140.77	1170.05	3.07
15	1472.97	837.84	2.92
20	1496.62	814.19	2.91
30	1506.76	804.05	2.91
45	1747.75	563.06	2.75
60	1865.99	444.82	2.65
90	1932.43	378.38	2.58
120	2064.19	246.62	2.39
180	2161.04	149.77	2.18
240	2202.70	108.11	2.03
300	2248.87	61.94	1.79
360	2310.81	0.00	

Table F-11 Pseudo-second-order of BCH-SDS

Time (min)	Pseudo-second-order	
	BCH-SDS	
	q_e (mg/g)	t/q_t
0	0.00	0.0000
5	1072.07	0.0047
10	1140.77	0.0088
15	1472.97	0.0102
20	1496.62	0.0134
30	1506.76	0.0199
45	1747.75	0.0257
60	1865.99	0.0322
90	1932.43	0.0466
120	2064.19	0.0581
180	2161.04	0.0833
240	2202.70	0.1090
300	2248.87	0.1334
360	2310.81	0.1558

Table F-12 Intraparticla diffusion of BCH-SDS

$t^{0.5}$	q_t (mg/g)
0.00	0.00
2.24	1072.07
3.16	1140.77
3.87	1472.97
4.47	1496.62
5.48	1506.76
6.71	1747.75
7.75	1865.99
9.49	1932.43
10.95	2064.19
13.42	2161.04
15.49	2202.70
17.32	2248.87
18.97	2310.81

Appendix G Effect of temperature

Table G-1 Effect of temperature on adsorption capacity (mg/g) at pH 3of chitosan and blended chitosan/PVA 1:1

Time (min)	Chitosan				Blended chitosan/PVA 1:1			
	pH 3				pH 3			
	33 ^{0}C	38 ^{0}C	43 ^{0}C	48 ^{0}C	33 ^{0}C	38 ^{0}C	43 ^{0}C	48 ^{0}C
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	23.84	25.34	29.84	29.09	15.20	24.77	24.02	28.15
10	24.40	28.53	31.16	33.03	20.27	26.46	26.09	30.97
15	23.84	29.09	31.72	33.03	25.15	24.02	26.46	32.28
20	25.71	30.22	32.28	33.03	26.46	24.59	27.03	33.03
30	25.34	31.16	32.09	33.03	24.77	25.90	29.28	33.03
45	25.71	31.91	32.85	33.03	24.77	26.84	29.28	33.03
60	27.78	31.72	33.03	33.03	24.40	27.03	30.22	33.03
90	28.15	31.53	33.03	33.03	24.96	26.65	30.22	33.03
120	30.59	31.53	33.03	33.03	24.59	27.21	30.22	33.03
180	29.65	31.72	33.03	33.03	24.59	25.90	30.22	33.03
240	29.47	31.72	33.03	33.03	24.96	26.28	30.22	33.03
300	28.72	32.47	33.03	33.03	24.59	25.90	31.16	33.03
360	29.09	32.85	33.03	33.03	25.15	26.46	31.72	33.03

Table G-2 Effect of temperature on adsorption capacity (mg/g) at pH 3 of benzoyl chitosan and quateraminated chitosan

Time (min)	Benzoyl chitosan				Quateraminated chitosan			
	pH 3				pH 3			
	33 ^{0}C	38 ^{0}C	43 ^{0}C	48 ^{0}C	33 ^{0}C	38 ^{0}C	43 ^{0}C	48 ^{0}C
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	1.31	4.69	8.63	8.82	3.38	6.76	4.88	5.07
10	2.06	7.51	8.26	12.20	3.94	7.88	6.76	8.63
15	3.19	7.88	10.32	12.58	7.32	9.20	9.01	9.76
20	4.69	8.07	11.26	14.26	5.82	9.76	10.51	11.45
30	4.88	9.57	13.70	15.95	8.26	12.58	13.70	14.26
45	5.44	10.14	14.64	17.83	11.07	16.14	15.95	17.64
60	6.38	11.45	16.14	19.52	10.89	18.77	20.83	21.40
90	7.51	12.95	21.21	23.46	15.77	24.96	26.09	29.28
120	10.32	13.89	22.15	25.15	22.33	30.41	30.97	33.03
180	10.70	16.52	24.77	30.41	29.84	33.03	32.47	33.03
240	15.02	18.77	30.22	32.47	33.03	33.03	33.03	33.03
300	19.33	21.21	32.85	33.03	33.03	33.03	33.03	33.03
360	20.83	24.21	33.03	33.03	33.03	33.03	33.03	33.03

Table G-3 Effect of temperature on adsorption capacity (mg/g) at pH 3 of CH-SDS, CH-C-Tab and CH-Tween 80

Time (min)	CH-SDS				CH-C-Tab				CH-Tween 80			
	pH 3				pH 3				pH 3			
	33 ^{0}C	38 ^{0}C	43 ^{0}C	48 ^{0}C	33 ^{0}C	38 ^{0}C	43 ^{0}C	48 ^{0}C	33 ^{0}C	38 ^{0}C	43 ^{0}C	48 ^{0}C
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	6.38	11.82	6.57	10.89	12.39	25.90	20.08	22.71	6.57	24.77	18.39	20.65
10	10.70	14.45	15.58	19.71	12.76	26.28	22.90	30.59	10.89	25.71	19.71	27.21
15	15.95	16.89	20.83	25.53	17.45	27.59	21.77	30.22	19.89	26.84	19.89	27.59
20	18.02	21.40	24.21	31.91	19.52	29.28	22.71	31.34	20.27	26.28	21.58	27.40
30	20.83	25.53	28.90	31.91	20.08	29.09	24.02	31.53	20.08	27.59	20.83	28.15
45	26.65	28.15	30.03	33.03	19.71	28.34	24.21	31.91	19.71	25.15	21.21	29.09
60	29.09	30.97	32.28	33.03	20.83	28.34	24.21	31.72	19.89	24.21	21.21	29.84
90	33.03	31.91	32.85	33.03	19.71	27.78	25.53	33.03	19.89	24.02	21.40	29.28
120	33.03	32.47	33.03	33.03	19.33	30.97	24.40	32.28	20.46	25.34	21.02	29.84
180	33.03	33.03	33.03	33.03	19.52	30.41	24.40	32.09	20.83	24.21	20.46	29.09
240	33.03	33.03	33.03	33.03	17.08	29.28	26.28	32.85	20.27	24.96	21.40	29.84
300	33.03	33.03	33.03	33.03	17.64	28.15	25.90	32.47	21.21	25.34	22.15	29.09
360	33.03	33.03	33.03	33.03	16.89	30.22	26.09	32.85	19.52	24.59	23.46	29.28

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Table G-5 Effect of temperature on adsorption capacity (mg/g) at pH 6.8of chitosan and blended chitosan/PVA 1:1

Time (min)	Chitosan				Blended chitosan/PVA 1:1			
	pH 6.8				pH 6.8			
	33 ^{0}C	38 ^{0}C	43 ^{0}C	48 ^{0}C	33 ^{0}C	38 ^{0}C	43 ^{0}C	48 ^{0}C
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	11.82	13.33	12.01	18.21	12.01	12.20	18.02	18.58
10	12.20	13.89	14.26	19.14	12.20	12.01	18.39	19.33
15	12.20	13.33	13.14	19.33	12.01	13.89	17.27	19.89
20	12.20	14.45	14.64	19.71	12.58	13.89	18.96	19.89
30	12.20	14.08	13.89	19.52	12.58	13.89	18.96	19.71
45	12.01	12.39	14.64	19.33	12.39	13.70	18.77	19.33
60	11.82	13.33	15.20	19.52	12.01	14.08	18.77	20.08
90	12.01	12.58	15.58	18.96	14.08	15.02	19.14	19.71
120	12.20	13.33	15.95	19.33	13.70	15.58	20.08	20.65
180	12.39	14.08	16.52	18.77	15.77	15.02	20.46	21.21
240	12.76	14.45	16.33	19.71	16.89	15.58	19.89	21.02
300	12.58	15.20	16.70	18.77	17.27	15.95	20.08	20.46
360	13.70	15.77	17.08	18.39	17.64	16.52	19.52	20.83

Table G-6 Effect of temperature on adsorption capacity (mg/g) at pH 6.8 of benzoyl chitosan and quateraminated chitosan

