

Supplementary Information

Reversible and Easy Post-crosslinking Method for Developing Surface Ion-imprinted Hypercrosslinked Monolith for Specific Cd(II) Ion Removal from Aqueous Solutions

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Surface Area Measurements

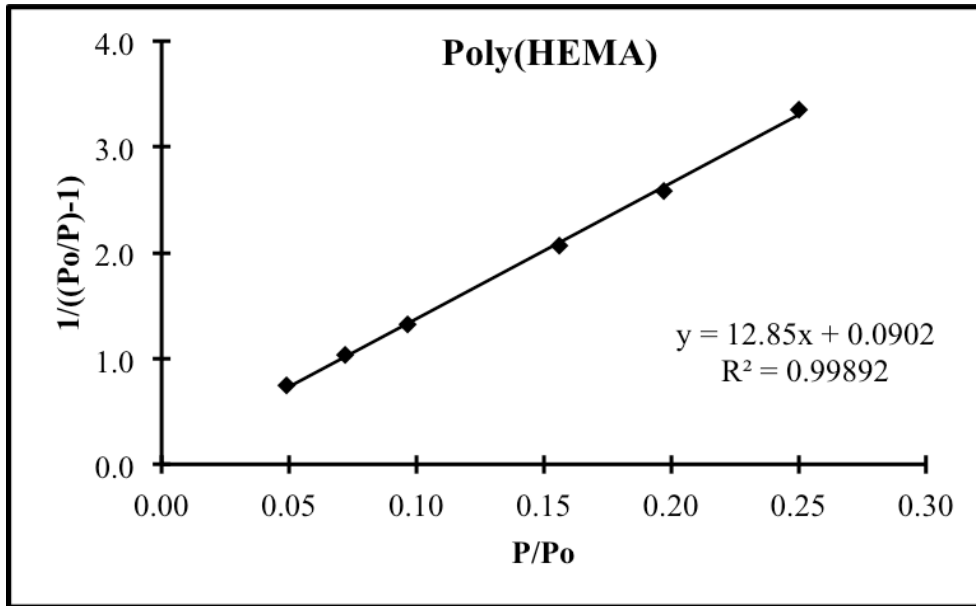


Figure SI-1. Multipoint surface area measurement of poly(HEMA) monolith.

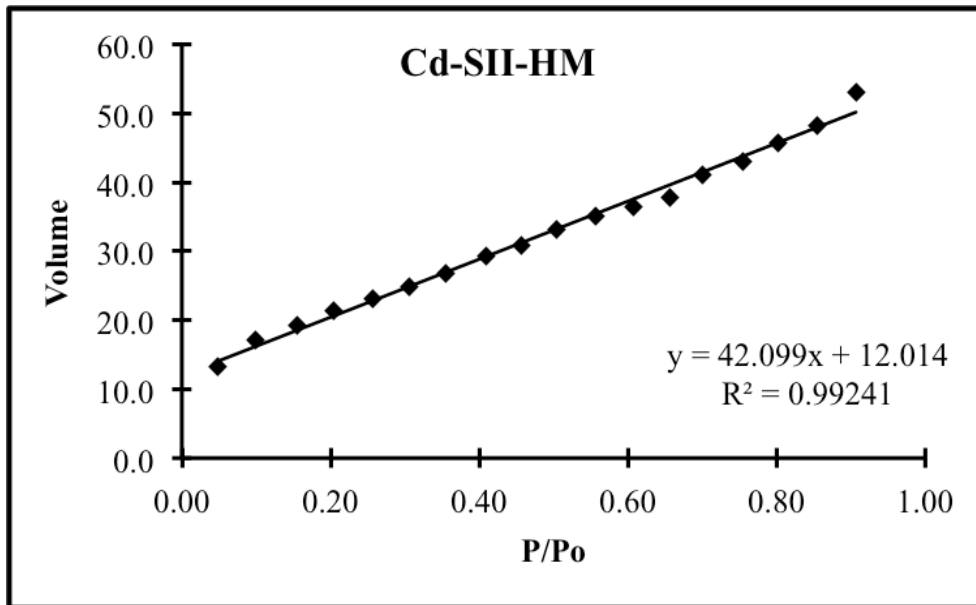


Figure SI-2. Multipoint surface area measurement of Cd-SII-HM before urea treatment.

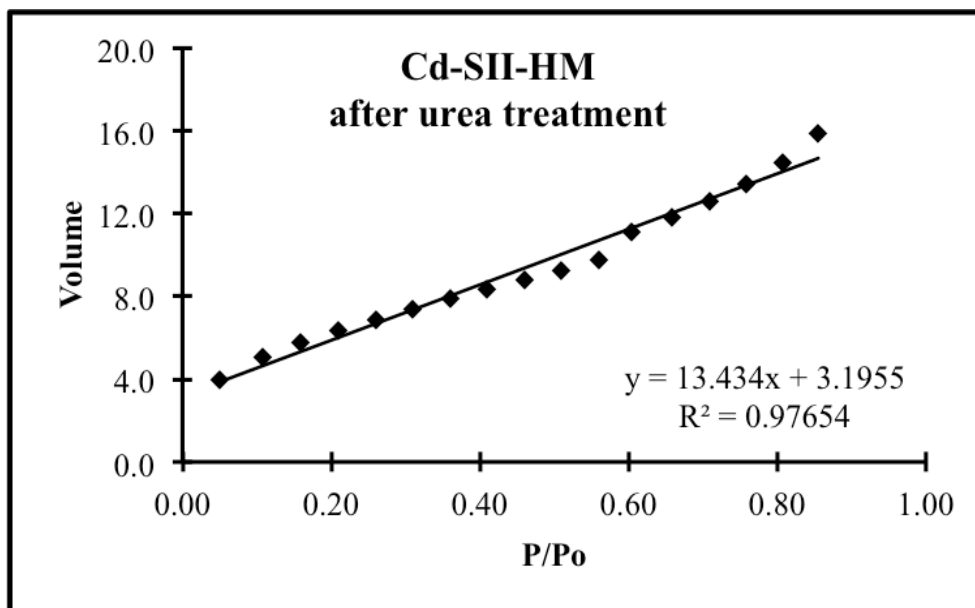


Figure SI-3. Multipoint surface area measurement of Cd-SII-HM after urea treatment.

