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APPENDICES

APPENDIX A

A.1 Crystal characteristics of raw bentonite

2008- 4-28 11:47

SQX Calculation Result

Sample : Ben1
Application : EZS002XNV Model : Bulk
Date analyzed : 2008- 4-18 10:19
Balance :
File : apr18-004

No.	Component	Result	Unit	Det.limit	El.line	Intensity	w/o normal
1	Na2O	0.358	mass%	0.0161	Na-KA	0.2700	0.1603
2	MgO	1.16	mass%	0.0170	Mg-KA	2.3821	0.5218
3	Al2O3	12.7	mass%	0.0136	Al-KA	71.5939	5.6867
4	SiO2	44.5	mass%	0.0248	Si-KA	208.8226	19.9152
5	SO3	0.314	mass%	0.0096	S -KA	2.3336	0.1407
6	Cl	0.562	mass%	0.0143	Cl-KA	2.4114	0.2517
7	CaO	2.57	mass%	0.0052	Ca-KA	40.9655	1.1518
8	TiO2	2.09	mass%	0.0159	Ti-KA	7.6008	0.9355
9	MnO	0.394	mass%	0.0816	Mn-KB1	1.0158	0.1764
10	Fe2O3	35.4	mass%	0.0138	Fe-KA	618.6149	15.8511

A.1 Crystal characteristics of raw bentonite (con)

2008- 4-29 10:45

SQX Calculation Result

Sample : Ben2 Date analyzed : 2008- 4-18 10:38
Application : EZS002XNV Model : Bulk Balance :
File : apr18-005

No.	Component	Result	Unit	Det.limit	El.line	Intensity	w/o normal
1	Na2O	0.304	mass%	0.0170	Na-KA	0.2292	0.1361
2	MgO	1.06	mass%	0.0166	Mg-KA	2.1603	0.4731
3	Al2O3	12.7	mass%	0.0141	Al-KA	71.5230	5.6729
4	SiO2	44.6	mass%	0.0245	Si-KA	209.5691	19.9586
5	SO3	0.289	mass%	0.0096	S -KA	2.1489	0.1295
6	Cl	0.584	mass%	0.0144	Cl-KA	2.5049	0.2613
7	CaO	2.60	mass%	0.0051	Ca-KA	41.3562	1.1633
8	TiO2	2.17	mass%	0.0175	Ti-KA	7.8902	0.9725
9	MnO	0.471	mass%	0.0804	Mn-KB1	1.2100	0.2108
10	Fe2O3	35.3	mass%	0.0140	Fe-KA	615.4437	15.8071

A.1 Crystal characteristics of raw bentonite (con)

2008- 4-28 12:05

SQX Calculation Result

Sample : Ben3
Application : EZS002XNV Model : Bulk
Date analyzed : 2008- 4-18 11:08
Balance :
File : apr18-006

No.	Component	Result	Unit	Det.limit	El.line	Intensity	w/o normal
1	Na2O	0.347	mass%	0.0172	Na-KA	0.2617	0.1553
2	MgO	1.06	mass%	0.0164	Mg-KA	2.1764	0.4765
3	Al2O3	12.8	mass%	0.0138	Al-KA	72.1068	5.7186
4	SiO2	44.6	mass%	0.0252	Si-KA	209.6110	19.9786
5	SO3	0.308	mass%	0.0096	S -KA	2.2872	0.1379
6	Cl	0.539	mass%	0.0141	Cl-KA	2.3115	0.2413
7	CaO	2.52	mass%	0.0054	Ca-KA	40.1652	1.1289
8	TiO2	2.13	mass%	0.0167	Ti-KA	7.7544	0.9532
9	MnO	0.418	mass%	0.0812	Mn-KB1	1.0786	0.1872
10	Fe2O3	35.3	mass%	0.0143	Fe-KA	617.5289	15.8113

A.2 Crystal characteristics of natural clay from Koh Kred

2008- 7- 2 15:51

SQX Calculation Result

Sample : Clay1
Application : EZS002MNV Model : Bulk
Date analyzed : 2008- 6-24 11:37
Balance :
File : clay

No.	Component	Result	Unit	Det.limit	El.line	Intensity	w/o normal
1	MgO	0.485	mass%	0.0180	Mg-KA	1.0100	0.1883
2	Al2O3	16.2	mass%	0.0159	Al-KA	92.3842	6.2868
3	SiO2	56.3	mass%	0.0292	Si-KA	249.5941	21.8661
4	SO3	0.138	mass%	0.0113	S -KA	0.8710	0.0536
5	K2O	4.68	mass%	0.0075	K -KA	74.8392	1.8183
6	CaO	1.75	mass%	0.0065	Ca-KA	22.1028	0.6777
7	TiO2	2.51	mass%	0.0231	Ti-KA	6.9134	0.9761
8	MnO	0.188	mass%	0.0095	Mn-KA	2.2493	0.0731
9	Fe2O3	17.5	mass%	0.0634	Fe-KB1	50.8914	6.7909
10	BaO	0.256	mass%	0.0508	Ba-KA	3.8152	0.0994

A.2 Crystal characteristics of natural clay from Koh Kred (con)

2008- 7- 2 15:58

SQX Calculation Result

Sample : Clay2
Application : EZS002MNV Model : Bulk
Date analyzed : 2008- 6-24 11:56
Balance :
File : clay002

No.	Component	Result	Unit	Det.limit	El.line	Intensity	w/o normal
1	MgO	0.494	mass%	0.0169	Mg-KA	1.0263	0.1903
2	Al2O3	16.0	mass%	0.0158	Al-KA	91.2939	6.1819
3	SiO2	56.9	mass%	0.0292	Si-KA	251.4475	21.9235
4	SO3	0.127	mass%	0.0114	S -KA	0.7948	0.0489
5	K2O	4.82	mass%	0.0076	K -KA	76.3351	1.8578
6	CaO	1.77	mass%	0.0065	Ca-KA	22.0961	0.6807
7	TiO2	2.49	mass%	0.0235	Ti-KA	6.7753	0.9614
8	MnO	0.369	mass%	0.0718	Mn-KB1	0.7975	0.1423
9	Fe2O3	16.7	mass%	0.0110	Fe-KA	254.7723	6.4508
10	BaO	0.253	mass%	0.0518	Ba-KA	3.7875	0.0975

A.2 Crystal characteristics of natural clay from Koh Kred (con)

SQX Calculation Result

Sample : SAMPLE1 Date analyzed : 2007- 2-16 14:43
Application : test Model : Bulk Balance :
File : ENV002

No.	Component	Result	Unit	Det.limit	E.Line	Intensity	w/o normal
1	MgO	0.446	mass%	0.0416	Mg-KA	0.5456	0.0983
2	Al2O3	15.6	mass%	0.0292	Al-KA	52.0724	3.4322
3	SiO2	60.4	mass%	0.0618	Si-KA	156.1709	13.3195
4	P2O5	0.191	mass%	0.0163	P -KA	0.8555	0.0422
5	K2O	5.26	mass%	0.0152	K -KA	46.8982	1.1596
6	CaO	0.635	mass%	0.0152	Ca-KA	4.1573	0.1402
7	TiO2	3.05	mass%	0.0580	Ti-KA	4.7459	0.6721
8	Cr2O3	0.0937	mass%	0.0309	Cr-KA	0.3766	0.0207
9	MnO	0.181	mass%	0.0222	Mn-KA	1.2821	0.0400
10	Fe2O3	13.6	mass%	0.1551	Fe-KB1	23.2454	2.9946
11	ZnO	0.308	mass%	0.0147	Zn-KA	7.2488	0.0681
12	GeO2	0.139	mass%	0.0170	Ge-KA	3.7271	0.0307
13	Rb2O	0.0840	mass%	0.0086	Rb-KA	6.4519	0.0185
14	SrO	0.0305	mass%	0.0091	Sr-KA	2.4466	0.0067
15	ZrO2	0.0968	mass%	0.0416	Zr-KB1	2.1240	0.0214

APPENDIX B

B.1 Cation-Exchange Capacity of Soils (Ammonium Acetate) Method 9080

1. Apparatus and materials

1.1 Erlenmeyer flask: 500-mL.

1.2 Buchner funnel or equivalent: 55-mm.

1.3 Sieve: 2-mm.

1.4 Aeration apparatus (assembled as in Figure 1):

1.4.1 Kjeldahl flask: 800-mL

1.4.2 Erlenmeyer flask: 800-mL

1.4.3 Glass wool filter

1.4.4 Glass tubing

1.4.5 Flow meter

2. Reagents

2.1 Ammonium acetate (NH_4OAc),1 N: Dilute 114 ml of glacial acetic acid (99.5%) with water to a volume of approximately 1 liter. Then add 138 ml of concentrated ammonium hydroxide (NH_4OH) and add water t obtain a volume of about 1,980 ml. Check the pH of the resulting solution. Add more NH_4OH, as needed, to obtain a pH of 7, and dilute the solution to a volume of 2 liters with water.

2.2 Isopropyl alcohol: 99%

2.3 Ammonium chloride (NH_4Cl) Dissolve 53.49 g of NH_4Cl in Type II water , adjust the pH to 7.0 with NH_4OH , and dilute to 1 L.

2.4 Ammonium chloride (NH_4Cl) , 0.25 N: Dissolve 13.37 g of NH_4Cl in Type II water , adjust the pH to 7.0 with NH_4OH , and dilute to 1 L.

2.5 .Ammonium oxalate ($(NH_4Cl)_2C_2O_4.H_2O$) , 10%: Add 90 mL of Type II water to 10 g of ammonium oxalate ($(NH_4Cl)_2C_2O_4.H_2O$) and mix well.