Time (min)	Benzoyl chitosan				Quateraminated chitosan			
	pH 6.8				pH 6.8			
	33 ^{0}C	38 ^{0}C	43 ^{0}C	48 ^{0}C	33 ^{0}C	38 ^{0}C	43 ^{0}C	48 ^{0}C
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	16.70	19.33	25.34	24.40	14.64	16.70	16.52	23.27
10	18.96	23.65	26.28	26.46	15.58	17.83	19.52	24.02
15	19.33	23.27	28.34	27.40	14.83	17.83	20.46	25.15
20	20.83	24.21	29.09	28.72	16.52	18.02	21.21	24.77
30	23.84	25.90	29.65	30.41	16.70	19.14	21.96	25.15
45	24.21	27.21	31.72	32.85	17.83	20.08	22.15	26.46
60	26.46	27.78	34.72	34.53	19.89	21.77	22.52	27.03
90	28.15	28.34	38.85	36.60	20.08	21.21	23.09	27.40
120	25.90	31.16	39.60	40.73	19.14	19.14	23.84	29.28
180	30.03	35.66	41.48	43.36	19.89	21.21	24.40	30.97
240	35.85	38.48	42.98	45.42	21.40	21.21	28.72	31.72
300	36.97	41.48	45.80	46.36	22.52	22.33	28.72	34.16
360	37.73	43.92	47.30	48.05	22.33	24.02	28.72	33.97

Table G-7 Effect of temperature on adsorption capacity (mg/g) at pH 6.8 of CH-SDS, CH-C-Tab and CH-Tween 80

Time (min)	CH-SDS				CH-C-Tab				CH-Tween 80			
	pH 6.8				pH 6.8				pH 6.8			
	33 ^{0}C	38 ^{0}C	43 ^{0}C	48 ^{0}C	33 ^{0}C	38 ^{0}C	43 ^{0}C	48 ^{0}C	33 ^{0}C	38 ^{0}C	43 ^{0}C	48 ^{0}C
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	16.14	17.83	21.02	23.84	10.14	13.51	15.20	20.08	12.01	13.14	15.77	21.21
10	18.39	19.71	21.77	25.90	10.14	14.26	15.58	19.71	12.58	14.45	18.77	20.27
15	19.52	20.65	23.65	27.03	13.70	14.26	15.02	20.08	12.58	14.08	20.27	20.08
20	21.21	21.77	24.21	27.59	13.51	15.20	17.83	20.65	12.95	13.14	18.21	21.21
30	22.90	22.52	24.96	29.28	15.20	15.39	20.08	21.58	13.70	14.45	19.14	21.21
45	24.77	23.27	25.34	29.09	16.70	15.02	21.40	21.40	14.64	16.33	19.52	20.83
60	25.34	23.09	25.15	28.72	16.33	14.26	23.65	22.33	13.70	15.39	19.52	21.58
90	24.40	23.84	25.15	29.47	15.77	13.33	23.27	21.77	14.08	17.64	20.08	21.77
120	24.96	23.65	24.77	29.09	18.96	15.77	23.46	21.96	14.08	17.27	20.83	21.02
180	25.15	24.21	24.40	29.47	17.27	16.70	22.90	22.52	14.26	17.45	21.96	20.46
240	25.90	22.71	25.53	29.65	18.21	14.64	22.71	22.90	13.51	15.02	21.96	20.83
300	25.71	24.96	26.28	29.28	19.33	14.64	22.33	21.58	14.83	12.58	21.58	20.83
360	26.09	25.15	27.03	29.09	19.52	12.20	23.65	20.46	15.02	11.64	22.15	21.02

Table G-8 Effect of temperature on adsorption capacity (mg/g) at pH 6.8 of BCH-SDS, BCH-C-Tab and BCH-Tween 80

Time (min)	BCH-SDS				BCH-C-Tab				BCH-Tween 80			
	pH 6.8				pH 6.8				pH 6.8			
	33 ^{0}C	38 ^{0}C	43 ^{0}C	48 ^{0}C	33 ^{0}C	38 ^{0}C	43 ^{0}C	48 ^{0}C	33 ^{0}C	38 ^{0}C	43 ^{0}C	48 ^{0}C
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	14.64	12.95	19.52	19.71	11.64	13.14	17.64	21.21	8.26	13.70	17.08	21.40
10	14.64	13.70	21.58	19.33	12.01	13.70	18.39	21.21	11.45	14.08	18.21	20.27
15	17.08	15.39	21.02	19.52	13.51	14.83	18.02	21.21	12.76	14.45	19.71	21.58
20	17.45	15.02	21.02	22.33	12.58	14.64	19.89	21.77	12.20	15.20	19.71	21.77
30	17.64	16.14	21.96	24.96	13.89	13.70	19.89	20.65	10.89	15.39	20.27	21.40
45	17.08	16.33	23.27	23.84	13.89	13.70	19.14	21.58	11.07	17.64	19.71	21.96
60	17.45	16.14	25.71	25.34	14.64	14.45	19.52	21.21	11.45	16.33	20.08	21.96
90	19.33	15.77	27.40	24.96	14.08	15.39	19.14	21.58	11.07	16.14	20.08	21.21
120	19.33	15.95	27.97	24.59	13.33	13.14	19.71	21.40	11.82	15.77	20.83	21.58
180	18.96	19.89	28.15	24.21	15.58	16.52	18.96	21.40	11.82	17.27	21.02	22.15
240	18.21	18.96	28.34	25.34	15.39	12.39	20.83	21.58	14.83	17.27	22.33	21.40
300	18.39	18.96	28.72	25.15	15.02	13.14	23.65	21.02	15.77	17.64	22.71	20.83
360	18.02	16.70	29.47	25.71	15.02	12.01	23.84	21.02	16.52	17.45	23.27	21.40

Table G-9 Cutting fluids effluent at pH 3 adsorption on chitosan for enthalpy, Entropy and Arrhenius

T (K)	K_d	1/T	ln (k_d/T)	ln (k_d)
306	0.059	0.003268	-8.5538	-2.83022
311	0.1072	0.003215	-7.97285	-2.23306
316	0.1529	0.003165	-7.63371	-1.87797
321	0.2038	0.003115	-7.36206	-1.59062

Table G-10 Cutting fluids effluent at pH 3 adsorption on blended chitosan/PVA 1:1 for enthalpy, entropy and Arrhenius

T (K)	K_d	1/T	ln (k_d/T)	ln (k_d)
306	0.079	0.003268	-8.26189	-2.53831
311	0.0518	0.003215	-8.70016	-2.96037
316	0.0726	0.003165	-8.37853	-2.62279
321	0.2176	0.003115	-7.29654	-1.5251

Table G-11 Cutting fluids effluent at pH 3 adsorption on benzoyl chitosan for enthalpy, entropy and Arrhenius

T (K)	K_d	1/T	ln (k_d/T)	ln (k_d)
306	0.0073	0.003268	-10.6435	-4.91988
311	0.0179	0.003215	-9.76275	-4.02295
316	0.0134	0.003165	-10.0682	-4.3125
321	0.0256	0.003115	-9.4366	-3.66516

Table G-12 Cutting fluids effluent at pH 3 adsorption on quateraminated chitosan for enthalpy, entropy and Arrhenius

T (K)	K_d	1/T	ln (k_d/T)	ln (k_d)
306	0.0105	0.003268	-10.28	-4.55638
311	0.0158	0.003215	-9.88754	-4.14775
316	0.0183	0.003165	-9.7566	-4.00085
321	0.0204	0.003115	-9.66366	-3.89222

Table G-13 Cutting fluids effluent at pH 3 adsorption on CH-SDS for enthalpy, entropy and Arrhenius

T (K)	K_d	1/T	ln (k_d/T)	ln (k_d)
306	0.0398	0.003268	-8.94747	-3.22389
311	0.0464	0.003215	-8.81025	-3.07046
316	0.067	0.003165	-8.4588	-2.70306
321	0.1466	0.003115	-7.69149	-1.92005

Table G-14 Cutting fluids effluent at pH 3 adsorption on BCH-SDS for enthalpy, entropy and Arrhenius

T (K)	K_d	1/T	ln (k_d/T)	ln (k_d)
306	0.0326	0.003268	-9.14703	-3.42344
311	0.0545	0.003215	-8.64935	-2.90955
316	0.0741	0.003165	-8.35808	-2.60234
321	0.0447	0.003115	-8.87922	-3.10778

Table G-15 Cutting fluids effluent at pH 3 adsorption on CH-C-Tab for enthalpy, entropy and Arrhenius