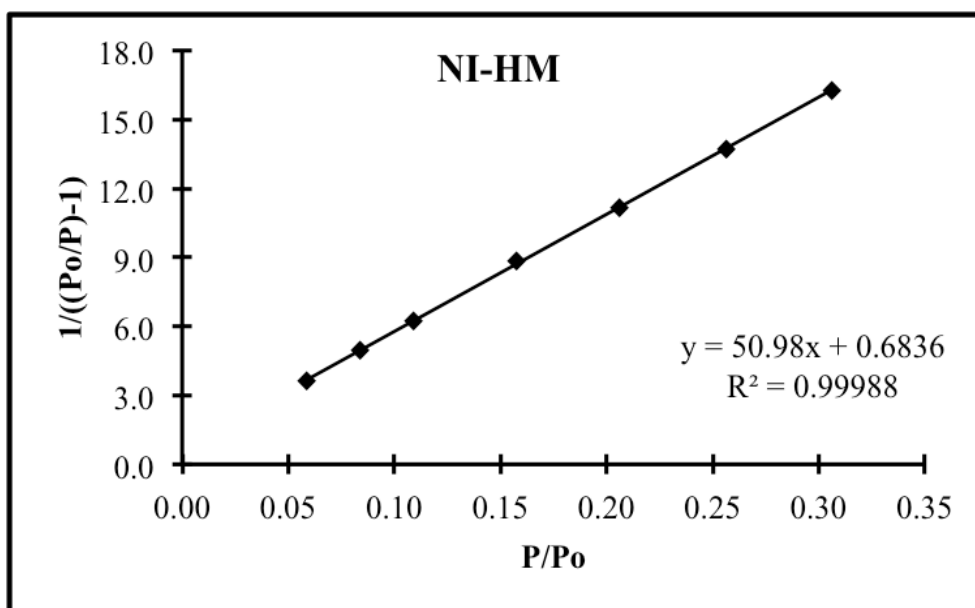


Figure SI-4. Multipoint surface area measurement of NI-HM before urea treatment.

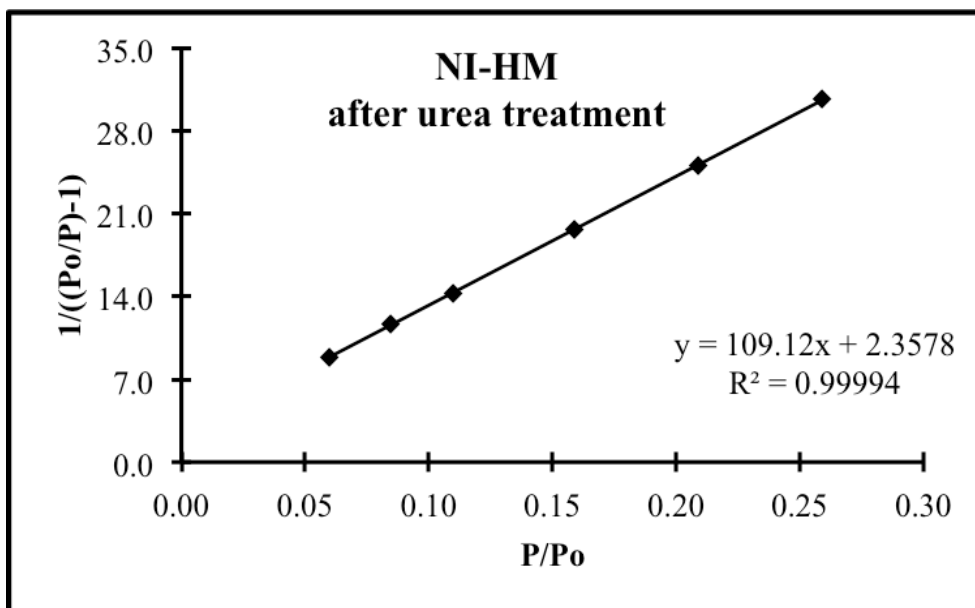


Figure SI-5. Multipoint surface area measurement of NI-HM after urea treatment.

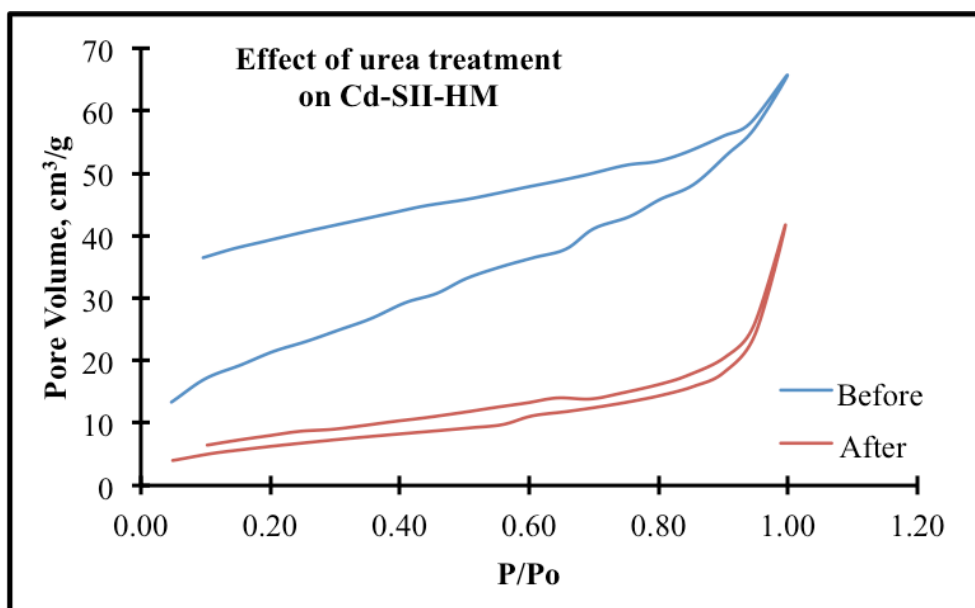


Figure SI-6. The effects of urea treatment on pore volume distribution through Cd-SII-HM.