2.6 Dilute ammonium hydroxide (NH_4OH): Add 1 volume of concentrated NH_4OH to an equal volume of water.

2.7 Silver nitrate (Ag_3NO) 0.10 N: Dissolve 15.39 g of $NgNo_3$ in Type II water , mix well , and dilute to 1 L.

B.1 Cation-Exchange Capacity of Soils (Ammonium Acetate) Method 9080 (con)

2.8 Reagents for aeration option:

2.8.1 Sodium carbonate solution (Na_2CO_3) , 5% Add 95 mL of Type II water to 5 g of Na_2CO_3 and mix well.

2.8.2 Paraffin oil.

2.8.3 Sulfuric acid (H_2SO_4) , 0.1 N standard: Add 2.8 mL concentrated H_2SO_4 to Type II water and dilute to 1 L. Standardize against a base of known concentration.

2.8.4 Sodium hydroxide (NaOH) , 0.1 N standard: Dissolve 4.0 g NaOH in Type II water and dilute to 1 L. Standardize against an acid of known concentration.

2.8.5 Methyl red indicator , 0.1%: Dissolve 0.1 g in 99.9 mL 95% ethanol and mix well.

2.9 Reagents for distillation option:

2.9.1 Sodium chloride , NaCl (acidified) , 10%: Dissolve 100 g of NaCl (ammonium-free) 900 mL of Type II water; mix well. Add approximately 0.42 mL of concentrated HCl to make the solution approximately 0.005 N.

2.9.2 Sodium hydroxide (NaOH) , 1 N: Dissolve 40 g of NaOh in Type II water and dilute to 1 L.

2.9.3 Boric acid (H_3BO_3) , 2% solution: Dissolve 20 g H_3BO_3 in 980 mL Type II water and mix well.

2.9.4 Standard sulfuric acid (H_2SO_4) , 0.1 N: See Step 5.8.3.

2.9.5 Bromocresol green-methyl red mixed indicator: Triturate 0.1 g of bromocresol green with 2 mL 0.1 N NaOH in an agate mortar and add 95% ethyl alcohol to obtain a total volume of 100 mL. Triturate 0.1 g of methyl red with a few mL of 95% ethyl alcohol in an agate mortar. Add 3 mL of 0.1 N NaOH and dilute the solution to a volume of 100 mL with 95% ethyl alcohol. Mix 75 mL of the bromocresol green solution with 25 mL of the methyl red solution and dilute the mixture to 200 mL with 95% ethyl alcohol.

B.1 Cation-Exchange Capacity of Soils (Ammonium Acetate) Method 9080 (con)

3 Procedure

3.1 Sieve a sample aliquot of soil through a 2-mm screen and allow the sieved soil to air dry (at a temperature of 60°). Place 10 g of the air-dried soil in a 500-mL Erlenmeyer flask and add 250 mL neutral , 1 N NH_4OAc. (Use 25 g of soil if the exchange capacity is very low , e.g., 3-5 meq per 100 g.) Shake the flask thoroughly and allow it stand overnight.

3.2 Filter the soil with light suction using a 55-mm Buchner funnel or equivalent. Do not allow the soil to become dry and cracked.

3.3 Leach the soil with the neutral NH_4OAc reagent until no test for calcium can be obtained in the effluent solution. (For the calcium test , add a few drops each of 1 N NH_4Cl and 10% ammonium oxalate, dilute NH_4OH to mL of the leachate in a test tube , and heat the solution to near the boiling point. The presence of calcium is indicated by white precipitate or turbidity.)

3.4 Then leach the soil four times with neutral 1 N and once with 0.25 N NH_4Cl.

3.5 Wash out the electrolyte with 150 to 200 mL of 99% isopropyl alcohol. When the test for chloride in the leachate (use 0.10 $AgNO_3$) becomes negligible . allow the soil to drain thoroughly.

3.6 Determine the adsorbed NH_4 either by the aeration method or by the acid-NaCl method.

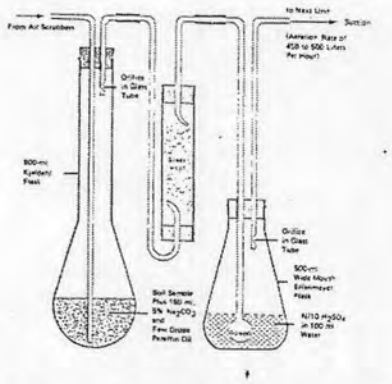

Figure B.1 Glassware set for CEC analysis by ammonium acetate method

B.2 Test Method for Determination of Iodine Number of Activated Carbon ASTM D 4607

1. Apparatus

1.1 Analytical Balance, accuracy ±0.0001 g.

1.2 Buret, 10-mL capacity or 5-mL precision buret.

1.3 Flasks, Erlenmeyer 250 mL capacity with ground glass stoppers.

1.4 Flask, Erlenmeyer wide-mounted, 250 mL capacity.

1.5 Beakers, assorted sizes.

1.6 Bottles, amber, for storage of iodine and thiosulfate solutions.

1.7 Funnels, 100-mm top inside diameter.

1.8 Filter Paper, 18.5-cm prefolded paper, Whatman No. 2V or equivalent.

1.9 Pipets, volumetric type, 5.0, 10.0, 25.0, 50.0, and 100.0-mL capacity.

1.10 Volumetric Flasks, 1 L.

1.11 Graduated Cylinders, 100 mL and 500 mL

2. Reagents

2.1 Purity of Reagents-Reagent grade chemicals shall be used in all tests. Unless otherwise indicated, it is intended that all reagents shall conform to the specifications of the Committee on Analytical Reagents of the American Chemical Society, where such specifications are available. Other grades may be used, provided it is first ascertained that the reagent is of sufficiently high purity to permit its use without lessening the accuracy of the determination.

2.2 Purity of Water-References to water shall be understood to mean reagent water conforming to Specification D1193 for type II reagent water.

2.3 Hydrochloric Acid, concentrated.

2.4 Sodium Thiosulfate, ($Na_2S_2O_3 . 5H_2O$)

2.5 Iodine, United States Pharmacopeia, resublimed crystals.

2.6 Potassium Iodide.

2.7 Potassium Iodate, primary standard.

2.8 Starch, soluble potato or arrowroot.

2.9 Sodium Carbonate.

B.2 Test Method for Determination of Iodine Number of Activated Carbon ASTM D 4607 (con)

3. Preparations of Solutions

3.1 *Hydrochloric Acid Solution* (5% by weight) - Add 70 mL of concentrated hydrochloric acid to 550 mL of distilled water and mix well. A graduated cylinder may be used for measurement of volume.

3.2 *Sodium Thiosulfate* (0.100 N) - Dissolve 24.820 g of sodium thiosulfate in approximately 75 ± 25 mL of freshly boiled distilled water. Add 0.10 ± 0.01 g of sodium carbonate to minimize bacterial decomposition of the thiosulfate solution. Quantitatively transfer the mixture to a 1-L volumetric flask and dilute to the mark. Allow the solution to stand at least 4 days before standardizing. The solutions should be stored in and amber bottle.

3.3 *Standard Iodine Solution* (0.100 ± 0.001 N) - Weigh 12.700 g of iodine and 19.100 g of potassium iodide (KI) into a beaker. Mix the dry iodine and potassium iodide. Add 2 to 5 mL of water to the beaker and stir well. Continue adding small increments of water (approximately 5 mL each) while stirring until the total volume is 50 to 60 mL. Allow the solution to stand a minimum of 4 h to ensure that all crystals are thoroughly dissolved. Occasional stirring during this 4-h period will aid in the dissolution. Quantitatively transfer to a 1-L volumetric flask and fill to the mark with distilled water. It is important that the standard iodine solution has and iodide-to-iodine weight ratio of 1.5 to 1. Store the solution in an amber bottle.

3.4 *Potassium Iodate Solution* (0.1000 N)-Dry 4 or more grams of primary standard grade potassium iodate (KIO_3) at 110 ± 5 °C for 2 h and cool to room temperature in a desiccator. Dissolve 3.5667 ± 0.1 mg of the dry potassium iodate in about 100 mL of distilled water. Quantitatively transfer to a 1-L volumetric flask and fill to the mark with distilled water. Mix thoroughly and store in a glass-stoppered bottle.

3.5 *Starch Solution*-Mix 1.0 ± 0.5 g of starch with 5 to 10 mL of cold water to make a paste. Add an additional 25 ± 5 mL of water while stirring to the starch paste.

B.2 Test Method for Determination of Iodine Number of Activated Carbon ASTM D 4607 (con)

Pour the mixture, while stirring, into 1 L of boiling water and boil for 4 to 5 min. This solution should be made fresh daily.

4. Standardization of Solutions

4.1 Standardization of 0.100 N Sodium Thiosulfate – Pipet 25.0 mL of potassium iodate (KIO3) solution from 8.4 into a 250-mL titration (or wide-mouthed Erlenmayer) flask. Add 2.00 $\pm$ 0.01 g of potassium iodide (KI) to the flask and shake the flask to dissolve the potassium iodide crystals. Pipet 5.0 mL of concentrated hydrochloric acid into the flask. Titrate the free iodine with sodium thiosulfate solution until a light yellow color is observes in the flask. Add a few drops of starch indicator (8.5) and continue the titration dropwise until one drop produces a colorless solution. Determine sodium thiosulfate normality as follows:

$$N_1 = (PR)/S$$

Where:

N_1 = sodium thiosulfate, N,

P = potassium iodate, mL,

R = potassium iodate, N, and

S = sodium thosulfate, mL

The titration step should be done in triplicate and the normality results average. Additional replications should be done if the range of values exceeds 0.003 N.