T (K)	K_d	1/T	ln (k_d/T)	ln (k_d)
306	0.0407	0.003268	-8.92511	-3.20153
311	0.0893	0.003215	-8.15555	-2.41575
316	0.0484	0.003165	-8.784	-3.02826
321	0.1368	0.003115	-7.76068	-1.98924

Table G-16 Cutting fluids effluent at pH 3 adsorption on BCH-C-Tab for enthalpy, entropy and Arrhenius

T (K)	K_d	1/T	ln (k_d/T)	ln (k_d)
306	0.0349	0.003268	-9.07885	-3.35527
311	0.0575	0.003215	-8.59576	-2.85597
316	0.0373	0.003165	-9.0445	-3.28876
321	0.0816	0.003115	-8.27737	-2.50593

Table G-17 Cutting fluids effluent at pH 3 adsorption on CH-Tween 80 for enthalpy, entropy and Arrhenius

T (K)	K_d	1/T	ln (k_d/T)	ln (k_d)
306	0.0512	0.003268	-8.6956	-2.97202
311	0.0675	0.003215	-8.43542	-2.69563
316	0.0438	0.003165	-8.88386	-3.12812
321	0.0848	0.003115	-8.2389	-2.46746

Table G-18 Cutting fluids effluent at pH 3 adsorption on BCH-Tween 80 for enthalpy, entropy and Arrhenius

T (K)	K_d	1/T	ln (k_d/T)	ln (k_d)
306	0.0367	0.003268	-9.02856	-3.30498
311	0.0481	0.003215	-8.77427	-3.03447
316	0.0469	0.003165	-8.81548	-3.05974
321	0.0572	0.003115	-8.63264	-2.8612

Table G-19 Cutting fluids effluent at pH 6.8 adsorption on chitosan for enthalpy, entropy and Arrhenius

T (K)	K_d	1/T	ln (k_d/T)	ln (k_d)
306	0.0113	0.003268	-10.2065	-4.48295
311	0.0135	0.003215	-10.0449	-4.30507
316	0.0143	0.003165	-10.0032	-4.2475
321	0.0296	0.003115	-9.29142	-3.51998

Table G-20 Cutting fluids effluent at pH 6.8 adsorption on blended chitosan/PVA 1:1 for enthalpy, entropy and Arrhenius

T (K)	K_d	1/T	ln (k_d/T)	ln (k_d)
306	0.0115	0.003268	-10.189	-4.46541
311	0.0138	0.003215	-10.0229	-4.28309
316	0.0184	0.003165	-9.75115	-3.9954
321	0.0209	0.003115	-9.63945	-3.86801

Table G-21 Cutting fluids effluent at pH 6.8 adsorption on benzoyl chitosan for enthalpy, entropy and Arrhenius

T (K)	K_d	1/T	ln (k_d/T)	ln (k_d)
306	0.0229	0.003268	-9.5002	-3.77662
311	0.0289	0.003215	-9.28371	-3.54391
316	0.037	0.003165	-9.05258	-3.29684
321	0.0362	0.003115	-9.09014	-3.3187

Table G-22 Cutting fluids effluent at pH 6.8 adsorption on quateraminated chitosan for enthalpy, entropy and Arrhenius

T (K)	K_d	1/T	ln (k_d/T)	ln (k_d)
306	0.016	0.003268	-9.85875	-4.13517
311	0.0184	0.003215	-9.7352	-3.9954
316	0.0243	0.003165	-9.47302	-3.71728
321	0.0285	0.003115	-9.32929	-3.55785

Table G-23 Cutting fluids effluent at pH 6.8 adsorption on CH-SDS for enthalpy, entropy and Arrhenius

T (K)	K_d	1/T	ln (k_d/T)	ln (k_d)
306	0.0239	0.003268	-9.45746	-3.73388
311	0.0244	0.003215	-9.45297	-3.71317
316	0.028	0.003165	-9.33129	-3.57555
321	0.0342	0.003115	-9.14697	-3.37553

Table G-24 Cutting fluids effluent at pH 6.8 adsorption on BCH-SDS for enthalpy, entropy and Arrhenius

T (K)	K_d	1/T	ln (k_d/T)	ln (k_d)
306	0.0184	0.003268	-9.71899	-3.9954
311	0.0155	0.003215	-9.90671	-4.16692
316	0.0226	0.003165	-9.54555	-3.78981
321	0.0233	0.003115	-9.53074	-3.7593

Table G-25 Cutting fluids effluent at pH 6.8 adsorption on CH-C-Tab for enthalpy, entropy and Arrhenius

T (K)	K_d	1/T	ln (k_d/T)	ln (k_d)
306	0.0143	0.003268	-9.97108	-4.2475
311	0.0148	0.003215	-9.95292	-4.21313
316	0.0173	0.003165	-9.81279	-4.05705
321	0.0211	0.003115	-9.62992	-3.85848

Table G-26 Cutting fluids effluent at pH 6.8 adsorption on BCH-C-Tab for enthalpy, entropy and Arrhenius

T (K)	K_d	1/T	ln (k_d/T)	ln (k_d)
306	0.0125	0.003268	-10.1056	-4.38203
311	0.0146	0.003215	-9.96653	-4.22673
316	0.0203	0.003165	-9.65288	-3.89713
321	0.0226	0.003115	-9.56125	-3.78981

Table G-27 Cutting fluids effluent at pH 6.8 adsorption on CH-Tween 80 for enthalpy, entropy and Arrhenius

T (K)	K_d	1/T	ln (k_d/T)	ln (k_d)
306	0.0122	0.003268	-10.1299	-4.40632
311	0.0126	0.003215	-10.1139	-4.37406
316	0.0207	0.003165	-9.63336	-3.87762
321	0.0211	0.003115	-9.62992	-3.85848

Table G-28 Cutting fluids effluent at pH 6.8 adsorption on BCH-Tween 80 for enthalpy, entropy and Arrhenius

T (K)	K_d	1/T	ln (k_d/T)	ln (k_d)
306	0.0133	0.003268	-10.0436	-4.31999
311	0.014	0.003215	-10.0085	-4.2687
316	0.0215	0.003165	-9.59544	-3.8397
321	0.0227	0.003115	-9.55683	-3.78539

Appendix H Continuous adsorption

Table H-1 Breakthrough profile for cutting fluids adsorption on chitosan, blended chitosan/PVA 1:1, CH-C-Tab, CH-Tween 80, BCH-C-Tab and BCH-Tween 80

Time (min)	Adsorbents					
	Chitosan	Blended chitosan/PVA 1:1	CH-C-Tab	CH-Tween 80	CH-C-Tab	CH-Tween 80
	C/C0	C/C0	C/C0	C/C0	C/C0	C/C0
0	0.00	0.00	0.00	0.00	0.00	0.00
15	0.39	0.22	0.71	0.86	0.80	0.69
30	0.61	0.51	0.85	0.90	0.83	0.80
60	0.82	0.67	0.88	0.91	0.88	0.94
90	0.90	0.77	0.94	0.96	0.92	0.98
120	0.95	0.80	0.97	0.98	0.95	1.00
150	0.99	0.86	0.98	1.00	0.95	
180	0.99	0.97	1.00		1.00	
210	1.00	0.98				
240		1.00				

Table H-2 Breakthrough profile for cutting fluids adsorption on benzoyl chitosan, quateraminated chitosan, CH-SDS, BCH-SDS

Time (h)	Adsorbents			
	Benzoyl chitosan	Quateraminated chitosan	CH-SDS	BCH-SDS
	C/C_o	C/C_o	C/C_o	C/C_o
0	0.00	0.00	0.00	0.00
1	0.02	0.00	0.14	0.07
2	0.03	0.00	0.18	0.07
3	0.04	0.00	0.19	0.07
4	0.04	0.00	0.21	0.08
5	0.05	0.01	0.22	0.09
6	0.05	0.04	0.23	0.09
7	0.06	0.07	0.24	0.10
8	0.06	0.08	0.26	0.10
9	0.05	0.09	0.27	0.11
10	0.05	0.09	0.27	0.11
24	0.08	0.18	0.32	0.35
26	0.08	0.19	0.36	0.38
28	0.12	0.19	0.38	0.41
30	0.15	0.24	0.38	0.43
32	0.17	0.25	0.39	0.45
34	0.19	0.26	0.40	0.47
36	0.20	0.27	0.41	0.50
38	0.22	0.29	0.42	0.51
40	0.23	0.32	0.42	0.56
48	0.42	0.44	0.49	0.69
50	0.43	0.44	0.52	0.71
56	0.49	0.48	0.56	0.74
72	0.76	0.54	0.79	0.75
76	0.86	0.57	0.85	0.77
80	0.90	0.58	0.91	0.81
96	0.93	0.57	1.00	0.88
100	0.95	0.60	1.00	0.90