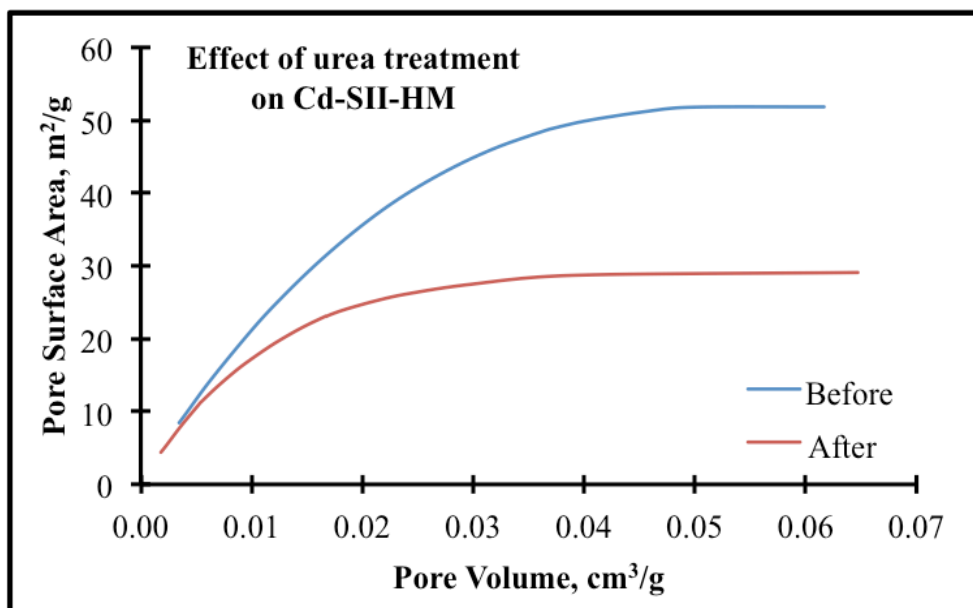


Figure SI-7. The effects of urea treatment on pore volume/pore surface area correlation through Cd-SII-HM.

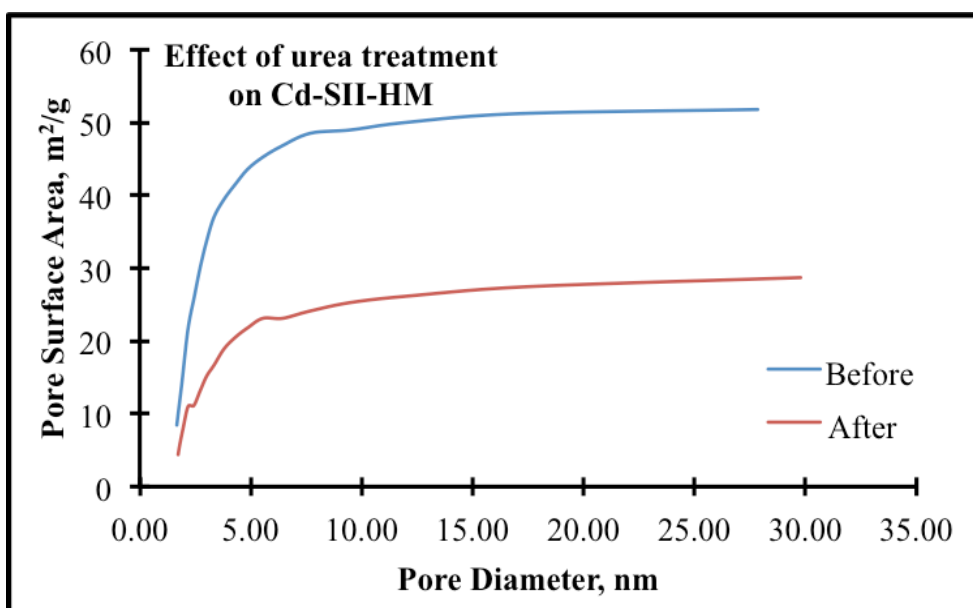


Figure SI-8. The effects of urea treatment on pore diameter/pore surface area correlation through Cd-SII-HM.

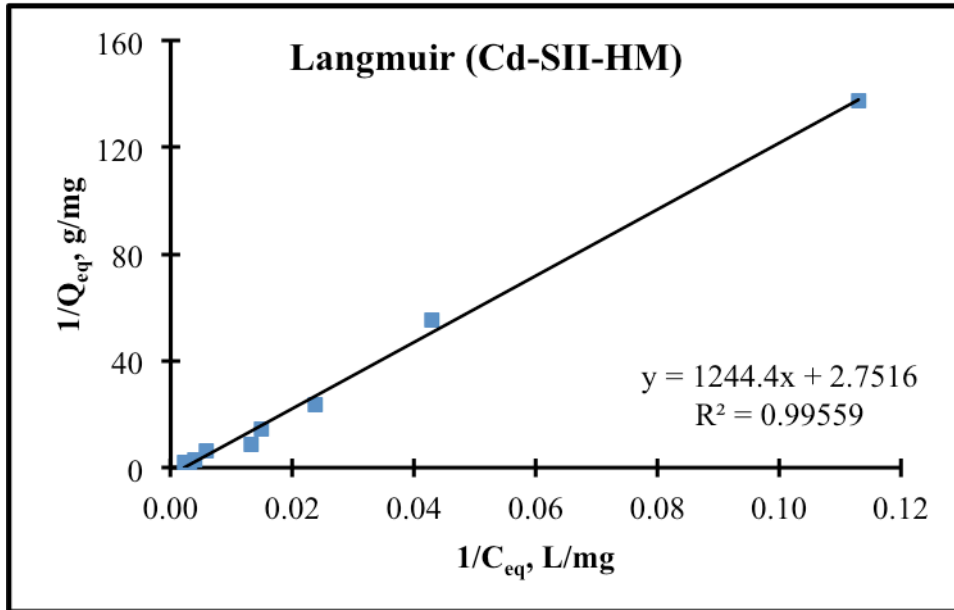


Figure SI-9. Langmuir isotherm for Cd-SII-HM.

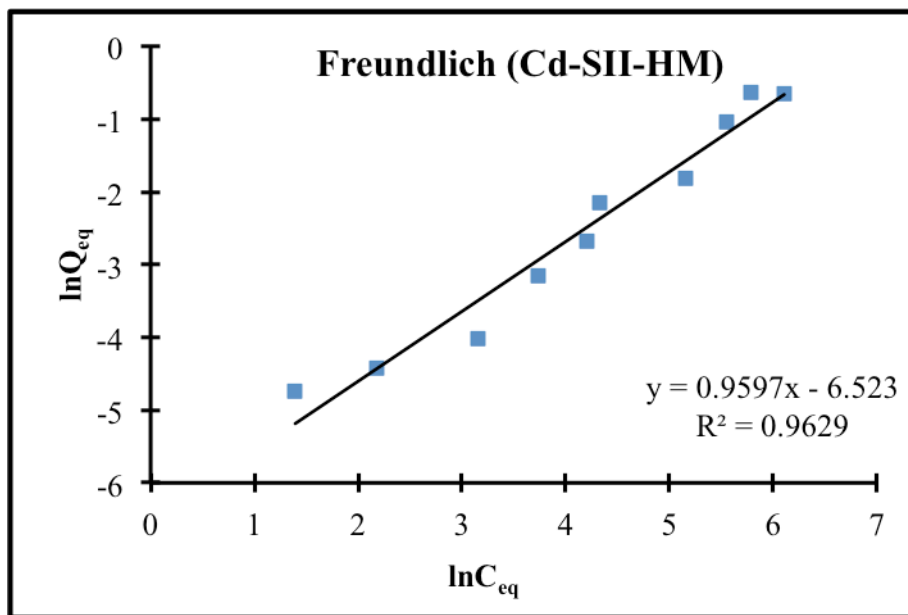


Figure SI-10. Freundlich isotherm for Cd-SII-HM.