4.2 Standardization of 0.100 $\pm$ 0.001 N Iodine Solution – Pipet 25.0 mL of iodine solution into a 250-mL widemouthed Erlenmayer flask. Titrate with standardized sodium thiosulfate until the iodine solution is a yellow color. Add a few drops of starch indicator and continue titration drop wise until one drop produces a colorless solution. Determine the iodine solution normality as follows:

$$N_2 = (S N_1)/I$$

B.2 Test Method for Determination of Iodine Number of Activated Carbon ASTM D 4607 (con)

Where:

N_2 = iodine, N,

S = sodium thosulfate, mL

N_1 = sodium thiosulfate, N, and

I = iodine, mL

The titration step should be done in triplicate and the normality results averaged. Additional replications should be done if range of values exceeds 0.003 $\pm$ 0.001 N. If this requirement is not met, repeat 8.3 and 9.2.

5. Procedure

5.1 The procedure applies to either powdered or granular activated carbon. When granular carbon is to be tested, grind a representative sample (see Practice E 300) of carbon until 60 wt% (or more will pass through a 325-mesh screen) and 95 wt% or more will pass through a 100-mesh screen (U.S. sieve series, see Specification E 11). Carbon received in the powdered form may need additional grinding to meet the particle size requirement given above.

5.2 Dry the ground carbon from 10.1 in accordance with Test Method D 2867.Cool the dry carbon to room temperature in a desiccator.

5.3 Determination of iodine number requires an estimation of three carbons dosages. Section 11.4 describes how to estimate the carbon dosages to be used. After estimating carbon dosages, weigh three appropriate amounts of dry carbon to the nearest milligram. Transfer each weighed sample of carbon to a clean, dry 250-mL Erlenmeyer flask equipped with a ground glass stopper.

5.4 Pipet 10.0 mL of 5 wt% hydrochloric acid solution into each flask containing carbon. Stopper each flask and swirl gently until the carbon is completely wetted. Loosen the stoppers to vent the flasks, place on a hot plate in a fume hood, and bring the contents to a boil. Allow to boil gently for 30 $\pm$ 2 s to remove any sulfur which may

B.2 Test Method for Determination of Iodine Number of Activated Carbon ASTM D 4607 (con)

interfere with the test result. Remove the flasks from the hot plate and cool to room temperature.

5.5 Pipet 100.0 mL of 0.100 N iodine solution into each flask. Standardize the iodine solution just prior to use. Stagger the addition of iodine to the three flasks so that no delays are encountered in handling. Immediately stopper the flasks, and shake the contents vigorously for 30 $\pm$ 1 s. quickly filter each mixture by gravity through one sheet of folded filter paper (Whatman No. 2V or equivalent) into a beaker. Filtration equipment must be prepared in advance so no delay is encountered in filtering the samples.

5.6 For each filtrate, use the first 20 to 30 mL to rinse a pipet. Discard the rinse potions. Use clean beakers to collect the remaining filtrates mix each filtrate by swirling the beaker and pipet 50.0 mL of each filtrate into a clean 250-mL Erlenmeyer flask. Titrate each filtrate with standardized 0.100 n sodium thiosulfate solution until the solution is a pale yellow. Add 2 mL of the starch indicator solution and continue the titration with sodium thiosulfate until one drop produces a colorless solution. Record the volume of sodium thiosulfate used.

6. Calculation

6.1 The capacity of a carbon for any adsorbate is dependent upon the concentration of the adsorbate in solution. The concentrations of the standard iodine solution and filtrates must be specified or known. This is necessary to determine an appropriate carbon weight to produce final concentrations agreeing with the definition of iodine number. The amount of carbon sample to be used in the determination is governed by the activity of the carbon. If filtrate normalities (C) are not within the range of 0.008 N to 0.040 N, repeat the procedure using different carbon weights.

6.2 Two calculations are required for each carbon dosage, as X/M and C.

B.3 Test Method for Surface Area Analysis by ASAP 2000

1. The default (Program-Defined) analysis

The program provides default information for all run conditioned except tables of pressure and calculation points. Standard tables are provided but must be selected from screen **3.3p3 Add Sample-Pressures.**

Analysis can be run using default information. To determine what default information is assigned to analysis parameters, refer to Section 7, **Entering and Maintenance Analysis Parameters and Data.**

To analyze a sample using default information:

1. Press [F3] twice from the Main Function Menu to display screen 3.3p1 Add Sample information.

2. Allow the program to assign the sample number. Enter the sample number on the Sample Data Sheet.

3. Enter the other information requested on the screen. Leave Type of Data? Defined as AUTO-MATICALLY COLLECTED. Press [PgDn].

4. Enter the Run Conditions Set number on page 2. This automatically satisfies the rest of the requirements of page 2, 3, and 4. Edit if required or press [PgDn] until page 5 is displayed.

5. Enter the Report Options Set number on page 5. Edit if required, then press [F2] twice to return to the Main Function Menu.

6. Start analysis

2. Start an analysis

1. Check the level of liquid nitrogen in the Dewar flask using the dipstick (refer to Figure B-1) Add liquid nitrogen if necessary. The Dewar should be filled to the level which will not be above the isothermal jacket when the elevator is up and sample tube submerged.

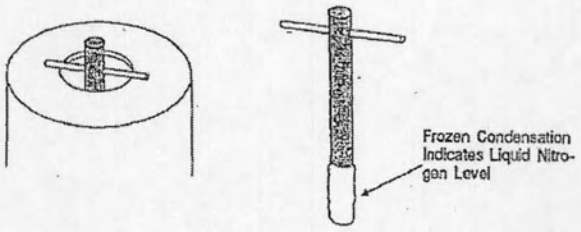

Figure B.2 Liquid Nitrogen Dipstick

2. Attach the sample tube to the sample port as shown in the following illustration. Then lower the safety shield.

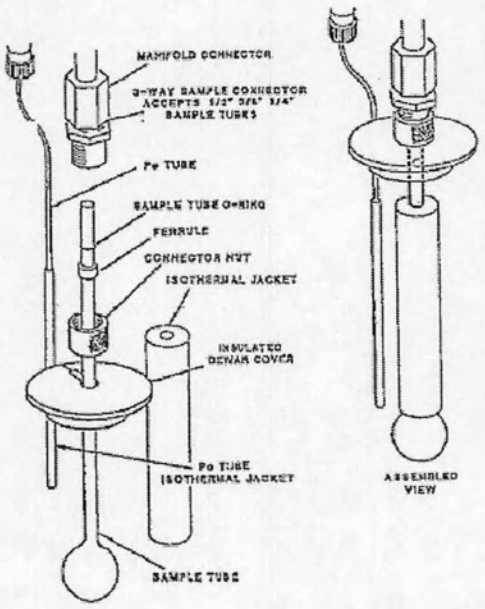

Figure B.3 Attachment of Sample Tube

3. Press F2 from the Main Function Menu to select screen 7. **Start Run.**

4. Select the unit number.

5. Enter the sample number.

6. Answer yes to the **Start report after analysis?** Prompt to print reports automatically after the analysis. Answer no if you do not want reports printed automatically. In either case, additional reports can be printed or displayed using the Start Report screen.

