REFERENCES

[1] MRG Report. 2005. Analyzes Hydrogen Market and R&D in the U.S. and E.U. 1-2. LA: MRG Co.,Ltd. (Mimeographed)

[2] Whysall,M.; and Picioccio, K. W. (1999). Selection and revamp of hydrogen purification processes. Proceeding of the 1999 AIChE Spring Meeting : 1-5.

[3] Thompson, J. R.; McConnell R. D.; and Mosleh, M. (2005). Cost analysis of a concentratorphotovoltaic hydrogen production system. Proceedings of the International Conference on Solar Concentrators for the Generation of Electricity or Hydrogen : 4.

[4] Isalski, W.H. (1989). Sources and users of industrial gases. In Separation of gases, pp. 29-32. New York: Oxford University Press.

[5] Hydrogen separations and purification. (2004). Proceedings of DOE Workshop on Hydrogen Separations and Purification: 2.

[6] Yang, R. T. 1985. Adsorbents and adsorption isotherms. In Gas Separation by Adsorption Processes, pp. 9-26. New York: Buffuro press.

[7] New sam, J. M.; and colleagues. 1859. Structural characterization of zeolite beta. Mathematical and physical Sciences. 420: 375-405.

[8] Tezel, F. H.; Peiyuan, L. T. 2007. Adsorption separation of N_2, O_2, CO_2 and CH_4 gases by b-zeolite. Microporous and Mesoporous Materials. 98: 94-101.

[9] Kohl, A. and Nielsen, R. 1997. Introduction. In Gas Purification, pp. 2. New York: Academic Press.

[10] Iyuke, S. E.; and colleagues. 2000. Application of Sn-activated carbon in pressure swing adsorption for purification of H_2. Chemical Engineering Science. 55: 4745-4755.

[11] ฐิติ เลิศวรสิริกุล และ ธราพงษ์ วิทิตศานต์ (2551). การแยกแบบดูดซับของของผสมเอทนอล-น้ำโดยโมเลกุลาร์ซีฟ ชนิด 3A และ 4A. การประชุมวิชาการเทคโนโลยี และนวัตกรรมสำหรับการพัฒนาอย่างยั่งยืน ณ. คณะวิศวกรรมศาสตร์ มหาวิทยาลัยขอนแก่น : 28-29.

[12] Liu, S. B.; and colleagues. 1991. On the thermal stability of zeolite beta. Journal of catalysis. 132: 432-439.

[13] Rodrigues, E.; and colleagues. 2006. Separation of $CH_4/CO_2/N_2$ mixtures by layered pressure swing adsorption for upgrade of natural gas. J.Chemical Engineering Science. 61: 3893–3906.

[14] Breck, D.W. (1984). Zeolite Molecular Sieve. New York: Robert E. Krieger Publishing.

