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APPENDIX

Table A1 Adsorption isotherm of CTAB on clinoptilolite at 30 °C

Weight of clinoptilolite = 0.2 g
 Volume of CTAB solution = 20 ml
 Molecular weight of CTAB = 364.46 g/mol

No.	Initial concentration		Equilibrium concentration		Amount of CTAB on clinoptilolite(μmol)	Amount of CTAB adsorbed (μmol /g of clinoptilolite)
	(ppm)	(μM)	(ppm)	(μM)		
1	46.1279	126.5650	6.3070	17.3051	2.1852	10.9260
2	92.2539	253.1250	9.5250	26.1346	4.5398	22.6990
3	138.3126	379.5000	14.4000	39.5105	6.7998	33.9989
4	184.5079	506.2500	36.3300	99.6817	8.1314	40.6568
5	307.5131	843.7500	94.3800	258.9585	11.6958	58.4792
6	615.0263	1687.5000	250.8000	688.1414	19.9872	99.9359
7	922.5394	2531.2500	452.6000	1241.8372	25.7883	128.9413
8	1230.0525	3375.0000	654.1000	1794.7100	31.6058	158.0290
9	1599.0683	4387.5000	902.4000	2475.9919	38.2302	191.1508
10	1722.0735	4725.0000	1018.0000	2793.1735	38.6365	193.1827
11	2050.0875	5625.0000	1354.0000	3715.0853	38.1983	190.9915

Table A2 Zeta – Potential data for CTAB adsorption on clinoptilolite

No.	Amount of surfactant adsorbed (μmol/g)	zeta potential (mV)					
		1 st	2 nd	3 rd	4 th	5 th	average
1	10.92599459	-23.62	-22.32	-23.95	-23.52	-22.89	-23.26
2	22.69904448	-18.26	-19.25	-21.33	-22.36	-21.9	-20.62
3	33.99894913	-16.32	-19.02	-18.22	-15.33	-19.21	-17.62
4	40.65682791	-13.26	-12.32	-16.33	-17.65	-19.74	-15.86
5	58.47915409	-9.66	-9.89	-8.65	-8.23	-9.72	-9.23
6	99.93586402	2.03	1.94	2.52	2.33	2.33	2.23
7	128.9412761	20.88	19.65	18.98	22.55	19.74	20.36
8	158.0290018	24.68	21.33	27.15	25.96	30.08	25.84
9	191.1508122	29.44	30.25	28.24	27.51	25.31	28.15
10	193.1826538	30.21	29.25	29.12	28.42	29.15	29.23
11	190.9914668	28.66	29.21	27.56	28.45	25.92	27.96

Table A3 Amount of cadmium adsorbed on clinoptilolite at pH 8 as a function of time

Weight of Clinoptilolite = 1.0 g
 Volume of cadmium solution = 200 ml
 Initial concentration of cadmium = 400 mg/l

No.	Time (min)	Equilibrium concentration of cadmium (mg/l)	Percent cadmium in solution
1	0	150	100.00
2	1	100	66.67
3	2	98	65.33
4	3	97	64.67
5	4	96	64.00
6	5	93	62.00
7	6	94	62.67
8	8	92	61.33
9	10	92	61.33
10	15	90	60.00
11	20	88	58.67
12	30	85	56.67
13	45	80	53.33
14	60	73	48.67
15	90	64	42.67
16	120	53	35.33
17	150	48	32.00
18	180	35	23.33
19	210	33	22.00
20	240	24	16.00
21	300	25	16.67
22	360	21	14.00

Table A4 Amount of cadmium adsorbed on SMZ at pH 8 as a function of time

Weight of SMZ = 1.0 g
 Volume of cadmium solution = 200 ml
 Initial concentration of cadmium = 400 mg/l