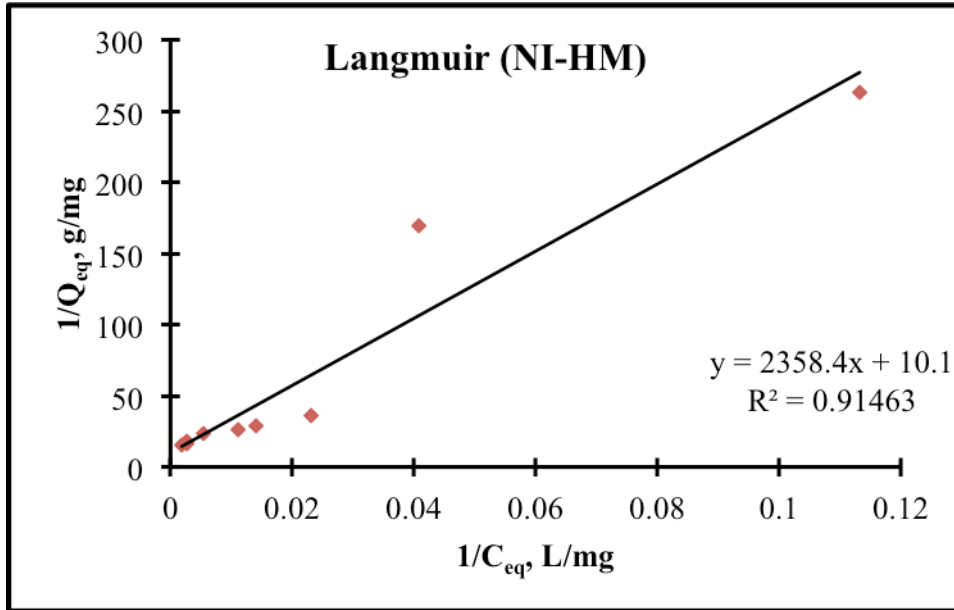


Figure SI-11. Langmuir isotherm for NI-HM.

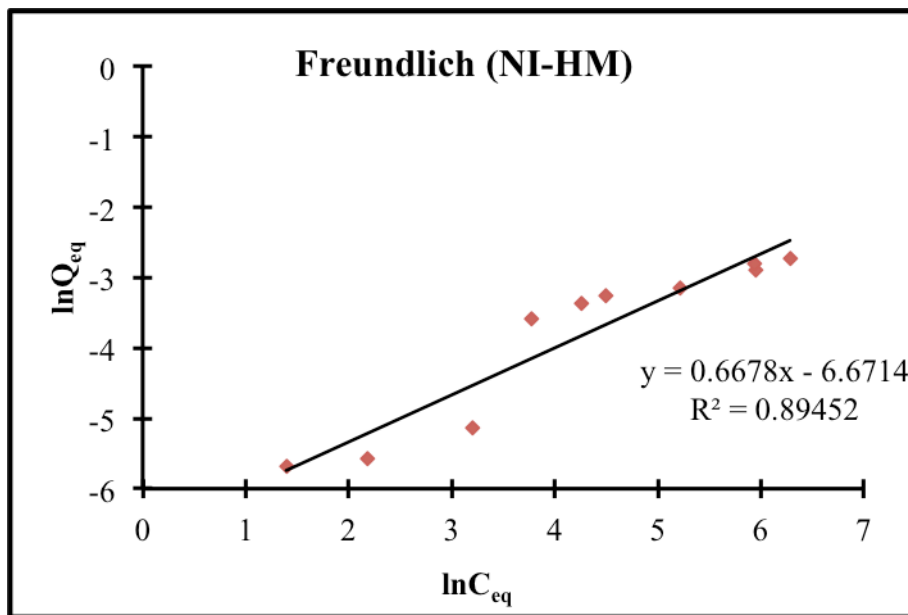


Figure SI-12. Freundlich isotherm for NI-HM.

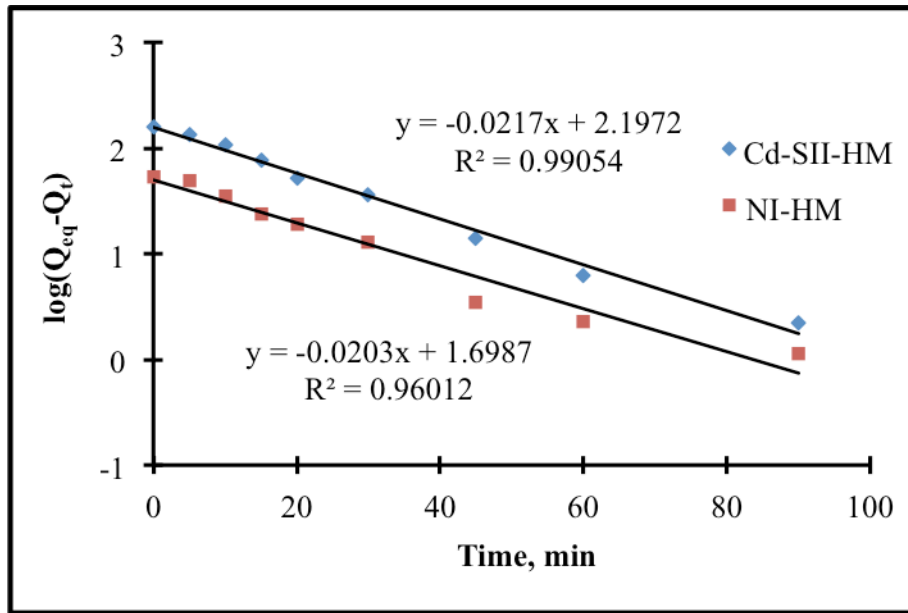


Figure SI-13. Pseudo-First order kinetic model for Cd-SII- and NI-HMs.