Table H-2 Breakthrough profile for cutting fluids adsorption on benzoyl chitosan, quateraminated chitosan, CH-SDS, BCH-SDS (Continued)

Time (h)	Adsorbents			
	Benzoyl chitosan	Quateraminated chitosan	CH-SDS	BCH-SDS
	C/C_o	C/C_o	C/C_o	C/C_o
104	0.97	0.61		0.92
120	0.99	0.65		0.95
122	1.00	0.66		0.97
124		0.68		1.00
126		0.69		
128		0.70		
144		0.80		
146		0.82		
148		0.85		
150		0.86		
152		0.87		
168		1.00		

Table H-3 Breakthrough curves adsorption cutting fluids of chitosan at flow rate 0.50 – 2.00 cm^3/min

Flow rate (cm^3 /min)	0.50	1.00	2.00
Time (min)	C/C_o	C/C_o	C/C_o
0	0.00	0.00	0.00
15	0.39	0.90	0.97
30	0.61	0.95	1.00
60	0.82	1.00	
90	0.90		
120	0.95		
150	0.99		
180	1.00		

Table H-4 Breakthrough curves adsorption cutting fluids of blended chitosan/PVA 1:1 at flow rate 0.50 – 2.00 cm^3/min

Flow rate (cm^3 /min)	0.50	1.00	2.00
Time (min)	C/C_o	C/C_o	C/C_o
0	0.00	0.00	0.00
15	0.22	0.45	0.60
30	0.51	0.58	0.69
60	0.67	0.71	0.80
90	0.77	0.85	0.91
120	0.80	0.96	0.98
150	0.86	1.00	1.00
180	0.97		
210	0.98		
240	1.00		

Table H-5 Breakthrough curves adsorption cutting fluids of CH-SDS at flow rate 0.50 – 2.00 cm^3/min

Time (h)	Flow rate (cm^3/min)		
	0.50	1.00	2.00
	C/C_o	C/C_o	C/C_o
0	0.00	0.00	0.00
1	0.14	0.16	0.41
2	0.18	0.21	0.45
3	0.19	0.27	0.51
4	0.21	0.32	0.59
5	0.22	0.37	0.62
6	0.23	0.40	0.68
7	0.24	0.45	0.79
8	0.26	0.51	0.91
9	0.27	0.56	0.95
10	0.27	0.64	1.00
24	0.32	0.93	
26	0.36	0.95	
28	0.38	0.99	
30	0.38	1.00	
32	0.39		
34	0.40		
36	0.41		
38	0.42		
40	0.42		
48	0.49		
50	0.52		
56	0.56		
72	0.79		
76	0.85		
80	0.91		
96	1.00		
100	1.00		

Table H-6 Breakthrough curves adsorption cutting fluids of chitosan at bed depth 5.0 – 20.0 cm

Bed depth (cm)	5.0	10.0	15.0	20.0
Time (min)	C/C_o	C/C_o	C/C_o	C/C_o
0	0.00	0.00	0.00	0.00
15	0.78	0.59	0.52	0.39
30	0.88	0.81	0.77	0.61
60	0.95	0.91	0.88	0.82
90	1.00	0.99	0.96	0.90
120		1.00	0.97	0.95
150			0.99	0.99
180			1.00	1.00

Table H-7 Breakthrough curves adsorption cutting fluids of blended chitosan/PVA 1:1 at bed depth 5.0 – 20.0 cm

Bed depth (cm)	5.0	10.0	15.0	20.0
Time (min)	C/C_o	C/C_o	C/C_o	C/C_o
0	0.00	0.00	0.00	0.00
15	0.77	0.54	0.30	0.22
30	0.87	0.81	0.60	0.51
60	0.94	0.92	0.85	0.67
90	1.00	0.97	0.92	0.77
120		1.00	0.99	0.80
150			1.00	0.86
180				0.97
180				0.98
210				1.00

Table H-8 Breakthrough curves adsorption cutting fluids of CH-SDS at bed depth 5.0 – 20.0 cm

Bed depth (cm)	5.0	10.0	15.0	20.0
Time (h)	C/C_o	C/C_o	C/C_o	C/C_o
0	0.00	0.00	0.00	0.00
1	0.52	0.28	0.14	0.14
2	0.58	0.33	0.28	0.18
3	0.59	0.37	0.30	0.19
4	0.59	0.41	0.32	0.21
5	0.62	0.43	0.37	0.22
6	0.67	0.46	0.39	0.23
7	0.67	0.48	0.42	0.24
8	0.68	0.50	0.45	0.26
9	0.71	0.52	0.46	0.27
10	0.71	0.55	0.48	0.27
24	0.82	0.69	0.64	0.32
26	0.83	0.71	0.65	0.36
28	0.84	0.73	0.67	0.38
30	0.85	0.74	0.68	0.38
32	0.88	0.79	0.69	0.39
34	0.93	0.81	0.71	0.40
36	0.97	0.88	0.72	0.41
38	0.99	0.90	0.73	0.42
40	1.00	0.96	0.74	0.42
48		1.00	0.89	0.49
50			0.90	0.52
56			0.93	0.56
72			0.98	0.79
76			1.00	0.85
80				0.91
96				1.00

Table H-9 Isoremoval line for different bed depth height on chitosan

High (cm)	C/C_o		
	0.2	0.4	0.6
5.0	3.0	6.0	10.5
10.0	4.5	9.0	16.5
15.0	5.0	12.0	20.0
20.0	8.0	17.0	28.0

Table H-10 Isoremoval line for different bed depth height on blended chitosan/PVA 1:1

High (cm)	C/C_o		
	0.2	0.4	0.6
5.0	3.0	8.0	10.0
10.0	6.0	11.0	18.0
15.0	9.0	20.0	31.0
20.0	14.0	25.0	49.0

Table H-11 Isoremoval line for different bed depth height on CH-SDS

High (cm)	C/C_o		
	0.2	0.4	0.6
5.0	0.2	0.6	4.2
10.0	0.8	3.8	15.0
15.0	1.8	6.2	21.0
20.0	3.5	34.0	79.0

Table H-12 Breakthrough curve of adsorption of cutting fluids on chitosan type two column

Column A	
Time (min)	C/C_o
0	0.00
10	0.48
20	0.52
30	0.58
40	0.63
50	0.67
60	0.70
75	0.78
90	0.84
105	0.90
120	0.94
150	0.97
180	0.99
210	1.00

Column B	
Time (min)	C/C_o
180	0.00
190	0.60
200	0.69
210	0.75
220	0.81
230	0.88
240	0.94
255	0.99
270	0.99

Table H-13 Breakthrough curve of adsorption of cutting fluids on CH-SDS type two column

Time (h)	Column A
	C/C_o
0.0	0.00
0.5	0.36
1.0	0.38
1.5	0.40
2.0	0.42
2.5	0.43
3.0	0.50
3.5	0.53
4.0	0.55
5.0	0.56
6.0	0.60
24.0	0.72
25.0	0.75
26.0	0.78
27.0	0.79
28.0	0.81
29.0	0.90
30.0	0.97
31.0	1.00

Time (h)	Column B
	C/C_o
3.0	0.00
3.5	0.00
4.0	0.00
4.5	0.00
5.0	0.00
5.5	0.00
6.0	0.00
6.5	0.00
7.0	0.00
7.5	0.00
8.0	0.00
9.0	0.00
10.0	0.00
24.0	0.39
25.0	0.42
26.0	0.43
27.0	0.44
28.0	0.45
29.0	0.47
30.0	0.49
31.0	0.50
32.0	0.51
48.0	0.62
49.0	0.64
50.0	0.67
51.0	0.68
52.0	0.70
53.0	0.73
54.0	0.74

Table H-13 Breakthrough curve of adsorption of cutting fluids on CH-SDS type two column (Continued)

Time (min)	Column B
	C/C_o
55.0	0.77
56.0	0.80
57.0	0.81
72.0	0.94
73.0	0.96
74.0	0.97
75.0	0.98
76.0	1.00