No.	Time (min)	Equilibrium concentration of cadmium (mg/l)	Percent cadmium in solution
1	0	150	100.00
2	1	116	77.33
3	2	107	71.33
4	3	106	70.67
5	4	105	70.00
6	5	107	71.33
7	6	107	71.33
8	8	105	70.00
9	10	102	68.00
10	15	100	66.67
11	20	100	66.67
12	30	101	67.33
13	45	95	63.33
14	60	88	58.67
15	90	87	58.00
16	120	84	56.00
17	150	70	46.67
18	180	68	45.33
19	210	67	44.67
20	240	68	45.33
21	300	66	44.00
22	360	70	46.67

Table A5 Adsorption isotherm of cadmium on clinoptilolite at pH 4,7 and 8

Weight of clinoptilolite = 0.2 g

Volume of cadmium solution = 40 ml

pH 4			
No.	Initial concentration of cadmium (ppm)	Equilibrium concentration of cadmium (ppm)	Amount of Cadmium adsorbed (mg of cadmium / g of clinoptilolite)
1	50	1.17	9.77
2	100	7.50	18.50
3	150	27.20	24.56
4	200	60.00	28.00
5	250	90.00	32.00
6	300	125.00	35.00
7	400	204.00	39.20
pH 7			
No.	Initial concentration of cadmium (ppm)	Equilibrium concentration of cadmium (ppm)	Amount of Cadmium adsorbed (mg of cadmium / g of clinoptilolite)
1	50	0.80	9.84
2	100	4.90	19.02
3	150	16.90	26.62
4	200	51.00	29.80
5	250	80.00	34.00
6	300	126.00	34.80
7	400	186.00	42.80
pH 8			
No.	Initial concentration of cadmium (ppm)	Equilibrium concentration of cadmium (ppm)	Amount of Cadmium adsorbed (mg of cadmium / g of clinoptilolite)
1	50	1.20	9.76
2	100	10.00	18.00
3	150	25.00	25.00
4	200	51.00	29.80
5	250	74.00	35.20
6	300	116.00	36.80
7	400	182.00	43.60

Table A6 Adsorption isotherm of cadmium on SMZ at pH 4, 7 and 8

Weight of SMZ = 0.2 g

Volume of cadmium solution = 40 ml

pH 4			
No.	Initial concentration of cadmium (ppm)	Equilibrium concentration of cadmium (ppm)	Amount of Cadmium adsorbed (mg of cadmium / g of clinoptilolite)
1	50	15.90	6.82
2	100	47.00	10.60
3	150	85.00	13.00
4	200	128.00	14.40
5	250	170.00	16.00
6	300	212.00	17.60
7	400	300.00	20.00
pH 7			
No.	Initial concentration of cadmium (ppm)	Equilibrium concentration of cadmium (ppm)	Amount of Cadmium adsorbed (mg of cadmium / g of clinoptilolite)
1	50	10.80	7.84
2	100	45.00	11.00
3	150	79.00	14.20
4	200	120.00	16.00
5	250	161.00	17.80
6	300	201.00	19.80
7	400	292.00	21.60
pH 8			
No.	Initial concentration of cadmium (ppm)	Equilibrium concentration of cadmium (ppm)	Amount of Cadmium adsorbed (mg of cadmium / g of clinoptilolite)
1	50	13.40	7.32
2	100	43.00	11.40
3	150	72.00	15.60
4	200	108.00	18.40
5	250	141.00	21.80
6	300	183.00	23.40
7	400	254.00	29.20

Table A7 Adsorption of cadmium on clinoptilolite at pH 8 and ionic strength 0, 10 and 100 mM.

Weight of clinoptilolite = 0.2 g
 Volume of cadmium solution = 40 ml

No.	ionic strength (mM)	Initial concentration of cadmium (ppm)	Equilibrium concentration of cadmium (ppm)	Amount of Cadmium adsorbed (mg of cadmium / g of clinoptilolite)
1	0	400	182	43.60
2	10	400	289	22.20
3	100	400	330	14.00

Table A8 Adsorption of cadmium on SMZ at pH 8 and ionic strength 0, 10 and 100 mM.