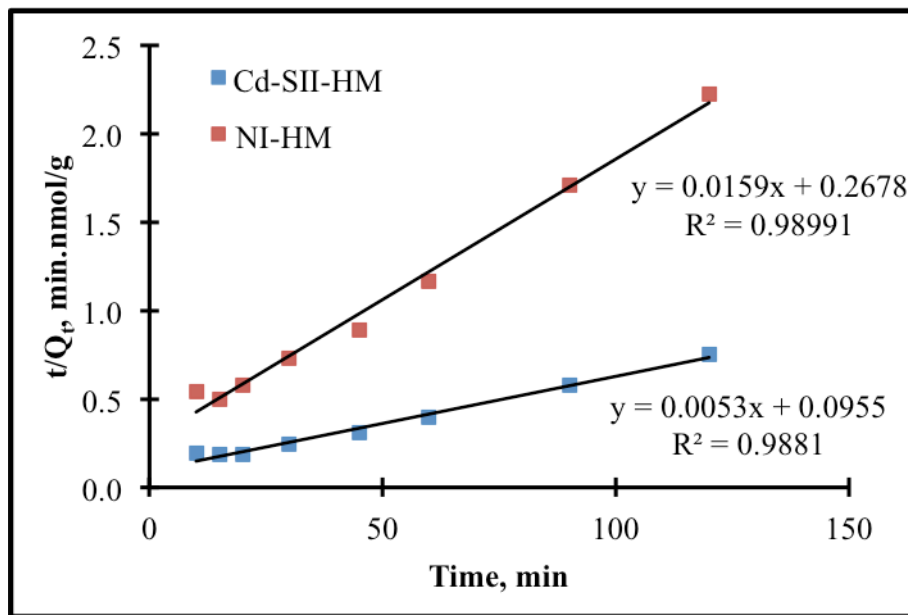


Figure SI-14. Pseudo-First order kinetic model for Cd-SII- and NI-HMs.

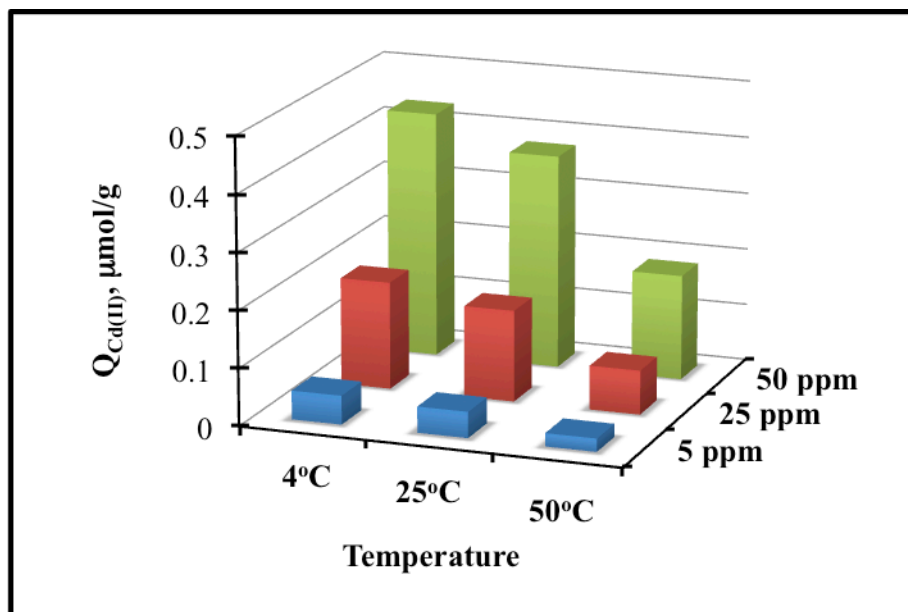


Figure SI-15. The comparison of the effect of temperature on Cd-SII-HMs adsorption capacity with correlation of initial Cd(II) ions concentration.

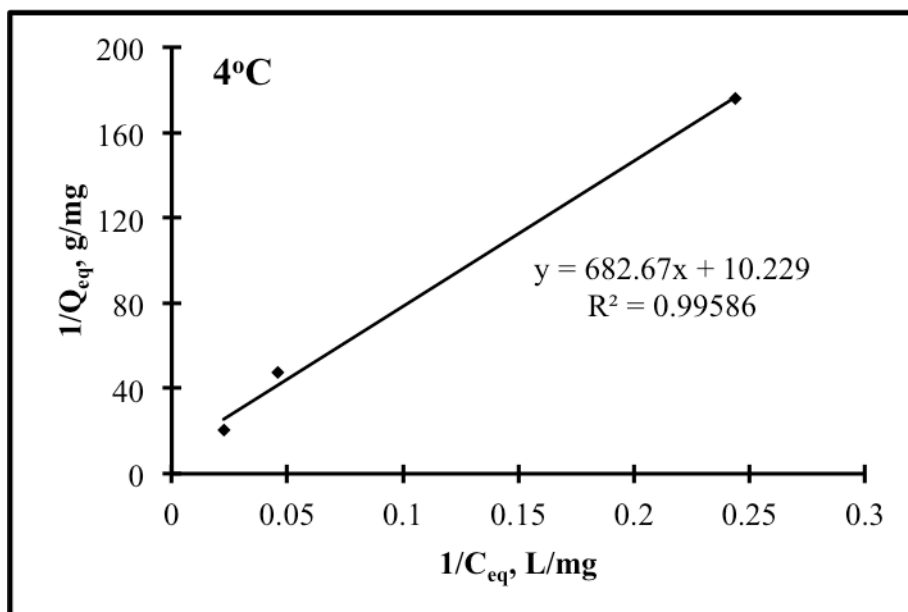


Figure SI-16. Langmuir isotherm for Cd-SII-HM at 4°C.