7. Press PgDn. The program reads the Sample Information file for the sample and the analysis begins.

APPENDIX C

C.1 Raw Materials

Figure C.1 Natural clay from Kohkred Traditional Village

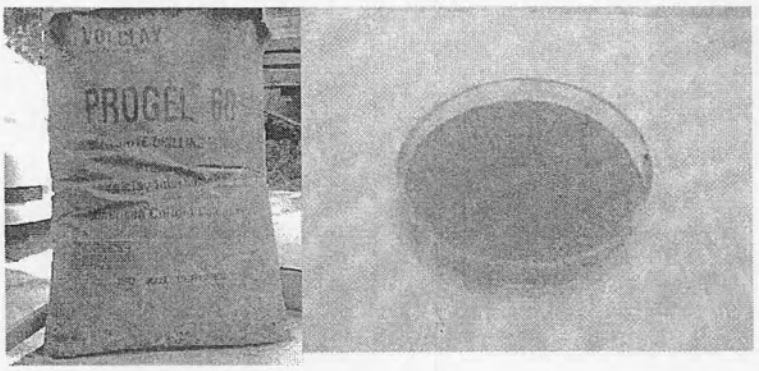

Figure C.2 Raw bentonite

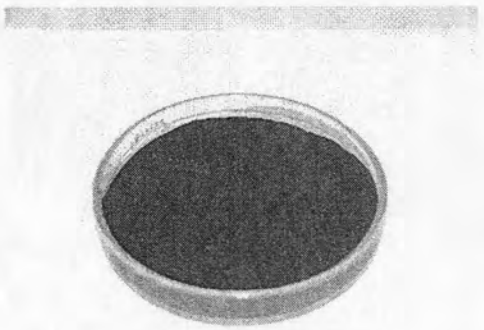

Figure C.3 Activated Carbon Filtrasorb-300

C.2 Equipments for material preparation

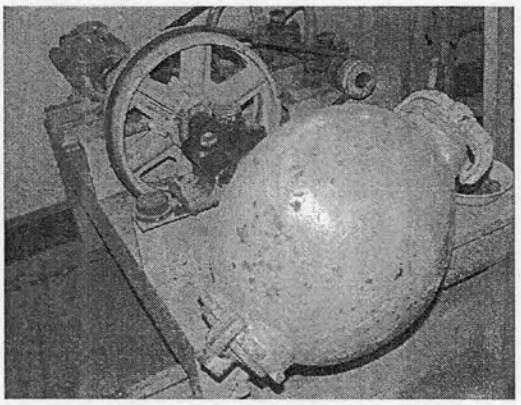

Figure C.4 Ball mill used for clay grinding

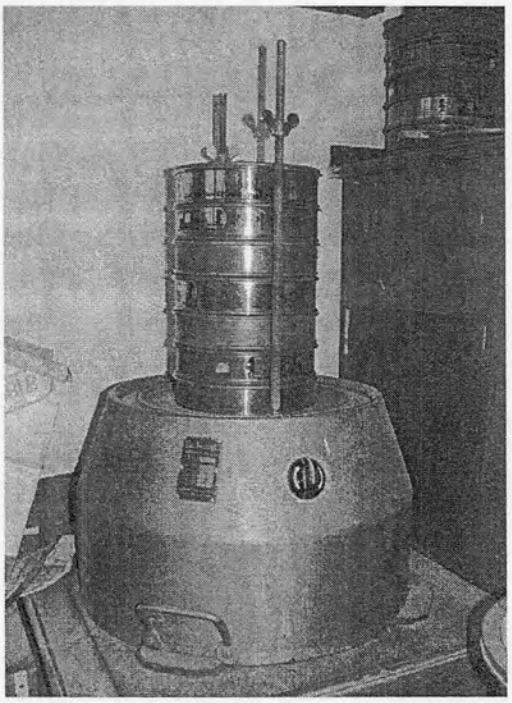

Figure C.5 Sieving machine

C.2 Equipments for material preparation (con)

Figure C.6 Oven for preparation of the testing materials

C.3 Methodology

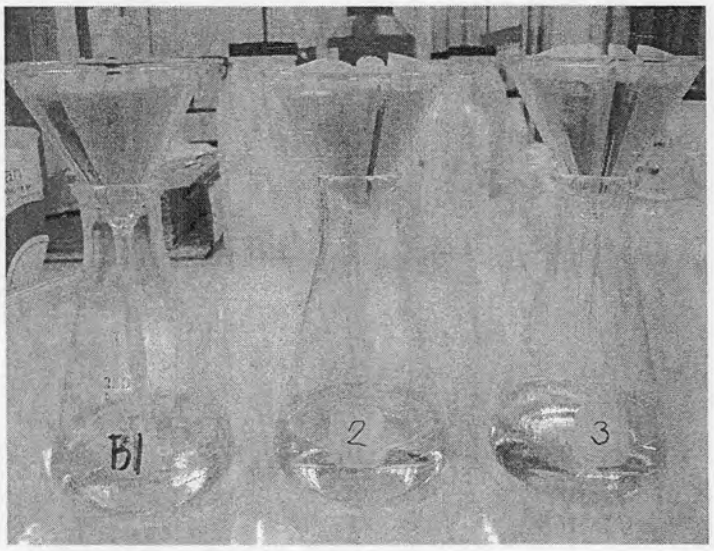

Figure C.7 Iodine testing

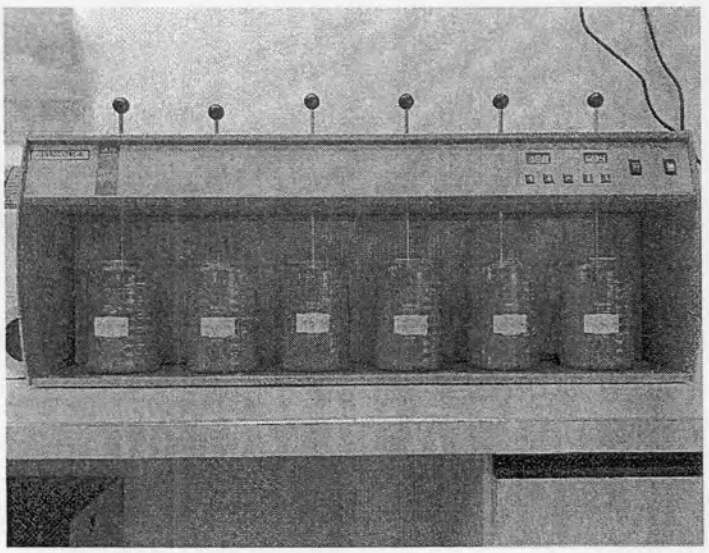

Figure C.8 Preparation of natural clay and raw bentonite by washing with deionized water to remove some contaminants

C.3 Methodology (con)

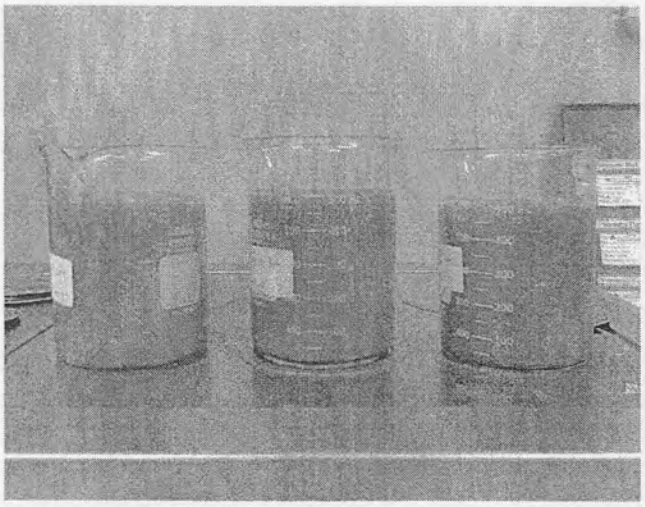

Figure C.9 Pillaring bentonite and natural clay by tetraethylammonium chloride

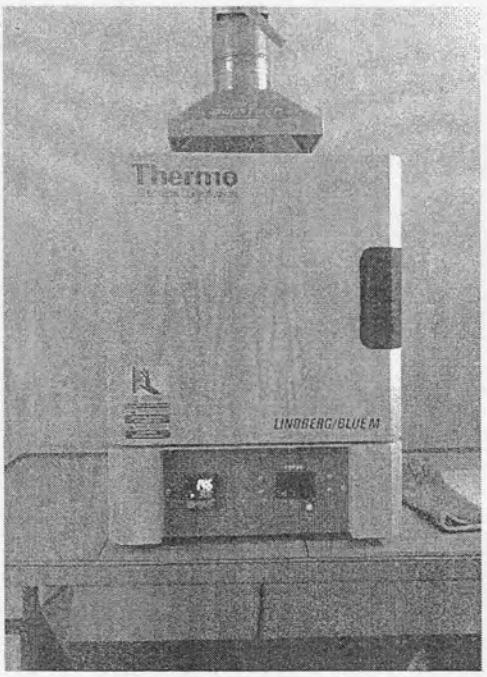

Figure C.10 Dehydration of pillared bentonite

C.4 Equipments for testing

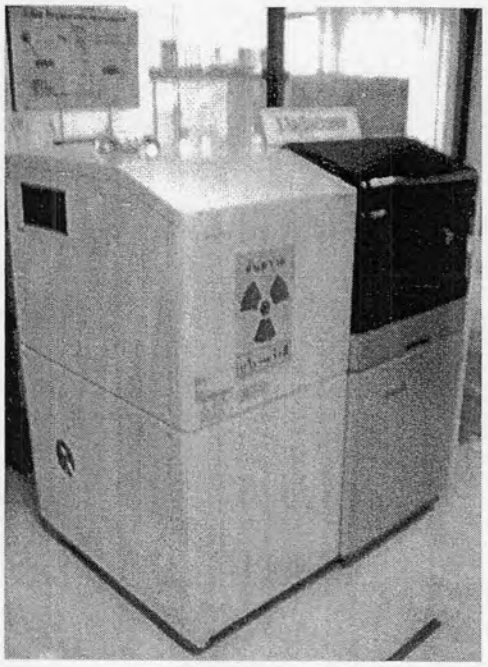

Figure C.11 X-ray fluorescence spectrometer (XRF)

Figure C.12 X-ray diffractometer (XRD)

C.4 Equipments for testing (con)

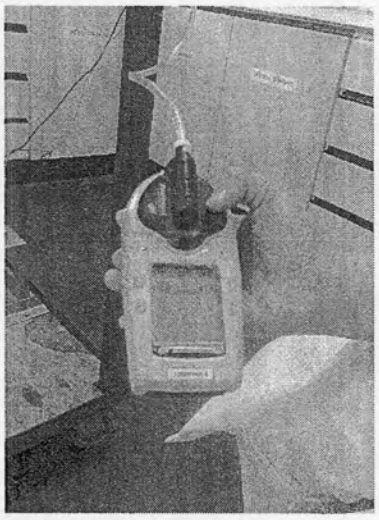

Figure C.13 PID/VOC gas detector

Figure C.14 Low flow gas pump and accessories for detecting organic vapors

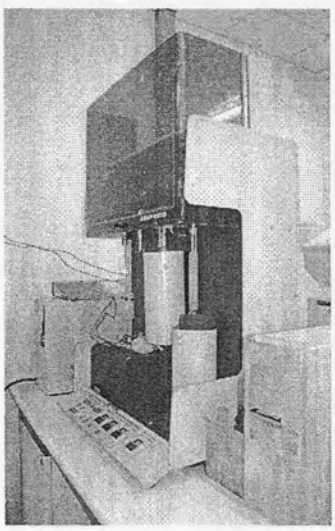

Figure C.15 BET/ASAP 2000 for surface area analysis

APPENDIX D

D.1 CEC fraction calculation for pillaring with tetraethylammonium chloride

$$f = \frac{M_{cation}}{CEC \cdot M_{clay} \cdot GMW_{cation} \cdot X}$$

Where f = fraction cation exchange capacity satisfied by organic cation,

M_{cation}= mass organic cation required to achieve required fraction of CEC (mass),

CEC = cation exchange capacity of clay (equivalents/mass),

M_{clay} = mass clay (mass),

GMW_{cation} = gram molecularweight of organic cation (mass/mol), and

X = moles of charge per equivalent = 1 mol/eq for the cations used in this study (mol/equivalent).