Weight of SMZ = 0.2 g
 Volume of cadmium solution = 40 ml

No.	ionic strength (mM)	Initial concentration of cadmium (ppm)	Equilibrium concentration of cadmium (ppm)	Amount of Cadmium adsorbed (mg of cadmium / g of clinoptilolite)
1	0	400	254	29.20
2	10	400	258	28.40
3	100	400	265	27.00

Table A9 Adsorption isotherm of toluene on clinoptilolite at pH 4,7 and 8

Weight of clinoptilolite	=	0.1	g
Volume of toluene solution	=	22.5	ml
Molecular weight of Toluene	=	92	g/mol

pH 4					
No.	Initial concentration of toluene		Equilibrium concentration of toluene		Amount of toluene adsorbed ($\mu\text{mol/g}$)
	(ppm)	(μM)	(ppm)	(μM)	
1	101.7440	1105.9127	87.1923	947.7420	35.5884
2	172.1027	1870.6816	149.4284	1624.2213	55.4536
3	395.7654	4301.7982	345.8173	3758.8832	122.1559
4	515.9887	5608.5732	443.3921	4819.4794	177.5461
5	573.9563	6238.6558	490.8814	5335.6679	203.1723
pH 7					
No.	Initial concentration of toluene		Equilibrium concentration of toluene		Amount of toluene adsorbed ($\mu\text{mol/g}$)
	(ppm)	(μM)	(ppm)	(μM)	
1	106.3960	1156.4777	97.7297	1062.2788	21.1948
2	191.8944	2085.8088	173.4151	1884.9467	45.1940
3	349.0397	3793.9094	311.2023	3382.6341	92.5370
4	547.9476	5955.9524	490.1542	5327.7636	141.3425
5	555.7430	6040.6852	491.8113	5345.7750	156.3548
pH 8					
No.	Initial concentration of toluene		Equilibrium concentration of toluene		Amount of toluene adsorbed ($\mu\text{mol/g}$)
	(ppm)	(μM)	(ppm)	(μM)	
1	97.3018	1057.6281	88.2150	958.8583	22.2232
2	162.2077	1763.1273	147.8107	1606.6382	35.2100
3	284.9929	3097.7494	262.6892	2855.3173	54.5472
4	513.2457	5578.7571	464.7916	5052.0824	118.5018
5	531.2146	5774.0719	478.5419	5201.5422	128.8192

Table A10 Adsorption isotherm of toluene on SMZ at pH 4, 7 and 8

Weight of SMZ = 0.1 g

Volume of toluene solution = 22.5 ml

pH 4					
No.	Initial concentration of toluene		Equilibrium concentration of toluene		Amount of toluene adsorbed ($\mu\text{mol/g}$)
	(ppm)	(μM)	(ppm)	(μM)	
1	97.6903	1061.8513	49.9822	543.2850	116.6774
2	138.4421	1504.8056	73.4123	797.9603	159.0402
3	338.2730	3676.8804	163.7169	1779.5319	426.9034
4	451.5390	4908.0327	199.1466	2164.6373	617.2640
5	489.9121	5325.1313	213.1535	2316.8856	676.8553
pH 7					
No.	Initial concentration of toluene		Equilibrium concentration of toluene		Amount of toluene adsorbed ($\mu\text{mol/g}$)
	(ppm)	(μM)	(ppm)	(μM)	
1	100.1582	1088.6765	60.6057	658.7576	96.7318
2	148.3138	1612.1064	84.5020	918.5003	156.0614
3	340.7409	3703.7056	168.1823	1828.0683	422.0184
4	426.8598	4639.7808	208.7980	2269.5433	533.3034
5	440.5537	4788.6276	213.5787	2321.5079	555.1019
pH 8					
No.	Initial concentration of toluene		Equilibrium concentration of toluene		Amount of toluene adsorbed ($\mu\text{mol/g}$)
	(ppm)	(μM)	(ppm)	(μM)	
1	89.1789	969.3355	55.4100	602.2824	82.5869
2	172.5895	1875.9733	107.2036	1165.2562	159.9113
3	305.2787	3318.2468	191.1824	2078.0700	279.0398
4	379.4409	4124.3579	233.5402	2538.4803	356.8225
5	474.4005	5156.5269	274.7585	2986.5055	488.2548