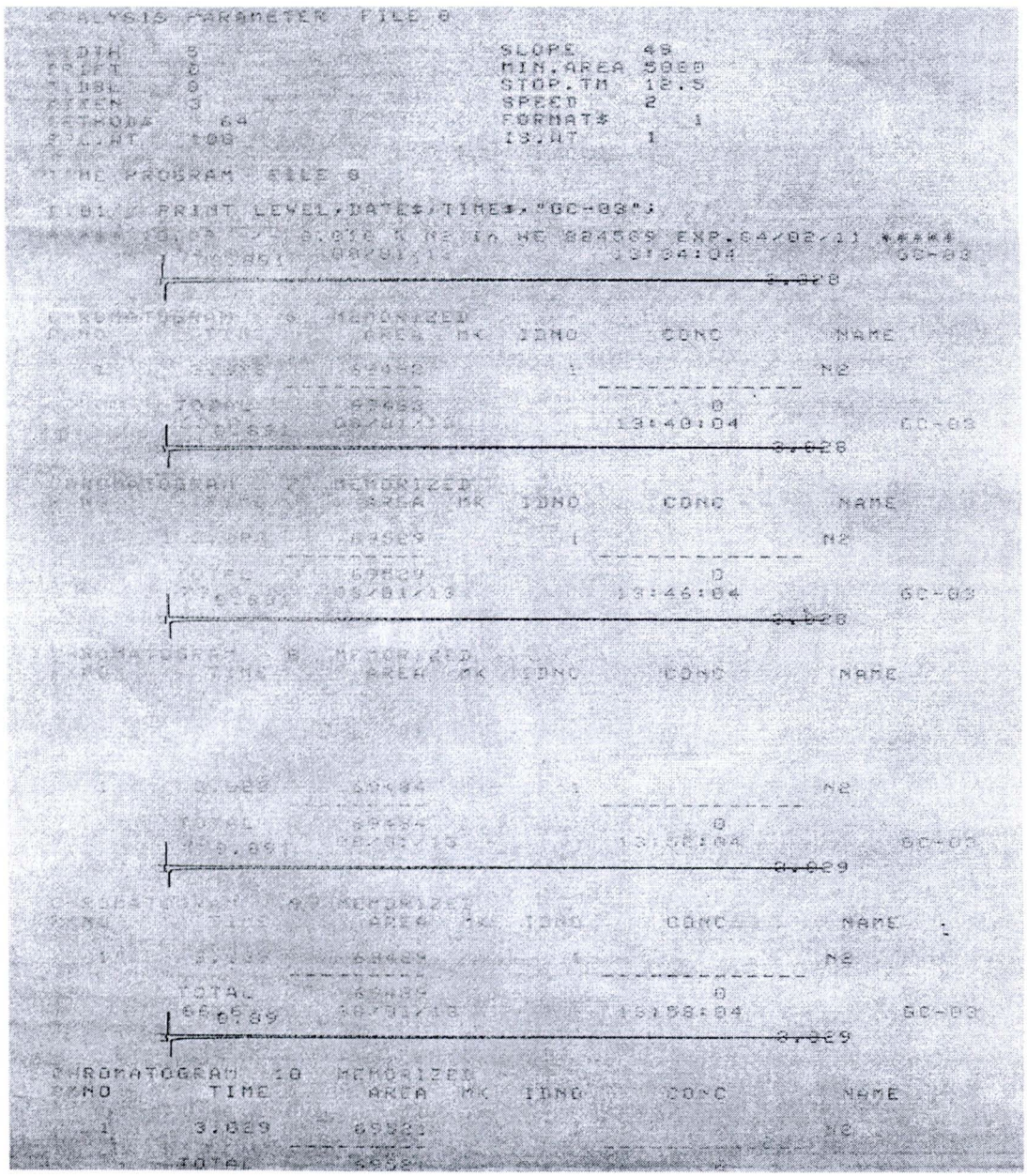
[15] Biltoft and colleagues. 2002. Vacuum Technology 60A & 60B 137. Arizona: Las Positas College. (Mimeographed)

[16] Delgado, J. A.; and collegues. 2005. Adsorption equilibrium of carbon dioxide, methane and nitrogen onto Na- and H-mordenite at high pressures. Studies in Surface Science and Catalysis. 158: 1065-1072.