Table D.1 Calculation sheet for pillaring

Type of Clay	Fraction of CEC					
	0.75	1.00	1.25	1.50	1.75	2.00
Natural Clay	0.3575	0.4766	0.5958	0.7150	0.8341	0.9533
Bentonite	0.8378	1.1171	1.3964	1.6757	1.9550	2.2343

Remarks:

1. CEC of raw bentonite and natural clay are 67.5 and 28.8 meq/100 g. respectively.
2 .Calculation sheet is based on 10 g clay weight.
3. Molecular weight of tetraethylammonium chloride is 165.5 g/mol

APPENDIX E

E.1 Summary Report of Natural Clay from Koh Kred

SAMPLE DIRECTORY/NUMBER: AICL /373	START 11:07:26 03/01/08
SAMPLE ID: Raw clay (2)	COMPL 14:34:15 02/29/08
SUBMITTER:	REPRT 12:04:44 03/01/08
OPERATOR: Jirawan	SAMPLE WT: 0.3905 g
UNIT NUMBER: 1	FREE SPACE: 42.3794 cc
ANALYSIS GAS: Nitrogen	EQUIL INTRVL: 10 sec

SUMMARY REPORT

AREA

BET SURFACE AREA:	49.2864 sq. m/g
LANGMUIR SURFACE AREA:	68.2510 sq. m/g
SINGLE POINT SURFACE AREA AT P/Po 0.1995:	47.5873 sq. m/g
BJH CUMULATIVE ADSORPTION SURFACE AREA OF PORES	
BETWEEN 17.0000 AND 3000.0000 A DIAMETER:	51.8065 sq. m/g
BJH CUMULATIVE DESORPTION SURFACE AREA OF PORES	
BETWEEN 17.0000 AND 3000.0000 A DIAMETER:	57.6091 sq. m/g
MICROPORE AREA:	4.3710 sq. m/g

VOLUME

SINGLE POINT TOTAL PORE VOLUME OF PORES LESS THAN	
1816.9406 A DIAMETER AT P/Po 0.9892:	0.079559 cc/g
BJH CUMULATIVE ADSORPTION PORE VOLUME OF PORES	
BETWEEN 17.0000 AND 3000.0000 A DIAMETER:	0.084616 cc/g
BJH CUMULATIVE DESORPTION PORE VOLUME OF PORES	
BETWEEN 17.0000 AND 3000.0000 A DIAMETER:	0.085071 cc/g
MICROPORE VOLUME:	0.001492 cc/g

PORE SIZE

AVERAGE PORE DIAMETER (4V/A BY BET):	64.5683 A
BJH ADSORPTION AVERAGE PORE DIAMETER (4V/A):	65.3326 A
BJH DESORPTION AVERAGE PORE DIAMETER (4V/A):	59.0676 A

E.2 Summary Report of Raw Bentonite

SAMPLE DIRECTORY/NUMBER: AICL /374	START 11:17:47 03/02/08
SAMPLE ID: Raw bentonite (2)	COMPL 16:53:19 03/01/08
SUBMITTER:	REPRT 10:59:47 02/29/08
OPERATOR: Jirawan	SAMPLE WT: 0.3806 g
UNIT NUMBER: 1	FREE SPACE: 42.5626 cc
ANALYSIS GAS: Nitrogen	EQUIL INTRVL: 10 sec

SUMMARY REPORT

AREA

BET SURFACE AREA:	80.5420 sq. m/g
LANGMUIR SURFACE AREA:	108.9404 sq. m/g
SINGLE POINT SURFACE AREA AT P/Po 0.1997:	80.0488 sq. m/g
BJH CUMULATIVE ADSORPTION SURFACE AREA OF PORES	
BETWEEN 17.0000 AND 3000.0000 A DIAMETER:	53.0841 sq. m/g
BJH CUMULATIVE DESORPTION SURFACE AREA OF PORES	
BETWEEN 17.0000 AND 3000.0000 A DIAMETER:	86.6370 sq. m/g
MICROPORE AREA:	29.7159sq. m/g

VOLUME

SINGLE POINT TOTAL PORE VOLUME OF PORES LESS THAN	
1561.5188 A DIAMETER AT P/Po 0.9875:	0.088504 cc/g
BJH CUMULATIVE ADSORPTION PORE VOLUME OF PORES	
BETWEEN 17.0000 AND 3000.0000 A DIAMETER:	0.077497 cc/g
BJH CUMULATIVE DESORPTION PORE VOLUME OF PORES	
BETWEEN 17.0000 AND 3000.0000 A DIAMETER:	0.099139 cc/g
MICROPORE VOLUME:	0.013265 cc/g

PORE SIZE

AVERAGE PORE DIAMETER (4V/A BY BET):	43.9543 A
BJH ADSORPTION AVERAGE PORE DIAMETER (4V/A):	58.3955A
BJH DESORPTION AVERAGE PORE DIAMETER (4V/A):	45.7722 A

E.3 Summary Report of Activated Carbon

SAMPLE DIRECTORY/NUMBER: AICL /156	START 12:15:01 09/11/07
SAMPLE ID: PAC	COMPL 15:15:52 09/11/07
SUBMITTER:	REPRT 11:45:48 03/01/08
OPERATOR: Jirawan	SAMPLE WT: 0.3495 g
UNIT NUMBER: 1	FREE SPACE: 47.7578 cc
ANALYSIS GAS: Nitrogen	EQUIL INTRVL: 10 sec

SUMMARY REPORT

AREA

BET SURFACE AREA:	1034.3771 sq. m/g
LANGMUIR SURFACE AREA:	1385.5194 sq. m/g
SINGLE POINT SURFACE AREA AT P/Po 0.1997:	1047.3585 sq. m/g
BJH CUMULATIVE ADSORPTION SURFACE AREA OF PORES	
BETWEEN 17.0000 AND 3000.0000 A DIAMETER:	170.3928 sq. m/g
BJH CUMULATIVE DESORPTION SURFACE AREA OF PORES	
BETWEEN 17.0000 AND 3000.0000 A DIAMETER:	190.8067 sq. m/g
MICROPORE AREA:	689.8140 sq. m/g

VOLUME

SINGLE POINT TOTAL PORE VOLUME OF PORES LESS THAN	
1494.6709 A DIAMETER AT P/Po 0.9869:	0.519955 cc/g
BJH CUMULATIVE ADSORPTION PORE VOLUME OF PORES	
BETWEEN 17.0000 AND 3000.0000 A DIAMETER:	0.127990 cc/g
BJH CUMULATIVE DESORPTION PORE VOLUME OF PORES	
BETWEEN 17.0000 AND 3000.0000 A DIAMETER:	0.136521 cc/g
MICROPORE VOLUME:	0.319180 cc/g

PORE SIZE

AVERAGE PORE DIAMETER (4V/A BY BET):	15.0111 A
BJH ADSORPTION AVERAGE PORE DIAMETER (4V/A):	30.0459 A
BJH DESORPTION AVERAGE PORE DIAMETER (4V/A):	28.6197 A

E.4 Summary Report of PILB

SAMPLE DIRECTORY/NUMBER: BET1 /1	START 15:31:12 03/04/08
SAMPLE ID: 0.75 CEC ben (2)	COMPL 00:29:51 03/02/08
SUBMITTER:	REPRT 10:00:32 02/29/08
OPERATOR: Jirawan	SAMPLE WT: 0.3724 g
UNIT NUMBER: 1	FREE SPACE: 42.6628 cc
ANALYSIS GAS: Nitrogen	EQUIL INTRVL: 10 sec

SUMMARY REPORT

AREA

BET SURFACE AREA:	105.4604 sq. m/g
LANGMUIR SURFACE AREA:	142.8067 sq. m/g
SINGLE POINT SURFACE AREA AT P/Po 0.1997:	104.0401 sq. m/g
BJH CUMULATIVE ADSORPTION SURFACE AREA OF PORES BETWEEN 17.0000 AND 3000.0000 A DIAMETER:	50.5464 sq. m/g
BJH CUMULATIVE DESORPTION SURFACE AREA OF PORES BETWEEN 17.0000 AND 3000.0000 A DIAMETER:	70.0998 sq. m/g
MICROPORE AREA:	47.7388 sq. m/g

VOLUME

SINGLE POINT TOTAL PORE VOLUME OF PORES LESS THAN 1074.1282 A DIAMETER AT P/Po 0.9816:	0.075138 cc/g
BJH CUMULATIVE ADSORPTION PORE VOLUME OF PORES BETWEEN 17.0000 AND 3000.0000 A DIAMETER:	0.052116 cc/g
BJH CUMULATIVE DESORPTION PORE VOLUME OF PORES BETWEEN 17.0000 AND 3000.0000 A DIAMETER:	0.059635 cc/g
MICROPORE VOLUME:	0.020647 cc/g