Appendix I Reynolds number of motor stirrer speed

Reynolds number of mixing can be calculate from

$$N_{Re} = \frac{D^2 N \rho}{\mu}$$

where N_{Re} is Reynolds number, D is diameter of impeller (m, 0.04 m), N is rev/s (600 -21000 rpm), ρ is mass density of liquid (kg/m^3, 995.7) μ is dynamic viscosity (N-s/m^2, 0.798x10^{-3} at 30 ^{0}C)

Thus Reynolds of motor stirrer speed at 600 rpm is

$$N_{Re} = \frac{(0.04)^2 \times 600 \times 995.7}{0.798 \times 10^{-3}} = 1.2 \text{x} 10^6$$

Reynolds of motor stirrer speed at 1200 rpm is 2.4x10^6

Reynolds of motor stirrer speed at 2000 rpm is 4.0x10^6

Reynolds of motor stirrer speed at 21000 rpm is 42.1x10^6

Appendix J Calculated mass diffusivity of cutting fluids

$$\omega = \frac{5.88\times10^{-15}\times(xM)^{1/2}T}{\mu V^{0.6}}$$

where ω is mass diffusivity (m^2/s), M is molecular of solvent (kg/mol), T is temperature (K), μ is viscosity of solution (kg/m-s), V is molar volume of cutting fluids at the normal boiling point (m^3/mol) and *x* is association constant parameter of water (= 2.6 for water)

Cutting fluids has molecular weight correspond to average carbon number of C_{23} for naphthenic mineral oil.

Thus molar volume of C_{23} is $23x(14.8x10^{-6}) = 3.3x10^{-4}$ m^3/mol

$$\omega = \frac{5.88\times10^{-15}\times(2.6\times18\times10^{-3})^{1/2}298}{0.798\times10^{-3}\times(3.3\times10^{-4})^{0.6}} = 5.82x10^{-8}\ m^2/s$$

Appendix K Calculate effect of temperature on chitosan adsorption in static batch

The rate of adsorption can be described as being proportion of the concentration of the cutting fluids effluent, if first-order kinetics is assumed:

$$-\frac{dC}{dt} = K_d C_a$$

Integrating and rearranging the above Equation gives:

$$\ln \frac{C_t}{C_0} = -K_d t$$

The calculation parameters of thermodynamic were done by plot ln (C_t/C_0) verses time. The slope of these plot is adsorption rate constant (K_d, min^{-1}). The result of chitosan as adsorbent at temperature 33 to 48 ^{0}C of cutting fluid effluent and pH 3 was shown in Figure below.

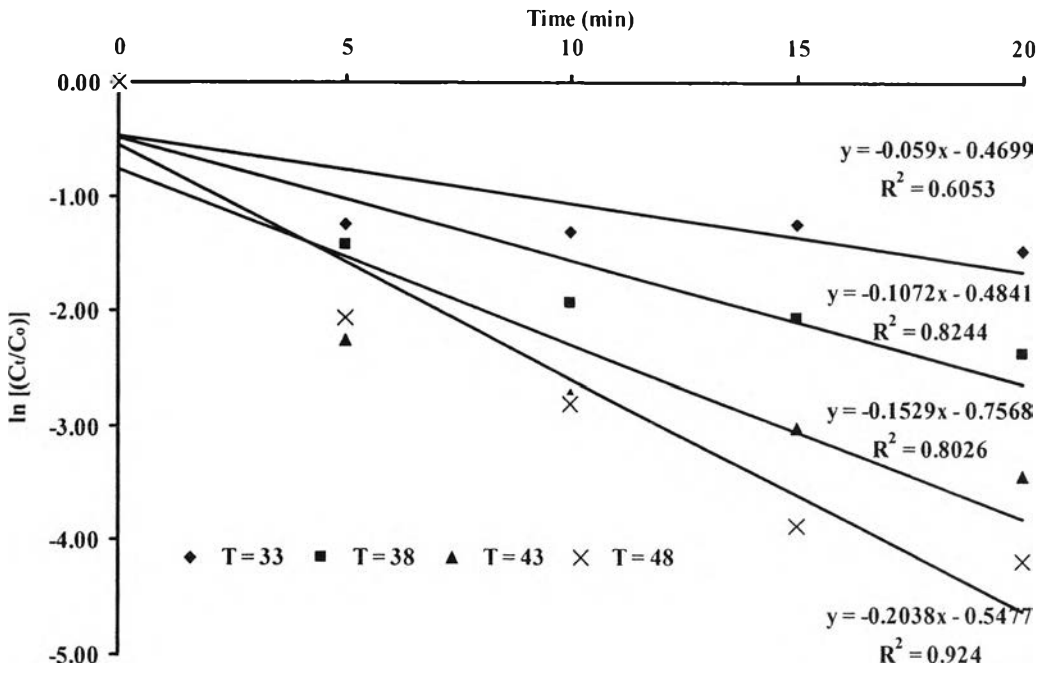


Figure Effect of temperature on effective adsorption on chitosan at pH 3

♦ 33 ^{0}C ■ 38 ^{0}C, ▲ 43 ^{0}C and ◊ 48^{0}C

The K_d was obtained from –slope of plot ln (C_t/C_0) verses time of effective adsorption of variation temperature from 33 to 48 ^{0}C. Thus K_d was collected in the below Table. The 1/T and ln(K_d/T) were calculated after know K_d and show in below Table too.

Table Adsorption rate constant on effective adsorption on chitosan at pH 3

T (K)	K_d (min^{-1})	1/T	ln (K_d/T)
306	0.059	0.003268	-8.5538
311	0.1072	0.003215	-7.97285
316	0.1529	0.003165	-7.63371
321	0.2038	0.003115	-7.36206

The adsorption rate constant can be expressed in term of enthalpy and entropy by the following Equation:

$$K_d = \left(\frac{\kappa T}{h_p}\right) e^{(\Delta S/R)} e^{(-\Delta H/RT)}$$

where h_p is the Planck's constant (6.6260x10^{-34}, J-sec), R is the gas constant (8.314 J/mol-K), T is the absolute temperature (K), ΔH is the enthalpy change during adsorption (kJ/mol), ΔS is the entropy change during adsorption (J/mol-K), κ is the Boltzmann's constant (1.38066x10^{-23}, J/K)

Plot of ln(K_d/T) versus 1/T gives a value of slope and intercept.

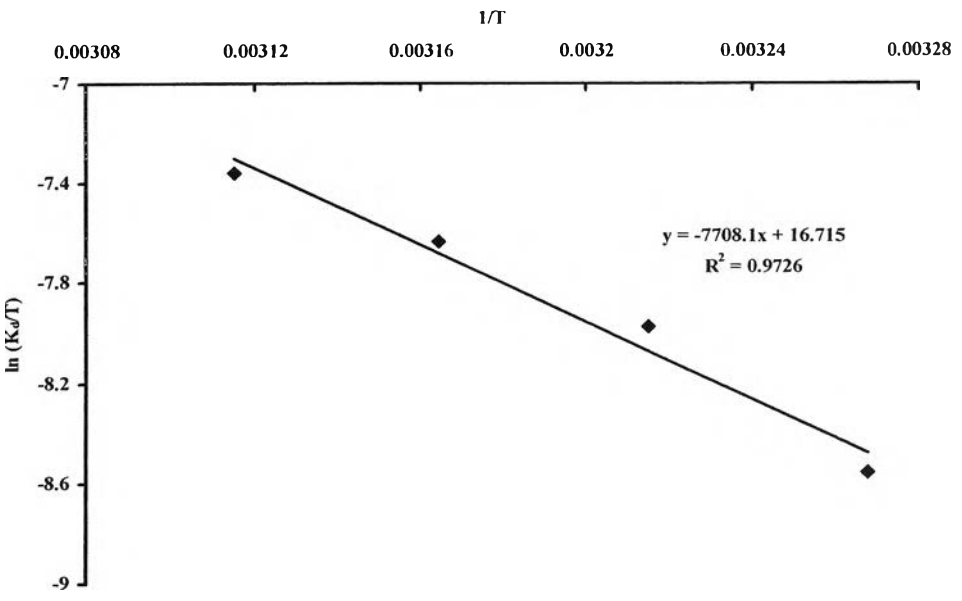


Figure. Plot for $\ln(K_d/T)$ versus 1/T of chitosan

The slope of $\ln(K_d/T)$ versus 1/T give ($\Delta H/R$). The intercept shows ln (κ/ h_p) + $\Delta S/R$. Therefore, enthalpy and entropy are obtained.