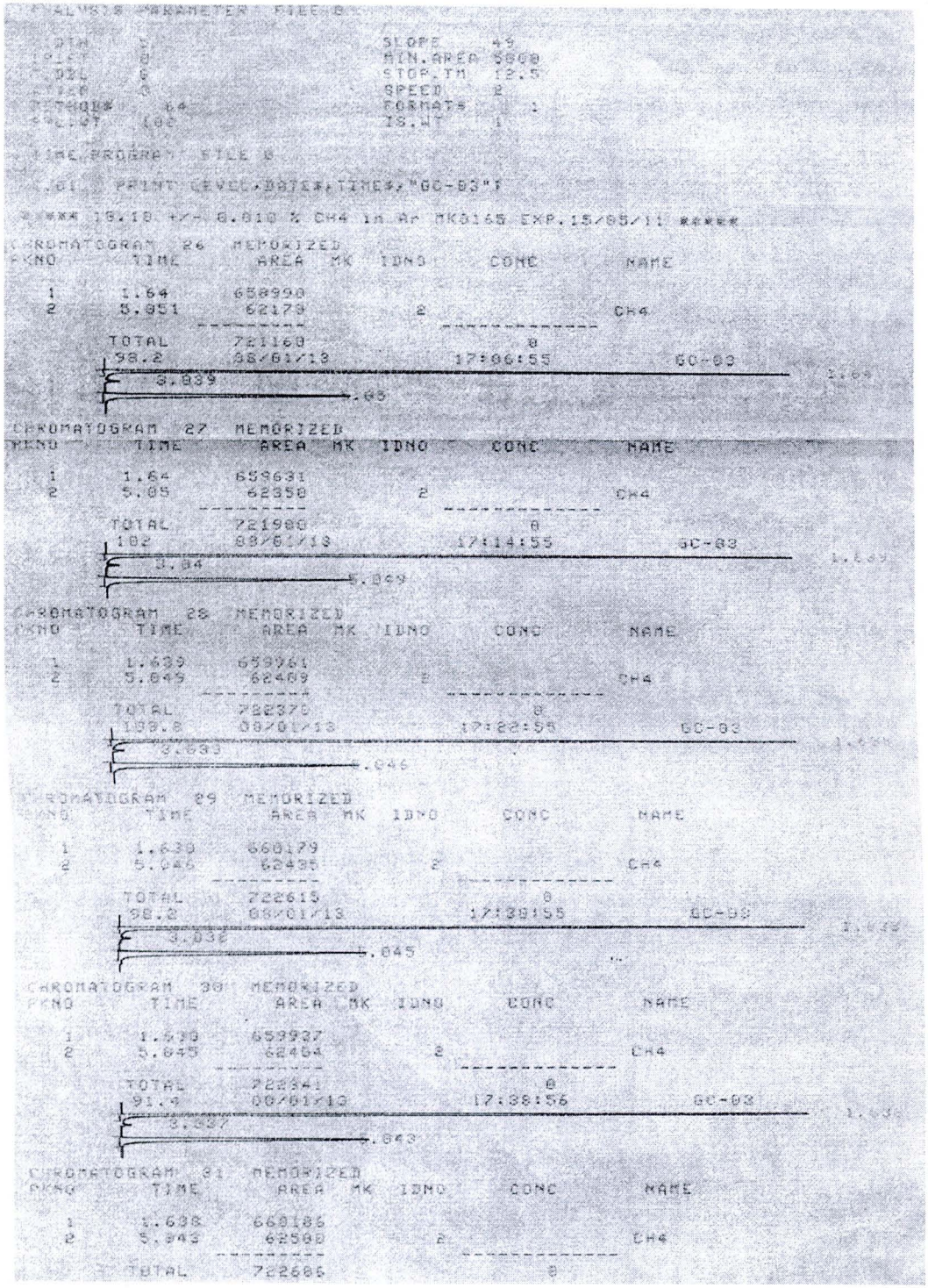
APPENDICES

APPENDIX A

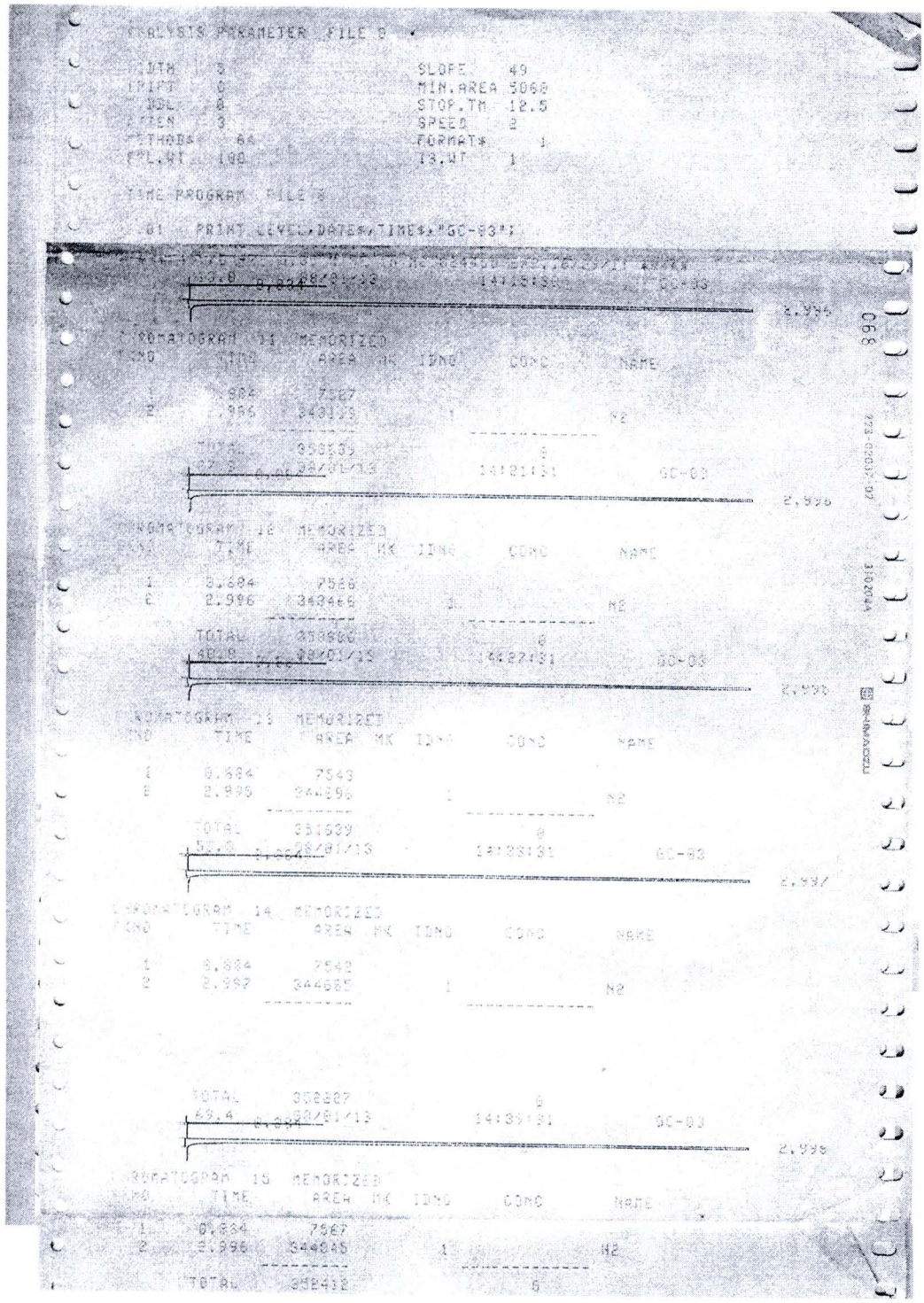