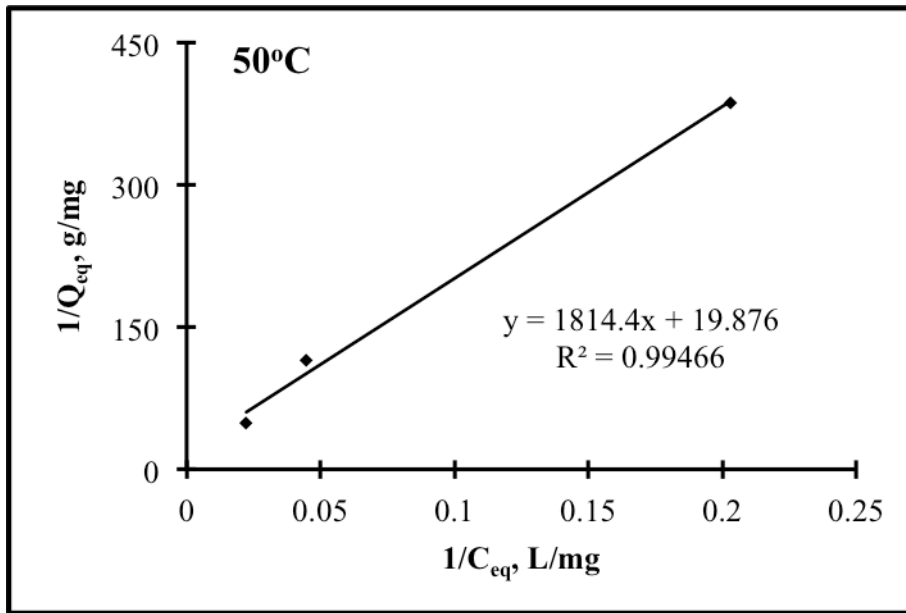


Figure SI-17. Langmuir isotherm for Cd-SII-HM at 50°C.

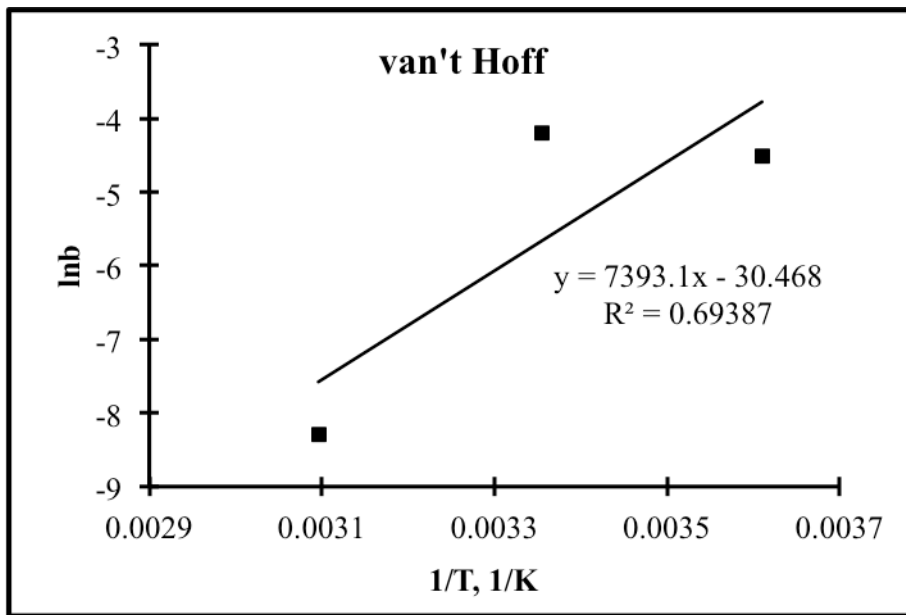


Figure SI-18. van't Hoff plot for Cd-SII-HM.

File name: C:\QCdata\PhysData\CA-3.RAW

Sample ID: 3 [poly(HEMA)]

Description: C. ARMUTCU

Comments:

Operator: KB Sample weight: 0.0969 g

Analysis gas: NITROGEN X sect. area: 16.2 Å²/molec Non-ideality: 6.58e-05

Adsorbate (DRP): Nitrogen Bath Temp.: 77.40

Outgas Temp: 100.0 °C Outgas Time: 1.0 hrs Analysis Time: 272.1 min

P/Po tolerance: 3 Equil. time: 2 End of run: 10/23/2015 14:29

Station #: 4 PC sw. version: 1.23

MULTIPOINT BET

P/Po	Volume [cc/g] STP	1/(W((Po/P)-1))
4.9215e-02	55.5882	7.450E-01
7.2023e-02	60.3241	1.029E+00
9.6737e-02	64.8915	1.321E+00
1.5608e-01	71.6528	2.065E+00
1.9731e-01	76.0386	2.587E+00
2.5038e-01	79.6786	3.354E+00

Area = 2.691E+02 m²/g

Slope = 1.285E+01

Y - Intercept = 9.033E-02

Correlation Coefficient = 0.999455

C = 1.432E+02

File name: C:\QCdata\PhysData\CA-4.RAW

Sample ID: 4 (NI-HM after urea)

Description: C. ARMUTCU

Comments:

Operator: KB Sample weight: 0.1176 g

Analysis gas: NITROGEN X sect. area: 16.2 Å²/molec Non-ideality: 6.58e-05

Adsorbate (DRP): Nitrogen Bath Temp.: 77.40

Outgas Temp: 100.0 °C Outgas Time: 1.0 hrs Analysis Time: 115.6 min

P/Po tolerance: 3 Equil. time: 2 End of run: 10/23/2015 11:52

Station #: 5 PC sw. version: 1.23

MULTIPOINT BET

P/Po	Volume [cc/g] STP	1/(W((Po/P)-1))
5.9846e-02	5.7142	8.913E+00
8.4539e-02	6.3551	1.163E+01
1.0976e-01	6.8992	1.430E+01
1.5900e-01	7.6894	1.967E+01
2.0901e-01	8.4302	2.508E+01
2.5914e-01	9.1115	3.072E+01

Area = 3.124E+01 m²/g

Slope = 1.091E+02

Y - Intercept = 2.358E+00

Correlation Coefficient = 0.999973

C = 4.728E+01

File name: C:\QCdata\PhysData\CA-5.RAW

Sample ID: 5 (NI-HM)

Description: C. ARMUTCU

Comments:

Operator: KB Sample weight: 0.1082 g

Analysis gas: NITROGEN X sect. area: 16.2 Å²/molec Non-ideality: 6.58e-05

Adsorbate (DRP): Nitrogen Bath Temp.: 77.40

Outgas Temp: 100.0 °C Outgas Time: 1.0 hrs Analysis Time: 153.2 min

P/Po tolerance: 3 Equil. time: 2 End of run: 10/23/2015 12:30

Station #: 6 PC sw. version: 1.23

MULTIPOINT BET

P/Po	Volume [cc/g] STP	1/(W((Po/P)-1))
5.8770e-02	13.8157	3.616E+00
8.4045e-02	14.7634	4.973E+00
1.0910e-01	15.6447	6.263E+00
1.5767e-01	16.9822	8.819E+00
2.0627e-01	18.5841	1.119E+01
2.5641e-01	20.1201	1.371E+01
3.0615e-01	21.6741	1.629E+01