ΔH = -slope x R = -(-7708.1x8.314) = 64.09 kJ/mol

$$\Delta S = \left[Intercept - \ln \frac{\kappa}{h_p} \right] \times R$$

$$= \left[16.715 - \ln \frac{1.38066 \times 10^{-23}}{6.6260 \times 10^{-34}} \right] \times 8.314$$

= -58.56 J/(mol-K)

The Gibb free energy of adsorption may be determined in terms of entropy and enthalpy according

$$\Delta G = \Delta H - T\Delta S$$

ΔG at 306 K = 64090 – (306x(-58.56)

= 82009 J/mol

= 82.01 kJ/mol

Table Calculation Gibb free energy at temperature 306 to 321 K on chitosan

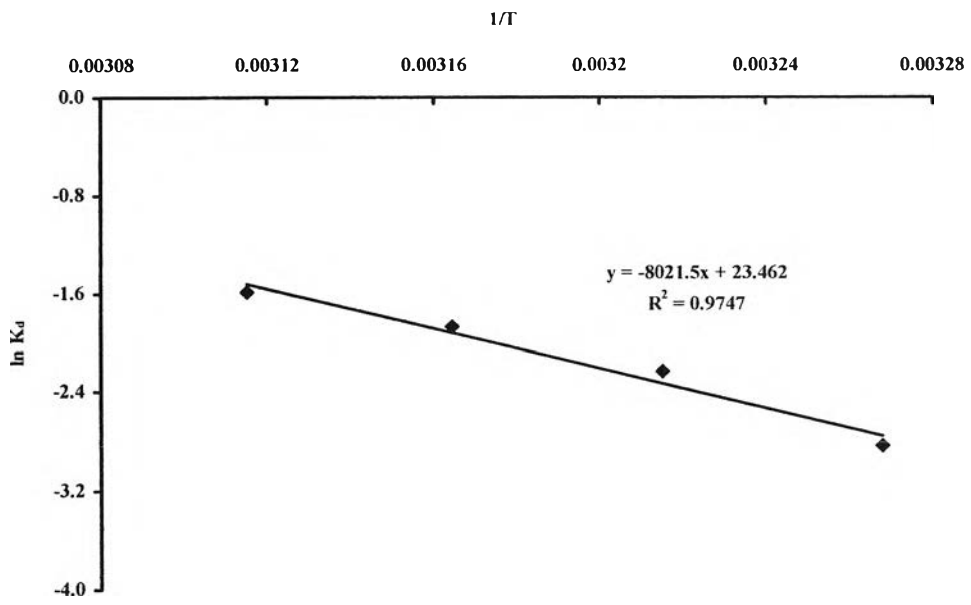
ΔG = ΔH-TΔS	ΔG (J/mol)
ΔG (T 306)	82005.67
ΔG (T 311)	82298.49
ΔG (T 316)	82591.31
ΔG (T 321)	82884.13
Average ΔG (J/mol)	**82444.9**

Activation energy was calculated from below Equation.

$$K_d = Ae^{(-E_a/RT)}$$

where A is the Arrhenius energy (min^{-1}) and E_a is the activation energy (kJ/mol)

The values of E_a and A are determined from the slope and intercept of plot $\ln(K_d)$ versus 1/T.



- Slope = E_a/R

E_a = (-Slope x R)

= (-8021.5 x 8.314)

= 66690.75 J/mol

= 66.69 kJ/mol

Appendix L Compare cost of adsorbents of CH, CH-SDS and BCH-SDS

Cost of chemicals

chitosan 1 kg	2500 baht
Sodium luaryl sulfate 0.5 kg	600 baht
Acetic acid 2.5 l	600 baht
Deionizated water 20 l	70 baht

1. Calculated cost from motor stirrer (70 W, 220 V, 50 Hz)

$$P = I \times E$$

Where is power (W), E is voltage (V) and I is electricity (A)

$$I = \frac{P}{E} = \frac{70}{220} = 0.3 \text{ A}$$

Calculated stirrer chitosan solution 100 cm^3

$$\text{Quantitative electric power} = \frac{I \times E \times t}{V} = \frac{0.3 \times 220 \times 24}{0.1} = 15.84 \frac{kWh}{l}$$

Rate of electricity = 1.357 baht/unit

Cost of electricity = 1.357x 15.84 = **21.50 baht/l**

2. Calculated cost of chitosan solution

$$\text{Using chitosan 2 g for prepared chitosan solution} = \frac{2500 \times 2}{1000} = 5 \text{ baht/100 cm}^3$$

or **50 baht/1000 cm^3 chitosan solution**

3. Calculated cost of Acetic acid solution

Acetic acid 2 cm^3 have cost $= \frac{600 \times 2}{2500}$

$= 0.48$ baht/ 100 cm^3 of acetic acid 2 % w/v

Thus acetic acid = **4.8 baht/chitosan 1000 cm^3 chitosan solution**

4. Calculated cost of SDS solution

SDS 1 g have cost = $\frac{600 \times 1}{500} = 1.2$ baht

1 time of inject SDS have cost $\frac{5 \times 20}{100} = 1.2$ baht/100 cm^3 chitosan solution

Thus SDS = **12 baht/1000 cm^3 chitosan solution**

5. Calculated cost of DI water

DI water have cost = 70 baht/20 l

1.0 l of DI water = 3.5 baht

Amount of DI water to used for prepared = 3.0 l (Chitosan solution + SDS + Aceetic acid)

Thus total cost of DI water = **10.5 bath**

6. Calculated cost of PVA solution

PVA 1.0 kg have cost 3000 baht; 1 g of PVA = 3 baht

DI 1000 cm^3 used PVA = $\frac{4 \times 1000}{100} = 40$ g

Show cost = **160 baht/1000 cm^3 of DI**

7. Calculated stirrer blended chitosan/PVA solution (hot plate stirrer, 500 W, 220 V)

Electricity of stirrer blended chitosan/PVA solution = $\frac{P}{E} = \frac{500}{220}$ 2.27 A

Quantitative electric power = $\frac{I \times E \times t}{V} = \frac{2.27 \times 220 \times 12}{0.1} \frac{kWh}{l}$ = 81.46 baht/ 1000 cm^3 PVA solution

A. Cost of prepared chitosan bead to treat cutting fluids effluent

Cost of prepared chitosan solution = Electricity + chitosan solution + Acetic acid + DI water 2.0 l

= 21.50 + 50 + 4.8 + 7

= 83.3 baht/l

1000 cm^3 of chitosan solution obtained 1260 g of chitosan bead

Each batch used cutting fluids effluent 50 cm^3 used chitosan bead = 2 g

Thus 1000 cm^3 of cutting fluids effluent used chitosan bead = 40 g

40 g of chitosan bead to treat cutting fluids effluent = $\frac{83.3 \times 40}{1260}$ = **2.64 baht**

B. Cost of prepared CH-SDS to treat cutting fluids effluent

Cost of prepared CH-SDS fiber = Electricity + Chitosan solution + Acetic acid + SDS + DI water 3.0 l

= 21.5 + 50 + 12 + 4.8 + 10.5

= 98.8 baht/l

1000 cm^3 chitosan obtained CH-SDS 49.9 g of CH-SDS

Each batch used cutting fluids effluent 50 cm^3 used CH-SDS = 2 g

Thus 1000 cm^3 of cutting fluids effluent used CH-SDS = 40 g

40 g of chitosan bead to treat cutting fluids effluent = $\frac{98.8 \times 40}{49.9}$ = **79.20 baht**

C. Cost of prepared BCH-SDS to treat cutting fluids effluent

Cost of prepared BCH-SDS fiber = Electricity + Chitosan solution + Acetic acid + SDS + DI water 4.0 l + PVA solution + Stirrer PVA solution