1. Chromatogram of standard mixed gas.
    - Reference standard 10.09 ± 0.010% N_2 in He



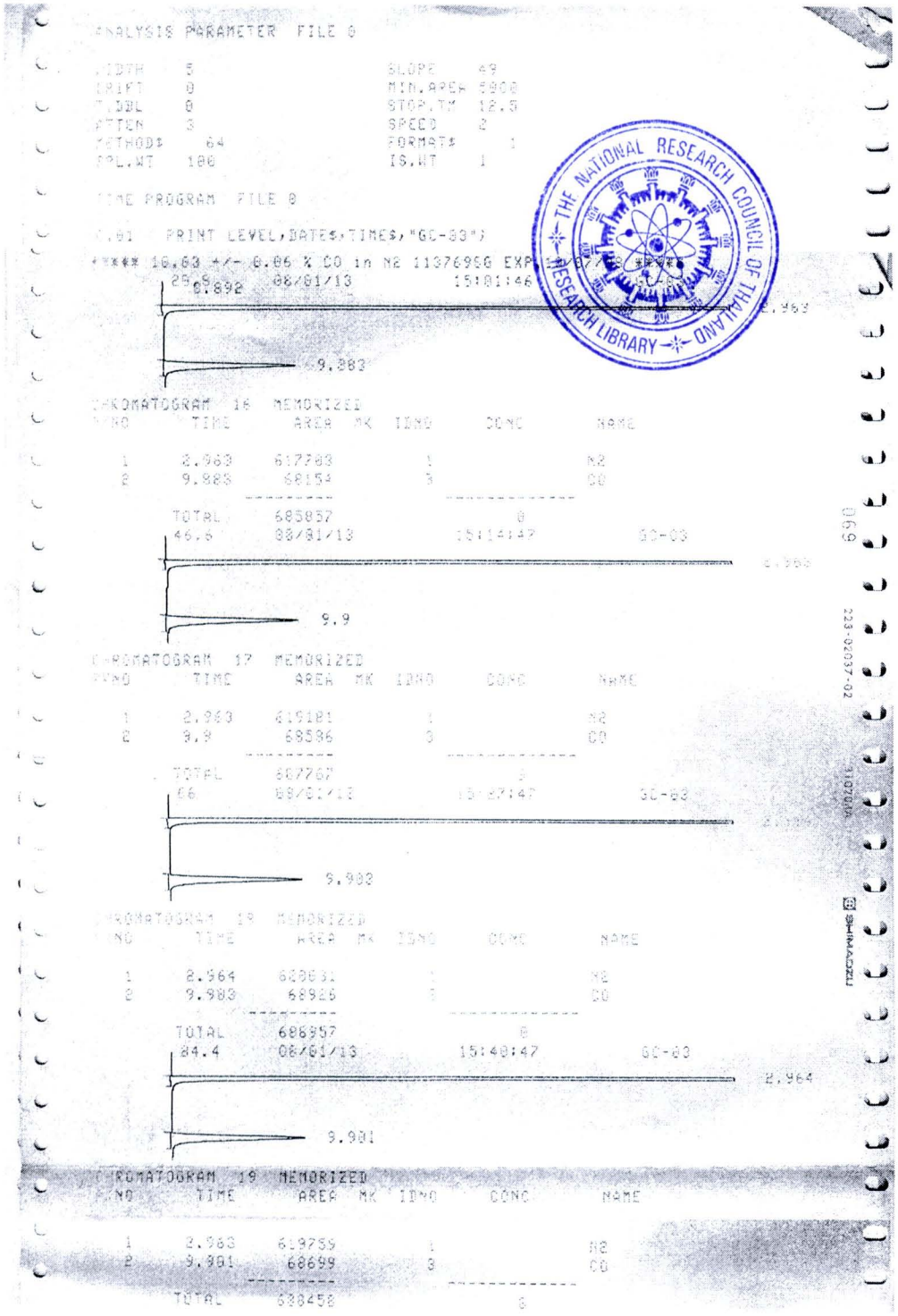
- Reference standard 10.10± 0.010% CH_4 in Ar