Area = 6.741E+01 m²/g

Slope = 5.098E+01

Y - Intercept = 6.837E-01

Correlation Coefficient = 0.999940

C = 7.557E+01

File name: C:\QCdata\PhysData\CA-6.RAW

Sample ID: 6 (Cd-SII-HM after urea)

Description: C. ARMUTCU

Comments:

Operator: KB Sample weight: 0.1223 g
Analysis gas: NITROGEN X sect. area: 16.2 Å²/molec Non-ideality: 6.58e-05
Adsorbate (DRP): Nitrogen Bath Temp.: 77.40
Outgas Temp: 100.0 °C Outgas Time: 1.0 hrs Analysis Time: 276.9 min
P/Po tolerance: 3 Equil. time: 2 End of run: 10/23/2015 20:45
Station #: 3 PC sw. version: 1.23

Isotherm

P/Po	Volume	P/Po	Volume	P/Po	Volume
	[cc/g] STP		[cc/g] STP		[cc/g] STP
4.9461e-02	3.9630	7.0825e-01	12.5898	6.4341e-01	14.0148
1.0770e-01	5.0874	7.5762e-01	13.4544	5.9652e-01	13.2208
1.5936e-01	5.7661	8.0679e-01	14.4986	5.4921e-01	12.5179
2.0956e-01	6.3596	8.5511e-01	15.8989	5.0220e-01	11.7671
2.5965e-01	6.8975	9.0103e-01	18.1062	4.3977e-01	10.8512
3.0970e-01	7.4151	9.4917e-01	24.2008	3.9188e-01	10.2590
3.5981e-01	7.8888	9.9608e-01	41.7265	3.4427e-01	9.5969
4.0987e-01	8.3391	9.4680e-01	25.5227	2.9625e-01	8.9913
4.5987e-01	8.7783	9.0312e-01	20.5619	2.4650e-01	8.6774
5.0973e-01	9.2344	8.4607e-01	17.6729	1.9853e-01	7.9805
5.5943e-01	9.7556	8.0227e-01	16.2215	1.5052e-01	7.2670
6.0466e-01	11.1400	7.4134e-01	14.7612	1.0274e-01	6.4647
6.5851e-01	11.8435	6.9511e-01	13.8553		

BJH DESORPTION PORE SIZE DISTRIBUTION

Diameter	Pore Vol	Pore Surf Area	Dv(d)	Ds(d)	Dv(log d)	Ds(log d)
Å	[cc/g]	[m ² /g]	[m ² /Å/g]	[cc/g]	[m ² /g]	
17.00	1.831E-03	4.309E+00	7.692E-04	1.810E+00	3.005E-02	7.073E+01
19.37	3.515E-03	7.786E+00	7.119E-04	1.470E+00	3.171E-02	6.549E+01
21.77	5.266E-03	1.100E+01	7.164E-04	1.316E+00	3.588E-02	6.591E+01
24.35	5.341E-03	1.113E+01	2.754E-05	4.525E-02	1.543E-03	2.534E+00
27.13	6.669E-03	1.309E+01	4.661E-04	6.873E-01	2.908E-02	4.289E+01
30.12	8.228E-03	1.516E+01	4.970E-04	6.600E-01	3.443E-02	4.573E+01
33.47	9.504E-03	1.668E+01	3.578E-04	4.276E-01	2.755E-02	3.292E+01
38.00	1.163E-02	1.892E+01	3.873E-04	4.077E-01	3.383E-02	3.561E+01
43.23	1.339E-02	2.054E+01	3.533E-04	3.270E-01	3.513E-02	3.251E+01
48.73	1.494E-02	2.182E+01	2.573E-04	2.112E-01	2.884E-02	2.367E+01
55.44	1.671E-02	2.310E+01	2.399E-04	1.731E-01	3.058E-02	2.206E+01
64.41	1.671E-02	2.310E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00
76.04	1.853E-02	2.405E+01	1.429E-04	7.518E-02	2.496E-02	1.313E+01
95.00	2.141E-02	2.527E+01	1.142E-04	4.809E-02	2.484E-02	1.046E+01
122.49	2.426E-02	2.620E+01	9.595E-05	3.133E-02	2.693E-02	8.793E+00
175.93	2.980E-02	2.746E+01	7.181E-05	1.633E-02	2.862E-02	6.507E+00

297.78 3.899E-02 2.869E+01 5.513E-05 7.406E-03 3.680E-02 4.943E+00
2647.63 6.471E-02 2.908E+01 5.676E-06 8.575E-05 2.317E-02 3.500E-01

AREA-VOLUME-PORE SIZE SUMMARY

SURFACE AREA DATA

Multipoint BET..... 2.352E+01 m²/g
BJH Method Cumulative Adsorption Surface Area..... 3.117E+01 m²/g
BJH Method Cumulative Desorption Surface Area..... 2.908E+01 m²/g
DH Method Cumulative Adsorption Surface Area..... 3.253E+01 m²/g
DH Method Cumulative Desorption Surface Area..... 3.040E+01 m²/g
DR Method Micro Pore Area..... 3.311E+01 m²/g

PORE VOLUME DATA

BJH Method Cumulative Adsorption Pore Volume..... 6.735E-02 cc/g
BJH Method Cumulative Desorption Pore Volume..... 6.471E-02 cc/g
DH Method Cumulative Adsorption Pore Volume..... 6.560E-02 cc/g
DH Method Cumulative Desorption Pore Volume..... 6.330E-02 cc/g
DR Method Micro Pore Volume..... 1.180E-02 cc/g
HK Method Cumulative Pore Volume..... 8.813E-03 cc/g
SF Method Cumulative Pore Volume..... 9.083E-03 cc/g

PORE SIZE DATA

BJH Method Adsorption Pore Diameter (Mode)..... 1.444E+01 Å
BJH Method Desorption Pore Diameter (Mode)..... 1.700E+01 Å
DH Method Adsorption Pore Diameter (Mode)..... 1.444E+01 Å
DH Method Desorption Pore Diameter (Mode)..... 1.700E+01 Å
DR Method Micro Pore Width 4.306E+01 Å
DA Method Pore Diameter (Mode)..... 2.100E+01 Å
HK Method Pore Width (Mode)..... 3.575E+00 Å
SF Method Pore Diameter (Mode)..... 4.477E+00 Å

DATA REDUCTION PARAMETERS

Thermal Transpiration : OFF
Last Po Acquired 784.41 mm Hg
Additional Initialization Information Not Recorded.