Table A11 Adsorption of cadmium on SMZ in the presence of toluene at pH 8

Weight of SMZ	=	0.1	g
Volume of mixed solutes solution	=	22.50	ml
Initial concentration of cadmium	=	150	mg/l
Initial concentration of toluene	=	4000	$\mu\text{mol/l}$

No.	Initial concentration of cadmium (ppm)	Equilibrium concentration of cadmium (ppm)	Amount of Cadmium adsorbed (mg of cadmium / g of SMZ)
1	150	79.00	14.20
2	150	87.00	12.60
3	150	85.00	13.00
4	150	70.00	16.00
Average	150	80.25	13.95

Table A12 Adsorption of toluene on SMZ in the presence of cadmium at pH 8

Weight of SMZ	=	0.1	g
Volume of mixed solutes solution	=	22.50	ml
Initial concentration of cadmium	=	150	mg/l
Initial concentration of toluene	=	4000	$\mu\text{mol/l}$

No.	Initial concentration of toluene		Equilibrium concentration of toluene		Amount of toluene adsorbed ($\mu\text{mol/g}$)
	(ppm)	(μM)	(ppm)	(μM)	
1	100.1582	1088.6765	60.6057	658.7576	96.7318
2	148.3138	1612.1064	84.5020	918.5003	156.0614
3	340.7409	3703.7056	168.1823	1828.0683	422.0184
4	426.8598	4639.7808	208.7980	2269.5433	533.3034
Average	440.5537	4788.6276	213.5787	2321.5079	555.1019

Table A13 Adsorption and desorption of cadmium by SMZ

Weight of SMZ = 0.2 g
Volume of cadmium solution = 40 ml
Initial concentration of cadmium = 280 mg/l
Volume of acid solution = 40 ml

The adsorption and desorption of cadmium by SMZ was performed at pH 8 and pH 3 respectively.

No.	Adsorption				Desorption	
	Initial concentration of cadmium (ppm)	Equilibrium concentration of cadmium (ppm)	Amount of cadmium adsorbed (mg of cadmium)	Amount of cadmium adsorbed (mg of cadmium / g of SMZ)	Cadmium concentration in aqueous phase (ppm)	Amount of Cadmium desorbed (mg of cadmium)
1	280.00	166.00	4.56	22.80	99.18	3.9672
2	280.00	163.00	4.68	23.40	90.09	3.6036
3	280.00	162.00	4.72	23.60	93.96	3.7584
4	280.00	164.00	4.64	23.20	101.48	4.0592
Average	280.00	163.75	4.65	23.25	96.18	3.8471

Table A14 Adsorption and desorption of toluene by SMZ

Weight of SMZ = 0.1 g
Volume of cadmium solution = 22.5 ml
Initial concentration of toluene = 4000 $\mu\text{mol/l}$