= 21.50 + 50 + 4.8 + 12 + 14 + 160 + 81.46

= 343.76 baht/l

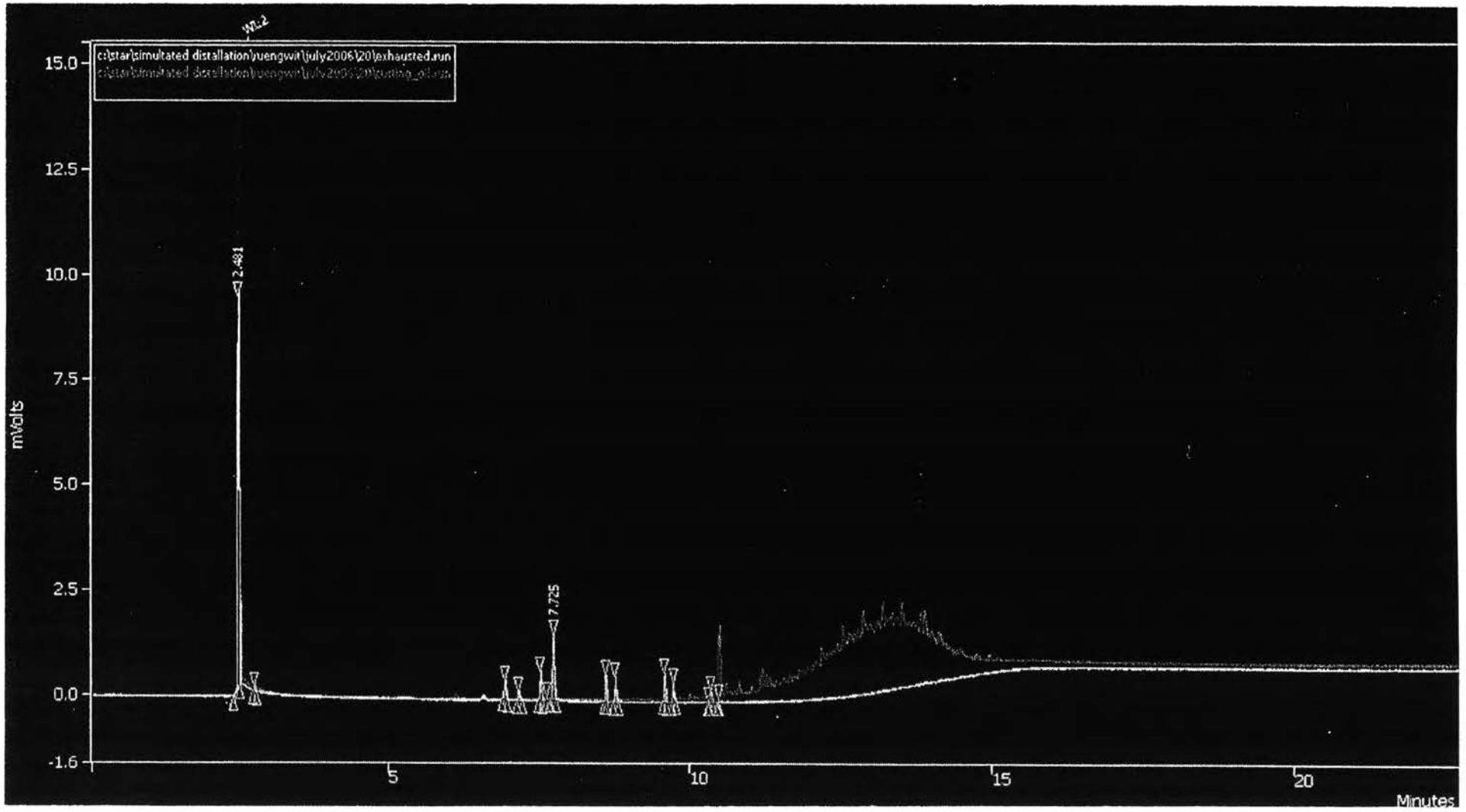
1000 cm^3 chitosan obtained CH-SDS 46.8 g of CH-SDS

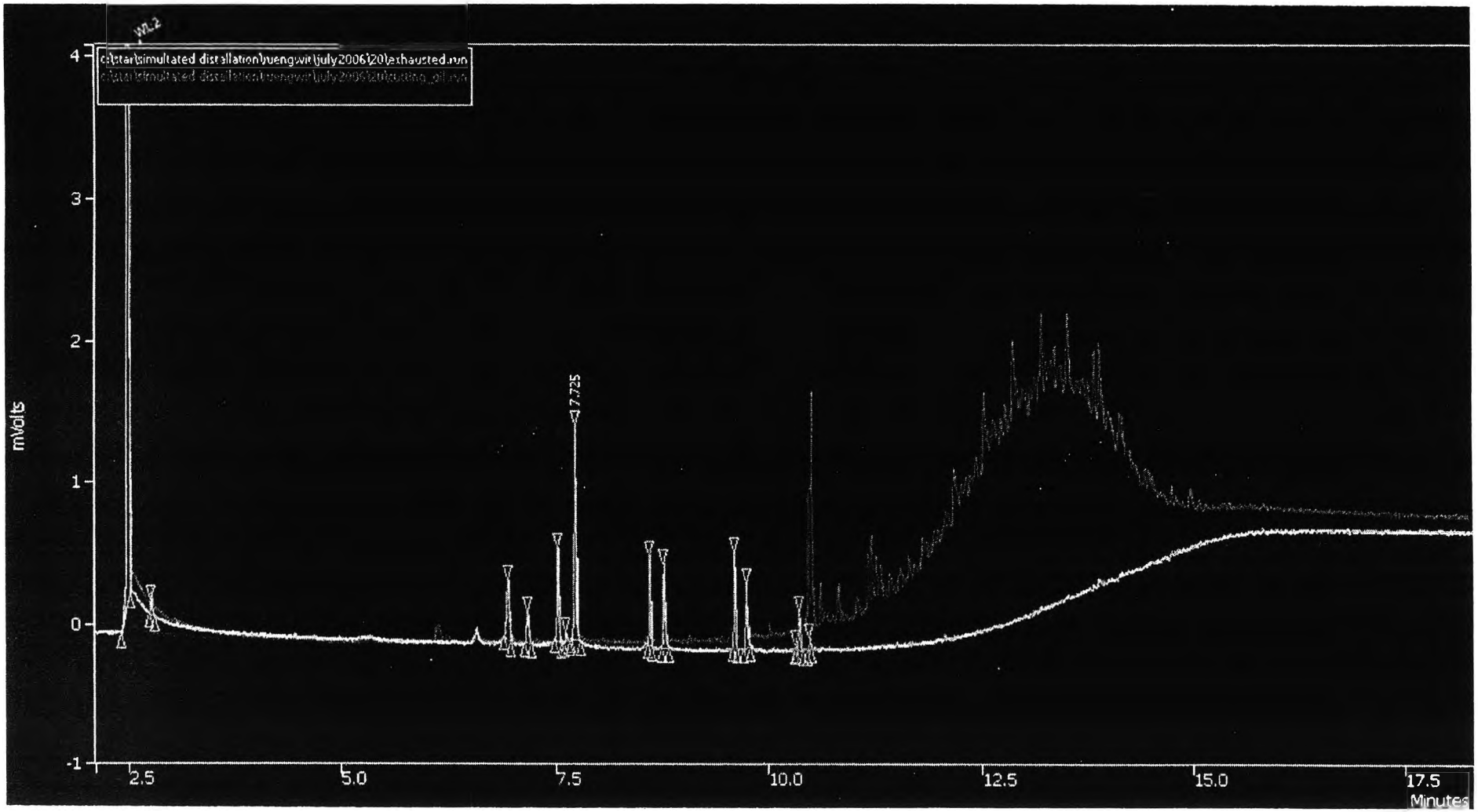
Each batch used cutting fluids effluent 50 cm^3 used CH-SDS = 2 g

Thus 1000 cm^3 of cutting fluids effluent used CH-SDS = 40 g

40 g of chitosan bead to treat cutting fluids effluent = $\frac{343.76 \times 40}{46.8}$ = **293.82 baht**