BJH/DH Moving Average Size : 1
Thickness method : DeBoer

Interaction Constant (K) 2.9600 nm³ x kJ/mol

File name: C:\QCdata\PhysData\CA-7.RAW

Sample ID: 7 (Cd-SII-HM)

Description: C. ARMUTCU

Comments:

Operator: KB Sample weight: 0.0979 g
Analysis gas: NITROGEN X sect. area: 16.2 Å²/molec Non-ideality: 6.58e-05
Adsorbate (DRP): Nitrogen Bath Temp.: 77.40
Outgas Temp: 100.0 °C Outgas Time: 1.0 hrs Analysis Time: 377.9 min
P/Po tolerance: 3 Equil. time: 2 End of run: 10/23/2015 22:26
Station #: 4 PC sw. version: 1.23

Isotherm

P/Po	Volume	P/Po	Volume	P/Po	Volume
	[cc/g] STP		[cc/g] STP		[cc/g] STP
4.7414e-02	13.3090	7.0013e-01	41.1376	6.4299e-01	48.7319
9.9470e-02	17.0815	7.5535e-01	43.0718	5.9633e-01	47.7786
1.5477e-01	19.3067	8.0200e-01	45.7882	5.4982e-01	46.7666
2.0484e-01	21.4594	8.5373e-01	48.1653	5.0306e-01	45.8066
2.5649e-01	23.0964	9.0659e-01	53.0489	4.3915e-01	44.7776
3.0566e-01	24.8840	9.4756e-01	57.0731	3.9252e-01	43.7486
3.5555e-01	26.7231	9.9908e-01	65.7272	3.4584e-01	42.7062
4.0875e-01	29.2701	9.4183e-01	58.0394	2.9907e-01	41.6586
4.5700e-01	30.7478	8.9951e-01	55.9204	2.5229e-01	40.5943
5.0316e-01	33.1512	8.4214e-01	53.3295	1.8948e-01	39.0504
5.5583e-01	34.9999	7.9725e-01	51.8911	1.4254e-01	37.8965
6.0701e-01	36.4809	7.4958e-01	51.2837	9.6341e-02	36.4800
6.5709e-01	37.8704	6.8941e-01	49.7657		

BJH DESORPTION PORE SIZE DISTRIBUTION

Diameter	Pore Vol	Pore Surf Area	Dv(d)	Ds(d)	Dv(log d)	Ds(log d)
Å	[cc/g]	[m ² /g]	[m ² /Å/g]	[cc/g]	[m ² /g]	
16.64	3.515E-03	8.452E+00	1.516E-03	3.646E+00	5.798E-02	1.394E+02
18.95	6.216E-03	1.415E+01	1.170E-03	2.471E+00	5.100E-02	1.077E+02
21.70	1.023E-02	2.156E+01	1.256E-03	2.316E+00	6.266E-02	1.155E+02
24.58	1.301E-02	2.607E+01	1.082E-03	1.761E+00	6.119E-02	9.957E+01
27.26	1.576E-02	3.012E+01	9.893E-04	1.452E+00	6.204E-02	9.104E+01
30.19	1.852E-02	3.378E+01	8.954E-04	1.186E+00	6.219E-02	8.240E+01
33.47	2.123E-02	3.701E+01	7.804E-04	9.327E-01	6.009E-02	7.182E+01
38.01	2.355E-02	3.945E+01	4.119E-04	4.334E-01	3.599E-02	3.787E+01
43.30	2.588E-02	4.160E+01	4.700E-04	4.341E-01	4.681E-02	4.324E+01
48.75	2.833E-02	4.361E+01	4.129E-04	3.388E-01	4.630E-02	3.799E+01
55.39	3.054E-02	4.521E+01	3.012E-04	2.175E-01	3.837E-02	2.771E+01
63.71	3.292E-02	4.670E+01	2.558E-04	1.606E-01	3.745E-02	2.352E+01
76.74	3.636E-02	4.849E+01	2.049E-04	1.068E-01	3.606E-02	1.880E+01
95.06	3.747E-02	4.896E+01	5.593E-05	2.353E-02	1.220E-02	5.132E+00
119.52	4.046E-02	4.997E+01	1.032E-04	3.453E-02	2.825E-02	9.455E+00

170.57 4.567E-02 5.119E+01 7.124E-05 1.671E-02 2.754E-02 6.460E+00
278.44 4.967E-02 5.176E+01 2.804E-05 4.028E-03 1.757E-02 2.525E+00
10554.12 6.166E-02 5.181E+01 5.875E-07 2.227E-06 6.761E-03 2.562E-02

AREA-VOLUME-PORE SIZE SUMMARY

SURFACE AREA DATA

Multipoint BET..... 7.912E+01 m²/g
BJH Method Cumulative Adsorption Surface Area..... 1.088E+02 m²/g
BJH Method Cumulative Desorption Surface Area..... 5.181E+01 m²/g
DH Method Cumulative Adsorption Surface Area..... 1.139E+02 m²/g
DH Method Cumulative Desorption Surface Area..... 5.346E+01 m²/g
DR Method Micro Pore Area..... 1.114E+02 m²/g

PORE VOLUME DATA

BJH Method Cumulative Adsorption Pore Volume..... 1.113E-01 cc/g
BJH Method Cumulative Desorption Pore Volume..... 6.166E-02 cc/g
DH Method Cumulative Adsorption Pore Volume..... 1.097E-01 cc/g
DH Method Cumulative Desorption Pore Volume..... 6.036E-02 cc/g
DR Method Micro Pore Volume..... 3.969E-02 cc/g
HK Method Cumulative Pore Volume..... 2.981E-02 cc/g
SF Method Cumulative Pore Volume..... 3.074E-02 cc/g

PORE SIZE DATA

BJH Method Adsorption Pore Diameter (Mode)..... 1.417E+01 Å
BJH Method Desorption Pore Diameter (Mode)..... 1.664E+01 Å
DH Method Adsorption Pore Diameter (Mode)..... 1.417E+01 Å
DH Method Desorption Pore Diameter (Mode)..... 1.664E+01 Å
DR Method Micro Pore Width 4.240E+01 Å
DA Method Pore Diameter (Mode)..... 2.080E+01 Å
HK Method Pore Width (Mode)..... 3.625E+00 Å
SF Method Pore Diameter (Mode)..... 4.477E+00 Å

DATA REDUCTION PARAMETERS

Thermal Transpiration : OFF
Last Po Acquired 764.69 mm Hg
Additional Initialization Information Not Recorded.

BJH/DH Moving Average Size : 1
Thickness method : DeBoer

Interaction Constant (K) 2.9600 nm³ x kJ/mol