PORE SIZE

AVERAGE PORE DIAMETER (4V/A BY BET):	28.4990 A
BJH ADSORPTION AVERAGE PORE DIAMETER (4V/A):	41.2421 A
BJH DESORPTION AVERAGE PORE DIAMETER (4V/A):	34.0288 A

E.4 Summary Report of PILB 32

SAMPLE DIRECTORY/NUMBER: AICL /400	START 12:36:52 03/01/08
SAMPLE ID: 0 0.75 ben 32 (2)	COMPL 16:32:28 02/29/08
SUBMITTER:	REPRT 17:01:03 02/29/08
OPERATOR: Jirawan	SAMPLE WT: 0.3868 g
UNIT NUMBER: 1	FREE SPACE: 43.1091 cc
ANALYSIS GAS: Nitrogen	EQUIL INTRVL: 10 sec

SUMMARY REPORT

AREA

BET SURFACE AREA:	445.6774 sq. m/g
LANGMUIR SURFACE AREA:	596.4193 sq. m/g
SINGLE POINT SURFACE AREA AT P/Po 0.1997:	450.8018 sq. m/g
BJH CUMULATIVE ADSORPTION SURFACE AREA OF PORES BETWEEN 17.0000 AND 3000.0000 A DIAMETER:	91.9671 sq. m/g
BJH CUMULATIVE DESORPTION SURFACE AREA OF PORES BETWEEN 17.0000 AND 3000.0000 A DIAMETER:	115.1987 sq. m/g
MICROPORE AREA:	316.3200 sq. m/g

VOLUME

SINGLE POINT TOTAL PORE VOLUME OF PORES LESS THAN 1150.3456 A DIAMETER AT P/Po 0.9829:	0.246190 cc/g
BJH CUMULATIVE ADSORPTION PORE VOLUME OF PORES BETWEEN 17.0000 AND 3000.0000 A DIAMETER:	0.088929 cc/g
BJH CUMULATIVE DESORPTION PORE VOLUME OF PORES BETWEEN 17.0000 AND 3000.0000 A DIAMETER:	0.096788 cc/g
MICROPORE VOLUME:	0.143349 cc/g

PORE SIZE

AVERAGE PORE DIAMETER (4V/A BY BET):	16.5112 A
BJH ADSORPTION AVERAGE PORE DIAMETER (4V/A):	38.6788 A
BJH DESORPTION AVERAGE PORE DIAMETER (4V/A):	33.6073 A

E.6 Summary Report of PILB 32 after 1st thermal testing at 80 °C

SAMPLE DIRECTORY/NUMBER: BET1 /74	START 20:28:26 03/01/08
SAMPLE ID: PILB 32 reg 1 80 C	COMPL 00:34:55 03/01/08
SUBMITTER:	REPRT 08:52:07 03/01/08
OPERATOR: Jirawan	SAMPLE WT: 0.3120 g
UNIT NUMBER: 1	FREE SPACE: 42.1130 cc
ANALYSIS GAS: Nitrogen	EQUIL INTRVL: 10 sec

SUMMARY REPORT

AREA

BET SURFACE AREA:	508.7707 sq. m/g
LANGMUIR SURFACE AREA:	679.2824 sq. m/g
SINGLE POINT SURFACE AREA AT P/Po 0.2035:	514.69 sq. m/g
BJH CUMULATIVE ADSORPTION SURFACE AREA OF PORES	
BETWEEN 17.0000 AND 3000.0000 A DIAMETER:	112.9889 sq. m/g
BJH CUMULATIVE DESORPTION SURFACE AREA OF PORES	
BETWEEN 17.0000 AND 3000.0000 A DIAMETER:	145.5696 sq. m/g
MICROPORE AREA:	357.5427 sq. m/g

VOLUME

SINGLE POINT TOTAL PORE VOLUME OF PORES LESS THAN	
1313.9207 A DIAMETER AT P/Po 0.9851:	0.293848 cc/g
BJH CUMULATIVE ADSORPTION PORE VOLUME OF PORES	
BETWEEN 17.0000 AND 3000.0000 A DIAMETER:	0.116765 cc/g
BJH CUMULATIVE DESORPTION PORE VOLUME OF PORES	
BETWEEN 17.0000 AND 3000.0000 A DIAMETER:	0.132441 cc/g
MICROPORE VOLUME:	0.162072 cc/g

PORE SIZE

AVERAGE PORE DIAMETER (4V/A BY BET):	17.3034 A
BJH ADSORPTION AVERAGE PORE DIAMETER (4V/A):	41.3370 A
BJH DESORPTION AVERAGE PORE DIAMETER (4V/A):	36.3926 A

E.7 Summary Report of PILB 32 after 2nd thermal testing at 80 °C

SAMPLE DIRECTORY/NUMBER: BET1 /76	START 15:22:02 03/01/08
SAMPLE ID: PILB 32 reg 2 80 C	COMPL 19:26:38 03/01/08
SUBMITTER:	REPRT 21:36:41 03/01/08
OPERATOR: Jirawan	SAMPLE WT: 0.3320 g
UNIT NUMBER: 1	FREE SPACE: 39.1811 cc
ANALYSIS GAS: Nitrogen	EQUIL INTRVL: 10 sec

SUMMARY REPORT

AREA

BET SURFACE AREA:	487.5213 sq. m/g
LANGMUIR SURFACE AREA:	651.2004 sq. m/g
SINGLE POINT SURFACE AREA AT P/Po 0.2035:	493.7695 sq. m/g
BJH CUMULATIVE ADSORPTION SURFACE AREA OF PORES	
BETWEEN 17.0000 AND 3000.0000 A DIAMETER:	105.3820 sq. m/g
BJH CUMULATIVE DESORPTION SURFACE AREA OF PORES	
BETWEEN 17.0000 AND 3000.0000 A DIAMETER:	140.3488 sq. m/g
MICROPORE AREA:	345.6625 sq. m/g

VOLUME

SINGLE POINT TOTAL PORE VOLUME OF PORES LESS THAN	
1313.9207 A DIAMETER AT P/Po 0.9852:	0.279617 cc/g
BJH CUMULATIVE ADSORPTION PORE VOLUME OF PORES	
BETWEEN 17.0000 AND 3000.0000 A DIAMETER:	0.108449 cc/g
BJH CUMULATIVE DESORPTION PORE VOLUME OF PORES	
BETWEEN 17.0000 AND 3000.0000 A DIAMETER:	0.125289 cc/g
MICROPORE VOLUME:	0.156904 cc/g

PORE SIZE

AVERAGE PORE DIAMETER (4V/A BY BET):	17.1755 A
BJH ADSORPTION AVERAGE PORE DIAMETER (4V/A):	41.1640 A
BJH DESORPTION AVERAGE PORE DIAMETER (4V/A):	35.7079 A

E.8 Summary Report of PILB 32 after 3rd thermal testing at 80 °C

SAMPLE DIRECTORY/NUMBER: BET1 /75	START 10:44:01 03/01/08
SAMPLE ID: PILB 32 reg 3 80 C	COMPL 14:17:53 03/01/08
SUBMITTER:	REPRT 14:21:13 03/01/08
OPERATOR: Jirawan	SAMPLE WT: 0.3291 g
UNIT NUMBER: 1	FREE SPACE: 48.4594 cc
ANALYSIS GAS: Nitrogen	EQUIL INTRVL: 10 sec

SUMMARY REPORT

AREA

BET SURFACE AREA:	472.2952 sq. m/g
LANGMUIR SURFACE AREA:	630.6513 sq. m/g
SINGLE POINT SURFACE AREA AT P/Po 0.2032:	478.1172 sq. m/g
BJH CUMULATIVE ADSORPTION SURFACE AREA OF PORES	
BETWEEN 17.0000 AND 3000.0000 A DIAMETER:	104.1780 sq. m/g
BJH CUMULATIVE DESORPTION SURFACE AREA OF PORES	
BETWEEN 17.0000 AND 3000.0000 A DIAMETER:	139.8100 sq. m/g
MICROPORE AREA:	334.2438 sq. m/g

VOLUME

SINGLE POINT TOTAL PORE VOLUME OF PORES LESS THAN	
1313.9207 A DIAMETER AT P/Po 0.9875:	0.271278 cc/g
BJH CUMULATIVE ADSORPTION PORE VOLUME OF PORES	
BETWEEN 17.0000 AND 3000.0000 A DIAMETER:	0.105978 cc/g
BJH CUMULATIVE DESORPTION PORE VOLUME OF PORES	
BETWEEN 17.0000 AND 3000.0000 A DIAMETER:	0.122444 cc/g
MICROPORE VOLUME:	0.151545 cc/g

PORE SIZE

AVERAGE PORE DIAMETER (4V/A BY BET):	17.2062 A
BJH ADSORPTION AVERAGE PORE DIAMETER (4V/A):	40.6912 A
BJH DESORPTION AVERAGE PORE DIAMETER (4V/A):	35.0316 A

E.9 Summary Report of Activated carbon after 1st thermal testing at 80 °C

SAMPLE DIRECTORY/NUMBER: BET1 /41	START 15:26:01 03/01/08
SAMPLE ID: AC reg 1 80 C	COMPL 19:14:01 03/01/08
SUBMITTER:	REPRT 08:10:59 02/29/08
OPERATOR: Jirawan	SAMPLE WT: 0.3099 g
UNIT NUMBER: 1	FREE SPACE: 43.6450 cc
ANALYSIS GAS: Nitrogen	EQUIL INTRVL: 10 sec