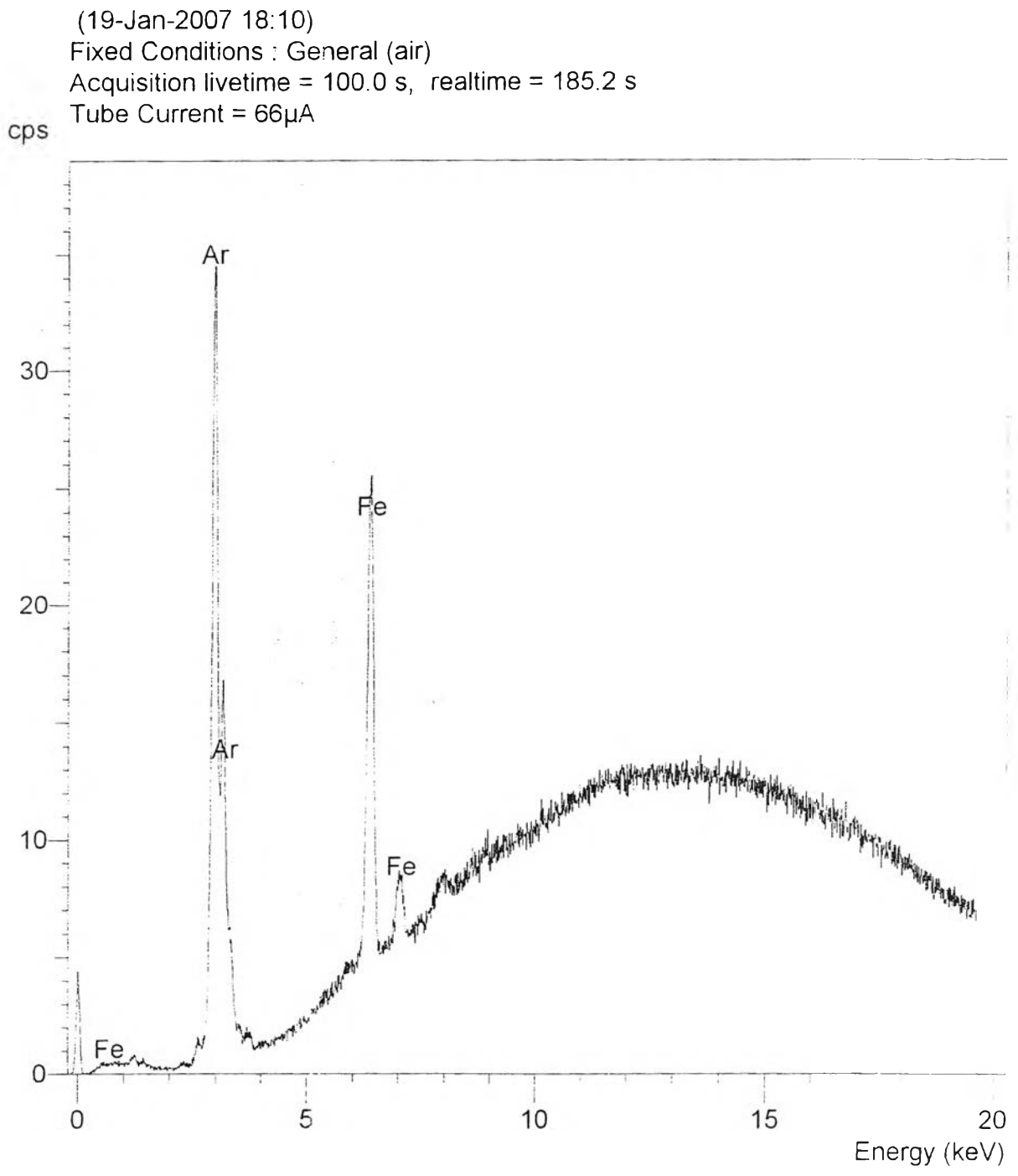
Appendix M GC chromatrgram of cutting fluids




c:\star\simultated distallation\bueng wit\july2006\20\exhausted.run
4
3
2
1
0
-1
mVolts
7.735
2.5
5.0
7.5
10.0
12.5
15.0
17.5
Minutes

Appendix N XRFS spectrum

Appendix N-1 XRFS spectrum of cutting fluids effluent



Appendix N-2 Percent element in cutting fluids effluent from drilling process

Sample: cutting fluid waste01
Fri 1/19/2007 at 4:35:23 PM
Method Name: Oxford: Geol. Majors + Traces

Analyte	Concentration
H2O	0.00 Wt %
CO2	0.00 Wt %
Na2O	0.00 Wt %
MgO	8.84 Wt %
Al2O3	5.55 Wt %
SiO2	5.77 Wt %
P2O5	6.63 Wt %
S	5.25 Wt %
Cl	1.74 Wt %
K2O	2.73 Wt %
CaO	2.50 Wt %
Sc	0.00 Wt %
TiO2	3815.7281ppm
V	124.4904ppm
Cr	268.3501ppm
MnO	5526.3347ppm
Fe2O3	54.96 Wt %
Co	2229.3776ppm
Ni	1244.9846ppm
Cu	1.09 Wt %
Zn	2.07 Wt %
Ga	373.3816ppm
Ge	0.00 Wt %
As	788.9328ppm
Se	0.00 Wt %
Br	856.8334ppm
Rb	0.00 Wt %
Sr	245.9584ppm
Y	40.0197ppm
Zr	332.7820ppm
Hf	5774.7479ppm
Ta	0.00 Wt %
W	0.00 Wt %
Hg	708.4656ppm
Tl	490.9447ppm
Pb	302.3978ppm
Bi	254.0914ppm
Th	0.00 Wt %
U	0.00 Wt %
Nb	0.00 Wt %
Mo	117.8900ppm
Ag	0.00 Wt %
Cd	88.9288ppm
In	0.00 Wt %
Sn	433.1238ppm
Sb	147.6203ppm
Te	0.00 Wt %
I	0.00 Wt %
Cs	0.00 Wt %
Ba	1637.0782ppm
La	1154.5750ppm
Ce	1177.3556ppm
Pr	556.1135ppm
Nd	0.00 Wt %

Appendix N-3 Percent element in cutting fluids effluent from turning process

Sample: Cutting fluid waste02
Fri 1/19/2007 at 5:05:06 PM
Method Name: Oxford: Geol. Majors + Traces

Analyte	Concentration
H2O	0.00 Wt %
CO2	0.00 Wt %
Na2O	0.00 Wt %
MgO	12.74 Wt %
Al2O3	7.39 Wt %
SiO2	3.59 Wt %
P2O5	10.87 Wt %
S	5.31 Wt %
Cl	3.92 Wt %
K2O	14.96 Wt %
CaO	5.56 Wt %
Sc	0.00 Wt %
TiO2	9801.3817ppm
V	461.3142ppm
Cr	153.4307ppm
MnO	6433.1508ppm
Fe2O3	30.09 Wt %
Co	1810.2724ppm
Ni	543.8526ppm
Cu	8407.9383ppm
Zn	1.22 Wt %
Ga	417.1954ppm
Ge	0.00 Wt %
As	455.3660ppm
Se	396.5028ppm
Br	827.2341ppm
Rb	119.9952ppm
Sr	0.00 Wt %
Y	0.00 Wt %
Zr	158.7191ppm
Hf	4042.4825ppm
Ta	0.00 Wt %
W	0.00 Wt %
Hg	611.3532ppm
Tl	0.00 Wt %
Pb	1251.9333ppm
Bi	2091.8153ppm
Th	0.00 Wt %
U	0.00 Wt %
Nb	66.8037ppm
Mo	51.9678ppm
Ag	31.0940ppm
Cd	0.00 Wt %
In	0.00 Wt %
Sn	742.2054ppm
Sb	0.00 Wt %
Te	0.00 Wt %
I	370.0348ppm
Cs	319.4386ppm
Ba	0.00 Wt %
La	3502.4292ppm
Ce	0.00 Wt %
Pr	397.1706ppm
Nd	0.00 Wt %

BIOGRAPHY

Mr. Kowit Piyamongkala was born on July 24, 1967, in Nakhon Ratchasima province, Thailand. He received the Bachelor's Degree in Industrial Chemistry form the Faculty of Applied Science, King Mongukut's Institute of Technology North Bangkok in 1992 and Master's Degree in Environmental Technology, Faculty of Energy and Material, King Mongkut's Institute of Thonburi in 1997.

The conference and patent involving his research are the following

International conference

1. Piyamongkala, K., Pongstabodee, S. and Mekasut, L., "Adsorption of Coolant Oil onto Chitin and Chitosan Resin", RSCE 2004, December 2004, Bangkok, Thailand

2. Piyamongkala, K., Pongstabodee, S. and Mekasut, L., "Cutting Fluid Removal in Packed-bed Column on Modified Chitosan", ASCON FBR 2006, November 2006, Busan, Korea.

3. Piyamongkala, K., Pongstabodee, S. and Mekasut, L., "Equilibrium Adsorption of Cutting Fluid Emulsion from Turning Effluent on Chitosan Beads and Blend Chitosan Polyvinyl Alcohol", 2 nd MPSGC, December 2006, Singapore.

Patent

Kowit Piyamongkala, Ssngobtip Pongstabodee and Lursuang Mekasut, "Soluble Metalworking Fluid Material Made by Modified Biopolymer" Patent No. 0601004582