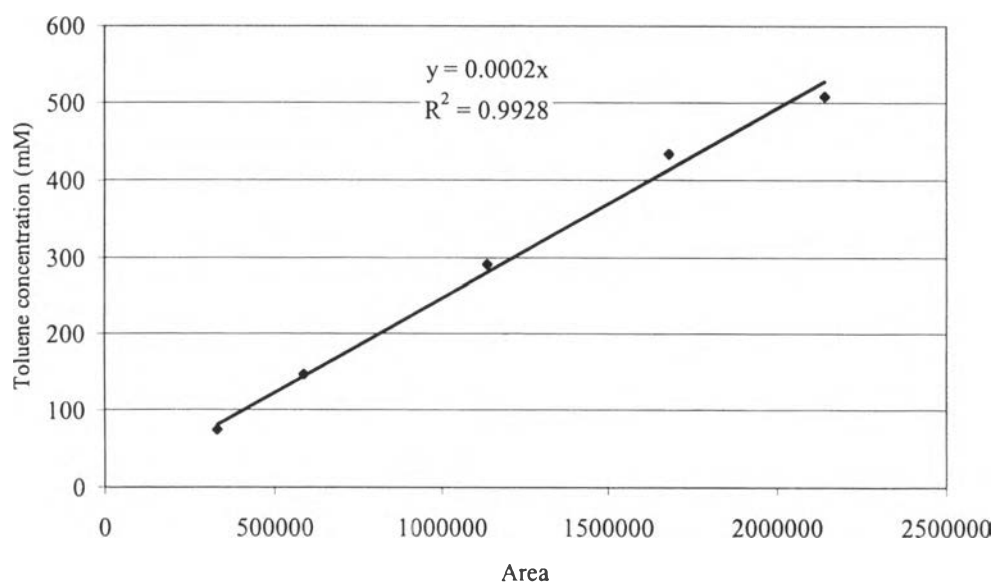
Desorption of toluene by SMZ was performed by air purging.

No.	Adsorption						Desorption		
	Initial concentration of toluene		Final concentration of toluene		Amount of toluene	Amount of toluene	Toluene concentration in aqueous phase		Amount of toluene
	(ppm)	(μM)	(ppm)	(μM)	adsorbed (μmol)	adsorbed ($\mu\text{mol/g}$)	(ppm)	(μM)	desorbed (μmol)
1	73.49	798.82	22.01	239.26	12.59	125.90	50.76	551.77	12.4148
2	73.49	798.82	22.02	239.34	12.59	125.88	50.65	550.51	12.3866
3	73.49	798.82	20.54	223.32	12.95	129.49	50.04	543.88	12.2372
4	73.49	798.82	21.35	232.04	12.75	127.53	50.22	545.89	12.2826
Average	73.49	798.82	21.48	233.49	12.72	127.20	50.42	548.01	12.3303

Table A15 Calibration curve of toluene by Head space gas chromatography

Density of toluene = 0.876 g/ml

No.	Amount of toluene (ml)	Toluene concentration		Area
		(ppm)	(μ M)	
1	8.50	73.70	801.03	329278.65
2	17.00	147.39	1602.07	587966.63
3	33.50	290.45	3157.07	1137089.87
4	50.00	433.50	4711.96	1679969.64
5	58.50	507.20	5512.99	2141617.95

**Figure A1** Calibration curve of toluene in water at 30 °CEquation $Y = 0.0002 X$ Where X = Area of Head space gas chromatography Y = Equilibrium concentration of toluene (mg/l or ppm)