SUMMARY REPORT

AREA

BET SURFACE AREA:	1095.4999 sq. m/g
LANGMUIR SURFACE AREA:	1470.5833 sq. m/g
SINGLE POINT SURFACE AREA AT P/Po 0.2083:	1110.8542 sq. m/g
BJH CUMULATIVE ADSORPTION SURFACE AREA OF PORES BETWEEN 17.0000 AND 3000.0000 A DIAMETER:	194.0910 sq. m/g
BJH CUMULATIVE DESORPTION SURFACE AREA OF PORES BETWEEN 17.0000 AND 3000.0000 A DIAMETER:	212.3484 sq. m/g
MICROPORE AREA:	797.5182 sq. m/g

VOLUME

SINGLE POINT TOTAL PORE VOLUME OF PORES LESS THAN 1313.9207 A DIAMETER AT P/Po 0.9845:	0.546367 cc/g
BJH CUMULATIVE ADSORPTION PORE VOLUME OF PORES BETWEEN 17.0000 AND 3000.0000 A DIAMETER:	0.136656 cc/g
BJH CUMULATIVE DESORPTION PORE VOLUME OF PORES BETWEEN 17.0000 AND 3000.0000 A DIAMETER:	0.144575 cc/g
MICROPORE VOLUME:	0.364274 cc/g

PORE SIZE

AVERAGE PORE DIAMETER (4V/A BY BET):	14.8612 A
BJH ADSORPTION AVERAGE PORE DIAMETER (4V/A):	28.1632 A
BJH DESORPTION AVERAGE PORE DIAMETER (4V/A):	27.2335 A

E.10 Summary Report of Activated carbon after 2nd thermal testing at 80 °C

SAMPLE DIRECTORY/NUMBER: BET1 /40	START 11:14:49 03/01/08
SAMPLE ID: AC reg 2 80 C	COMPL 14;52:09 03/01/08
SUBMITTER:	REPRT 08:30:57 02/29/08
OPERATOR: Jirawan	SAMPLE WT: 0.3286 g
UNIT NUMBER: 1	FREE SPACE: 48.2661 cc
ANALYSIS GAS: Nitrogen	EQUIL INTRVL: 10 sec

SUMMARY REPORT

AREA

BET SURFACE AREA:	996.5718 sq. m/g
LANGMUIR SURFACE AREA:	1334.1444 sq. m/g
SINGLE POINT SURFACE AREA AT P/Po 0.2093:	1009.7493 sq. m/g
BJH CUMULATIVE ADSORPTION SURFACE AREA OF PORES BETWEEN 17.0000 AND 3000.0000 A DIAMETER:	146.4302 sq. m/g
BJH CUMULATIVE DESORPTION SURFACE AREA OF PORES BETWEEN 17.0000 AND 3000.0000 A DIAMETER:	173.1523 sq. m/g
MICROPORE AREA:	685.3716 sq. m/g

VOLUME

SINGLE POINT TOTAL PORE VOLUME OF PORES LESS THAN 1313.9207 A DIAMETER AT P/Po 0.9844:	0.494074 cc/g
BJH CUMULATIVE ADSORPTION PORE VOLUME OF PORES BETWEEN 17.0000 AND 3000.0000 A DIAMETER:	0.108156 cc/g
BJH CUMULATIVE DESORPTION PORE VOLUME OF PORES BETWEEN 17.0000 AND 3000.0000 A DIAMETER:	0.119669 cc/g
MICROPORE VOLUME:	0.317125 cc/g

PORE SIZE

AVERAGE PORE DIAMETER (4V/A BY BET):	14.8132 A
BJH ADSORPTION AVERAGE PORE DIAMETER (4V/A):	29.5446 A
BJH DESORPTION AVERAGE PORE DIAMETER (4V/A):	27.6448 A

E.11 Summary Report of Activated carbon after 3rd thermal testing at 80 °C

SAMPLE DIRECTORY/NUMBER: BET1 /43	START 10:34:06 03/01/08
SAMPLE ID: AC reg 3 80 C	COMPL 14:16:09 03/01/08
SUBMITTER:	REPRT 08:26:04 02/29/08
OPERATOR: Jirawan	SAMPLE WT: 0.3688 g
UNIT NUMBER: 1	FREE SPACE: 43.7699 cc
ANALYSIS GAS: Nitrogen	EQUIL INTRVL: 10 sec

SUMMARY REPORT

AREA

BET SURFACE AREA:	970.2037 sq. m/g
LANGMUIR SURFACE AREA:	1300.4584 sq. m/g
SINGLE POINT SURFACE AREA AT P/Po 0.2100:	985.6025 sq. m/g
BJH CUMULATIVE ADSORPTION SURFACE AREA OF PORES BETWEEN 17.0000 AND 3000.0000 A DIAMETER:	132.4524 sq. m/g
BJH CUMULATIVE DESORPTION SURFACE AREA OF PORES BETWEEN 17.0000 AND 3000.0000 A DIAMETER:	165.4210 sq. m/g
MICROPORE AREA:	681.4242 sq. m/g

VOLUME

SINGLE POINT TOTAL PORE VOLUME OF PORES LESS THAN 1313.9207 A DIAMETER AT P/Po 0.9847:	0.479955 cc/g
BJH CUMULATIVE ADSORPTION PORE VOLUME OF PORES BETWEEN 17.0000 AND 3000.0000 A DIAMETER:	0.098132 cc/g
BJH CUMULATIVE DESORPTION PORE VOLUME OF PORES BETWEEN 17.0000 AND 3000.0000 A DIAMETER:	0.112594 cc/g
MICROPORE VOLUME:	0.316448 cc/g

PORE SIZE

AVERAGE PORE DIAMETER (4V/A BY BET):	14.7626 A
BJH ADSORPTION AVERAGE PORE DIAMETER (4V/A):	29.6354 A
BJH DESORPTION AVERAGE PORE DIAMETER (4V/A):	27.2260 A

E.12 Summary Report of PILB32 after 1st thermal testing at 800 °C

SAMPLE DIRECTORY/NUMBER: BET1 /118	START 21:12:50 01/21/09
SAMPLE ID: PILB 32 reg 1 800C	COMPL 23:50:42 01/21/09
SUBMITTER:	REPRT 16:13:30 03/23/09
OPERATOR: Jirawan	SAMPLE WT: 0.3270 g
UNIT NUMBER: 1	FREE SPACE: 47.7858 cc
ANALYSIS GAS: Nitrogen	EQUIL INTRVL: 10 sec

SUMMARY REPORT

AREA

BET SURFACE AREA:	472.1995 sq. m/g
LANGMUIR SURFACE AREA:	630.6974 sq. m/g
SINGLE POINT SURFACE AREA AT P/Po 0.2038:	477.5231 sq. m/g
BJH CUMULATIVE ADSORPTION SURFACE AREA OF PORES BETWEEN 17.0000 AND 3000.0000 A DIAMETER:	82.7600 sq. m/g
BJH CUMULATIVE DESORPTION SURFACE AREA OF PORES BETWEEN 17.0000 AND 3000.0000 A DIAMETER:	95.2592 sq. m/g
MICROPORE AREA:	302.2133 sq. m/g

VOLUME

SINGLE POINT TOTAL PORE VOLUME OF PORES LESS THAN 1256.9944 A DIAMETER AT P/Po 0.9844:	0.235545 cc/g
BJH CUMULATIVE ADSORPTION PORE VOLUME OF PORES BETWEEN 17.0000 AND 3000.0000 A DIAMETER:	0.060477 cc/g
BJH CUMULATIVE DESORPTION PORE VOLUME OF PORES BETWEEN 17.0000 AND 3000.0000 A DIAMETER:	0.065657 cc/g
MICROPORE VOLUME:	0.138979 cc/g

PORE SIZE

AVERAGE PORE DIAMETER (4V/A BY BET):	14.9387 A
BJH ADSORPTION AVERAGE PORE DIAMETER (4V/A):	29.2299 A
BJH DESORPTION AVERAGE PORE DIAMETER (4V/A):	27.5696 A

E.13 Summary Report of PILB32 after 2nd thermal testing at 800 °C

SAMPLE DIRECTORY/NUMBER: BET1 /117	START 15:32:37 01/21/09
SAMPLE ID: PILB 32 reg 2 800C	COMPL 18:30:35 01/21/09
SUBMITTER:	REPRT 08:40:21 01/22/09
OPERATOR: Jirawan	SAMPLE WT: 0.3108 g
UNIT NUMBER: 1	FREE SPACE: 43.0894 cc
ANALYSIS GAS: Nitrogen	EQUIL INTRVL: 10 sec

SUMMARY REPORT

AREA

BET SURFACE AREA:	466.7099 sq. m/g
LANGMUIR SURFACE AREA:	624.6108 sq. m/g
SINGLE POINT SURFACE AREA AT P/Po 0.2038:	473.8582 sq. m/g
BJH CUMULATIVE ADSORPTION SURFACE AREA OF PORES BETWEEN 17.0000 AND 3000.0000 A DIAMETER:	76.3276 sq. m/g
BJH CUMULATIVE DESORPTION SURFACE AREA OF PORES BETWEEN 17.0000 AND 3000.0000 A DIAMETER:	85.6618 sq. m/g
MICROPORE AREA:	287.7833 sq. m/g

VOLUME

SINGLE POINT TOTAL PORE VOLUME OF PORES LESS THAN 1379.6873 A DIAMETER AT P/Po 0.9858:	0.231830 cc/g
BJH CUMULATIVE ADSORPTION PORE VOLUME OF PORES BETWEEN 17.0000 AND 3000.0000 A DIAMETER:	0.055427 cc/g
BJH CUMULATIVE DESORPTION PORE VOLUME OF PORES BETWEEN 17.0000 AND 3000.0000 A DIAMETER:	0.059313 cc/g
MICROPORE VOLUME:	0.133920 cc/g