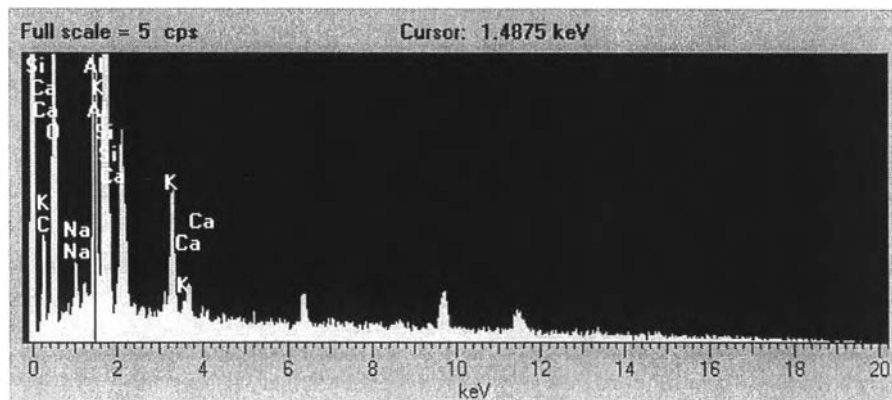


Figure A2 EDXS spectra of SMZ

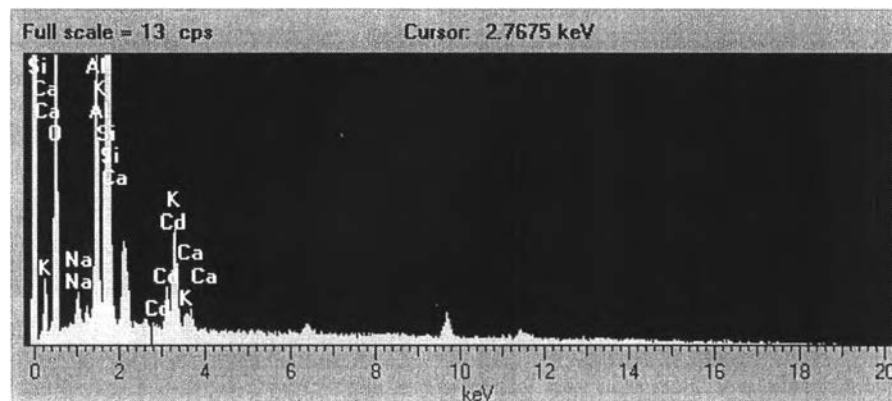


Figure A3 EDXS spectra of SMZ saturated with cadmium

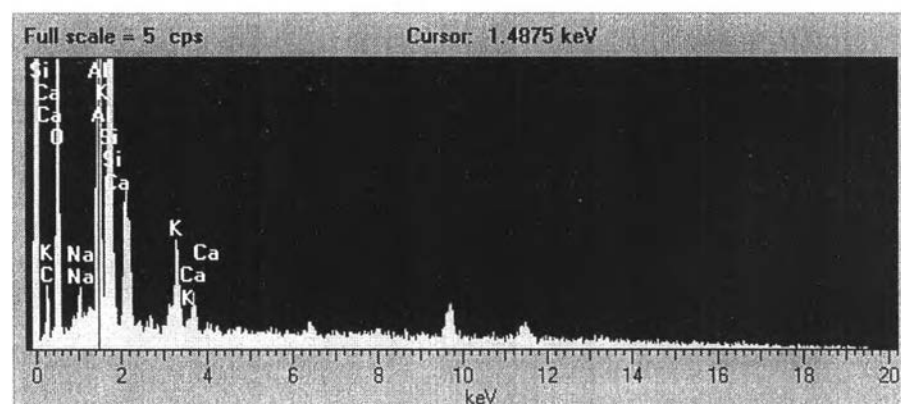


Figure A4 EDXS spectra of regenerated SMZ

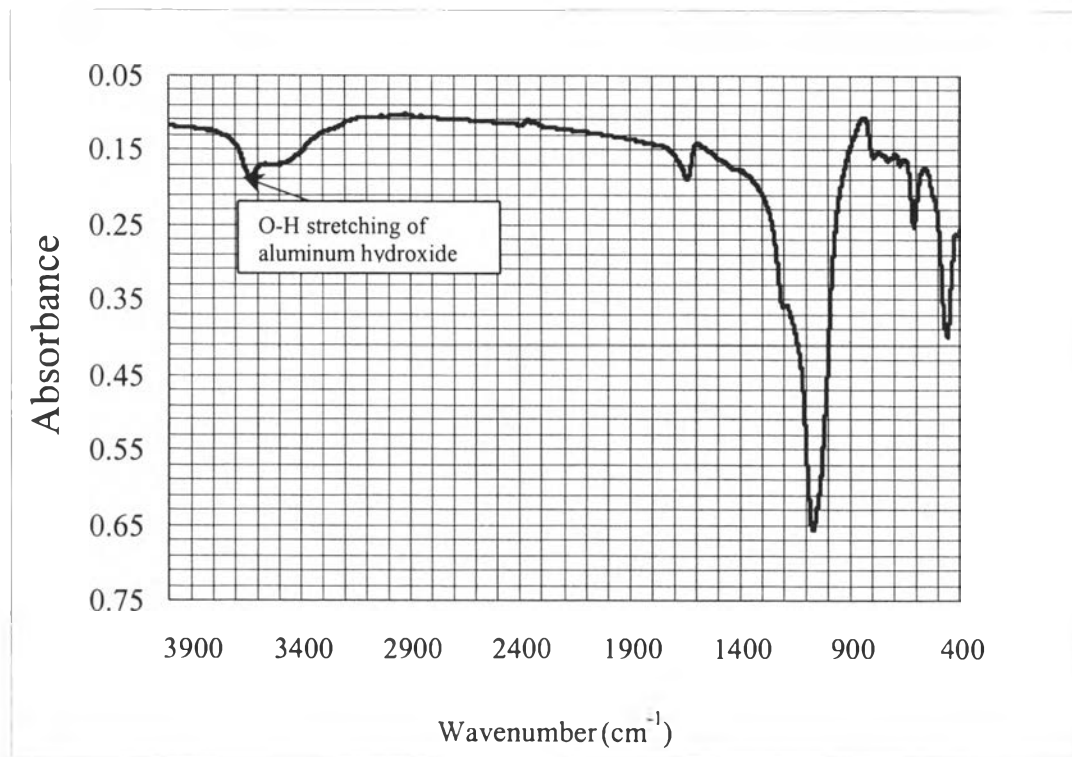


Figure A5 FTIR spectra of Clinoptilolite

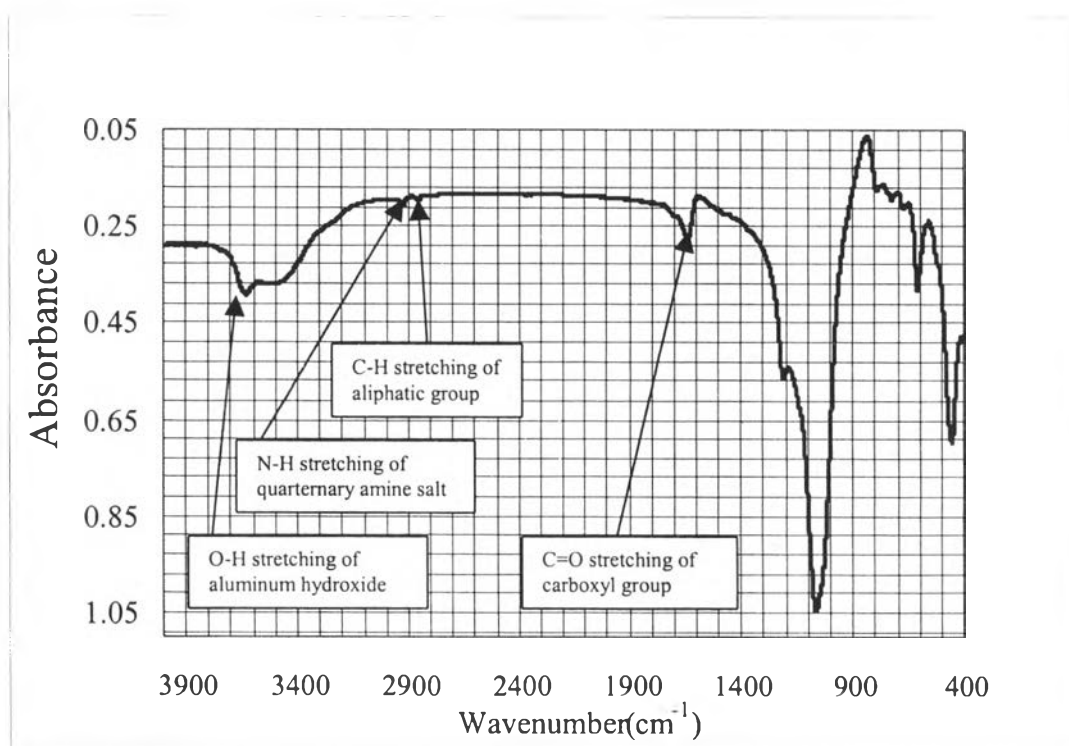


Figure A6 FTIR spectra of SMZ

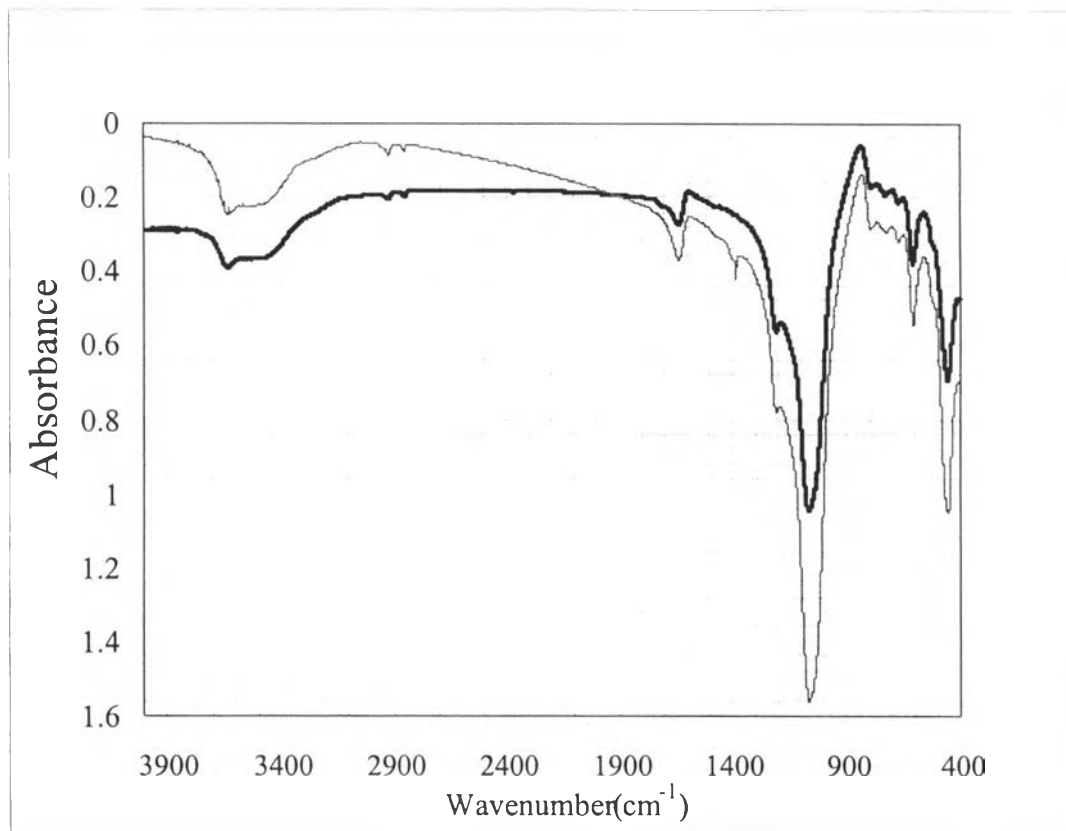


Figure A7 FTIR spectra of SMZ before and after saturated with cadmium

CURRICURUM VITAE

Name: Ms. Sasitorn Saengchote

Date of Birth: March 8, 1981

Nationality: Thai

University Education:

1997-2000 Bachelor Degree in Chemical Engineering (2nd class honor),
Faculty of Engineering, Srinakharinwirot University, Bangkok,
Thailand.