PORE SIZE

AVERAGE PORE DIAMETER (4V/A BY BET):	14.8464 A
BJH ADSORPTION AVERAGE PORE DIAMETER (4V/A):	29.0470 A
BJH DESORPTION AVERAGE PORE DIAMETER (4V/A):	27.6964 A

E.14 Summary Report of PILB32 after 3rd thermal testing at 800 °C

SAMPLE DIRECTORY/NUMBER: BET1 /119	START 16:59:24 01/22/09
SAMPLE ID: PILB 32 reg 3 800C	COMPL 14:49:27 01/22/09
SUBMITTER:	REPRT 09:22:24 01/23/09
OPERATOR: Jirawan	SAMPLE WT: 0.3332 g
UNIT NUMBER: 1	FREE SPACE: 48.2782 cc
ANALYSIS GAS: Nitrogen	EQUIL INTRVL: 10 sec

SUMMARY REPORT

AREA

BET SURFACE AREA:	426.0530 sq. m/g
LANGMUIR SURFACE AREA:	568.9549 sq. m/g
SINGLE POINT SURFACE AREA AT P/Po 0.2035:	426.1189 sq. m/g
BJH CUMULATIVE ADSORPTION SURFACE AREA OF PORES BETWEEN 17.0000 AND 3000.0000 A DIAMETER:	84.0630 sq. m/g
BJH CUMULATIVE DESORPTION SURFACE AREA OF PORES BETWEEN 17.0000 AND 3000.0000 A DIAMETER:	94.3483 sq. m/g
MICROPORE AREA:	257.9795 sq. m/g

VOLUME

SINGLE POINT TOTAL PORE VOLUME OF PORES LESS THAN 1379.1875 A DIAMETER AT P/Po 0.9858:	0.213858 cc/g
BJH CUMULATIVE ADSORPTION PORE VOLUME OF PORES BETWEEN 17.0000 AND 3000.0000 A DIAMETER:	0.060959 cc/g
BJH CUMULATIVE DESORPTION PORE VOLUME OF PORES BETWEEN 17.0000 AND 3000.0000 A DIAMETER:	0.066450 cc/g
MICROPORE VOLUME:	0.118150 cc/g

PORE SIZE

AVERAGE PORE DIAMETER (4V/A BY BET):	15.0352 A
BJH ADSORPTION AVERAGE PORE DIAMETER (4V/A):	29.0065 A
BJH DESORPTION AVERAGE PORE DIAMETER (4V/A):	27.6564 A

E.15 Summary Report of Activated carbon after 1st thermal testing at 800 °C

SAMPLE DIRECTORY/NUMBER: BET1 /120	START 15:59:22 01/22/09
SAMPLE ID: AC reg 1 800 C	COMPL 19:53:20 01/22/09
SUBMITTER:	REPRT 09:57:37 01/23/09
OPERATOR: Jirawan	SAMPLE WT: 0.2963 g
UNIT NUMBER: 1	FREE SPACE: 42.9811 cc
ANALYSIS GAS: Nitrogen	EQUIL INTRVL: 10 sec

SUMMARY REPORT

AREA

BET SURFACE AREA:	1259.1769 sq. m/g
LANGMUIR SURFACE AREA:	1698.3046 sq. m/g
SINGLE POINT SURFACE AREA AT P/Po 0.2124:	1270.8685 sq. m/g
BJH CUMULATIVE ADSORPTION SURFACE AREA OF PORES BETWEEN 17.0000 AND 3000.0000 A DIAMETER:	218.194 sq. m/g
BJH CUMULATIVE DESORPTION SURFACE AREA OF PORES BETWEEN 17.0000 AND 3000.0000 A DIAMETER:	234.1353 sq. m/g
MICROPORE AREA:	735.0363 sq. m/g

VOLUME

SINGLE POINT TOTAL PORE VOLUME OF PORES LESS THAN 1281.7700 A DIAMETER AT P/Po 0.9847:	0.628719 cc/g
BJH CUMULATIVE ADSORPTION PORE VOLUME OF PORES BETWEEN 17.0000 AND 3000.0000 A DIAMETER:	0.156873 cc/g
BJH CUMULATIVE DESORPTION PORE VOLUME OF PORES BETWEEN 17.0000 AND 3000.0000 A DIAMETER:	0.164036 cc/g
MICROPORE VOLUME:	0.343674 cc/g

PORE SIZE

AVERAGE PORE DIAMETER (4V/A BY BET):	14.8082 A
BJH ADSORPTION AVERAGE PORE DIAMETER (4V/A):	28.7585 A
BJH DESORPTION AVERAGE PORE DIAMETER (4V/A):	28.0241 A

E.16 Summary Report of Activated carbon after 2nd thermal testing at 800 °C

SAMPLE DIRECTORY/NUMBER: BET1 /124	START 11:32:45 01/24/09
SAMPLE ID: AC reg 2 800 C	COMPL 15:30:16 01/24/09
SUBMITTER:	REPRT 16:39:12 01/24/09
OPERATOR: Jirawan	SAMPLE WT: 0.3447 g
UNIT NUMBER: 1	FREE SPACE: 40.1701 cc
ANALYSIS GAS: Nitrogen	EQUIL INTRVL: 10 sec

SUMMARY REPORT

AREA

BET SURFACE AREA:	1083.9700 sq. m/g
LANGMUIR SURFACE AREA:	1461.4056 sq. m/g
SINGLE POINT SURFACE AREA AT P/Po 0.12122:	1099.7186 sq. m/g
BJH CUMULATIVE ADSORPTION SURFACE AREA OF PORES BETWEEN 17.0000 AND 3000.0000 A DIAMETER:	168.1706 sq. m/g
BJH CUMULATIVE DESORPTION SURFACE AREA OF PORES BETWEEN 17.0000 AND 3000.0000 A DIAMETER:	201.8152 sq. m/g
MICROPORE AREA:	686.7747 sq. m/g

VOLUME

SINGLE POINT TOTAL PORE VOLUME OF PORES LESS THAN 1340.4857 A DIAMETER AT P/Po 0.9853:	0.544067cc/g
BJH CUMULATIVE ADSORPTION PORE VOLUME OF PORES BETWEEN 17.0000 AND 3000.0000 A DIAMETER:	0.125992cc/g
BJH CUMULATIVE DESORPTION PORE VOLUME OF PORES BETWEEN 17.0000 AND 3000.0000 A DIAMETER:	0.140994 cc/g
MICROPORE VOLUME:	0.322045 cc/g

PORE SIZE

AVERAGE PORE DIAMETER (4V/A BY BET):	14.8916 A
BJH ADSORPTION AVERAGE PORE DIAMETER (4V/A):	29.9676 A
BJH DESORPTION AVERAGE PORE DIAMETER (4V/A):	27.9451 A

E.17 Summary Report of Activated carbon after 3rd thermal testing at 800 °C

SAMPLE DIRECTORY/NUMBER: BET1 /123	START 14:59:02 01/23/09
SAMPLE ID: AC reg 3 800 C	COMPL 18:33:22 01/23/09
SUBMITTER:	REPRT 10:10:21 01/24/09
OPERATOR: Jirawan	SAMPLE WT: 0.3476 g
UNIT NUMBER: 1	FREE SPACE: 49.4453 cc
ANALYSIS GAS: Nitrogen	EQUIL INTRVL: 10 sec

SUMMARY REPORT

AREA

BET SURFACE AREA:	1047.6748 sq. m/g
LANGMUIR SURFACE AREA:	1403.9771 sq. m/g
SINGLE POINT SURFACE AREA AT P/Po 0.2095:	1061.8749 sq. m/g
BJH CUMULATIVE ADSORPTION SURFACE AREA OF PORES BETWEEN 17.0000 AND 3000.0000 A DIAMETER:	156.7035 sq. m/g
BJH CUMULATIVE DESORPTION SURFACE AREA OF PORES BETWEEN 17.0000 AND 3000.0000 A DIAMETER:	176.3198 sq. m/g
MICROPORE AREA:	713.1361 sq. m/g

VOLUME

SINGLE POINT TOTAL PORE VOLUME OF PORES LESS THAN 1259.2091 A DIAMETER AT P/Po 0.9844:	0.518809 cc/g
BJH CUMULATIVE ADSORPTION PORE VOLUME OF PORES BETWEEN 17.0000 AND 3000.0000 A DIAMETER:	0.114110 cc/g
BJH CUMULATIVE DESORPTION PORE VOLUME OF PORES BETWEEN 17.0000 AND 3000.0000 A DIAMETER:	0.122636 cc/g
MICROPORE VOLUME:	0.330378 cc/g

PORE SIZE

AVERAGE PORE DIAMETER (4V/A BY BET):	14.7811 A
BJH ADSORPTION AVERAGE PORE DIAMETER (4V/A):	29.1276 A
BJH DESORPTION AVERAGE PORE DIAMETER (4V/A):	27.8213 A

BIOGRAPHY

Jirawan Jampanil was born in Suphanburi Province on 7 December 1976. She graduated from Chulalongkorn University in Bachelor Degree of General Science in 1998 and Master Degree of Environmental Science in 2001. At the present, she has worked at SCG-DOW Group (The Siam Cement and Dow Chemical Group of Joint Venture Companies) in the position of site environmental specialist.