- Reference standard 49.70±0.05% H_2 in N_2



- Reference standard 10.03±0.06% CO in N_2



- Reference standare 9.955±0.010% CO_2 in N_2

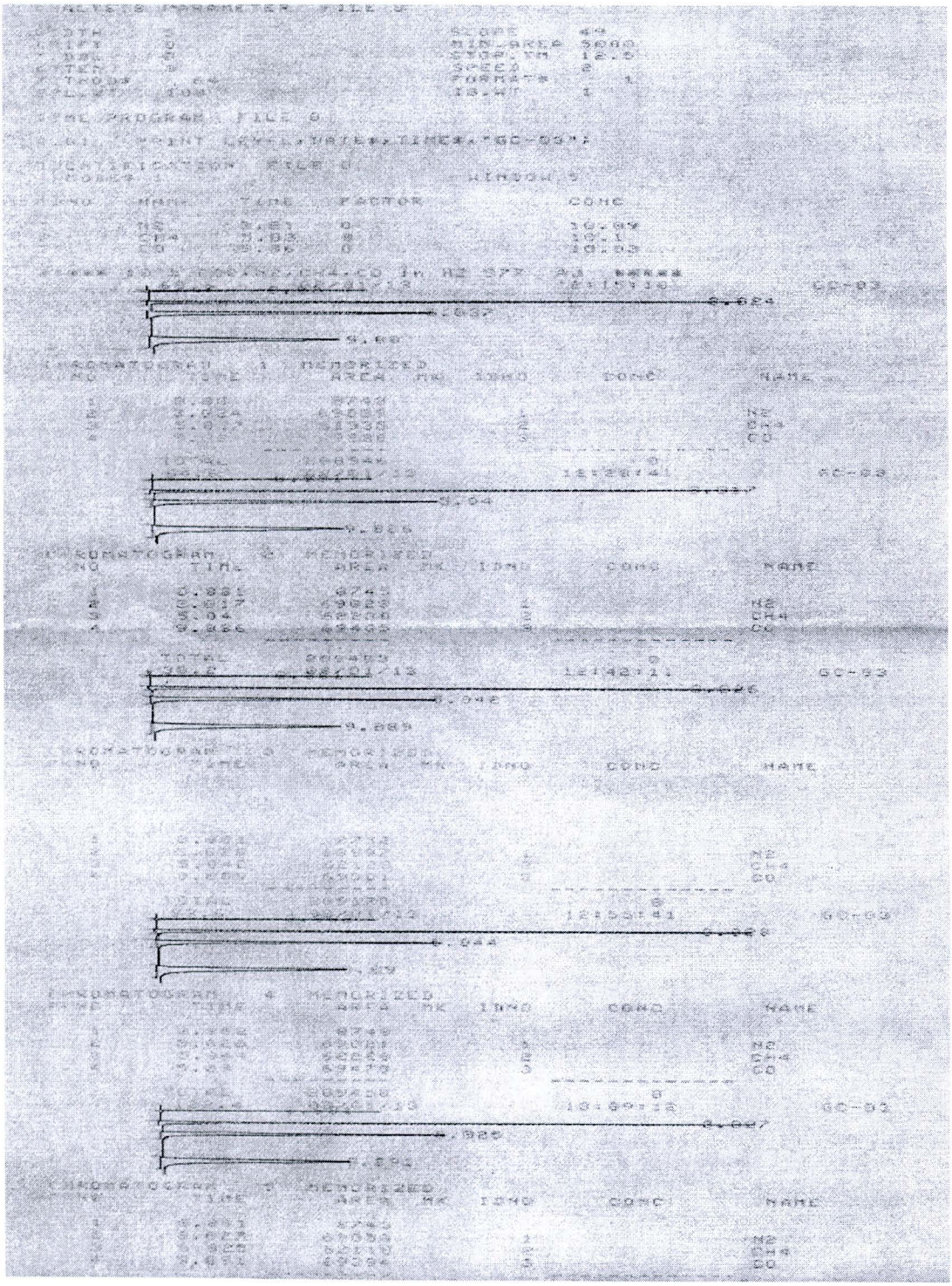
```
ANALYSIS PARAMETER  FILE 0

WIDTH       5                    SLOPE      47
DRIFT       0                    MIN.AREA  5000
T.DBL       0                    STOP.TM    3.5
ATTEN       5                    SPEED      2
METHOD$       61                 FORMAT$       1
SPL.WT    100                    IS.WT      1

TIME PROGRAM  FILE 0

0.01    PRINT LEVEL,DATE$,TIME$,"GC-03";

***** 9.955 +/- 0.010 % CO2 in N2 MK0227 EXP.01/11/10 *****
  83.8         08/01/15            17:56:38            GC-03        0.669
                     1.816

CHROMATOGRAM   1  MEMORIZED
PKNO        TIME        AREA  MK  IDNO      CONC            NAME

  1        0.669     641324                 88.6317
  2        1.816      82259/                11.3683
                   ---------           -------------
          TOTAL      723583                 100
  84.4         08/01/15            18:00:38            GC-03        0.668
                     1.815

CHROMATOGRAM   2  MEMORIZED
PKNO        TIME        AREA  MK  IDNO      CONC            NAME

  1        0.668     642346                 88.6352
  2        1.815      82361/                11.3648
                   ---------           -------------
          TOTAL      724707                 100
  82.2         08/01/15            18:04:38            GC-03        0.668
                     1.814

CHROMATOGRAM   3  MEMORIZED
PKNO        TIME        AREA  MK  IDNO      CONC            NAME

  1        0.668     641713                 88.6356
  2        1.814      82277/                11.3643
                   ---------           -------------
          TOTAL      723990                 100
  81.4         08/01/15            18:08:38            GC-03        0.669
                     1.814

CHROMATOGRAM   4  MEMORIZED
PKNO        TIME        AREA  MK  IDNO      CONC            NAME

  1        0.669     641615                 88.6384
  2        1.814      82241/                11.3616
                   ---------           -------------
          TOTAL      723856                 100
  79.6         08/01/15            18:12:38            GC-03        0.668
                     1.813

CHROMATOGRAM   5  MEMORIZED
PKNO        TIME        AREA  MK  IDNO      CONC            NAME

  1        0.668     642334                 88.6343
  2        1.813      82367/                11.3657
                   ---------           -------------
          TOTAL      724702                 100
IDENTIFICATION  FILE 0
  MODE$ 1                         WINDOW 5
```

METHOD NO. SG-CO-04
CHANGE: —

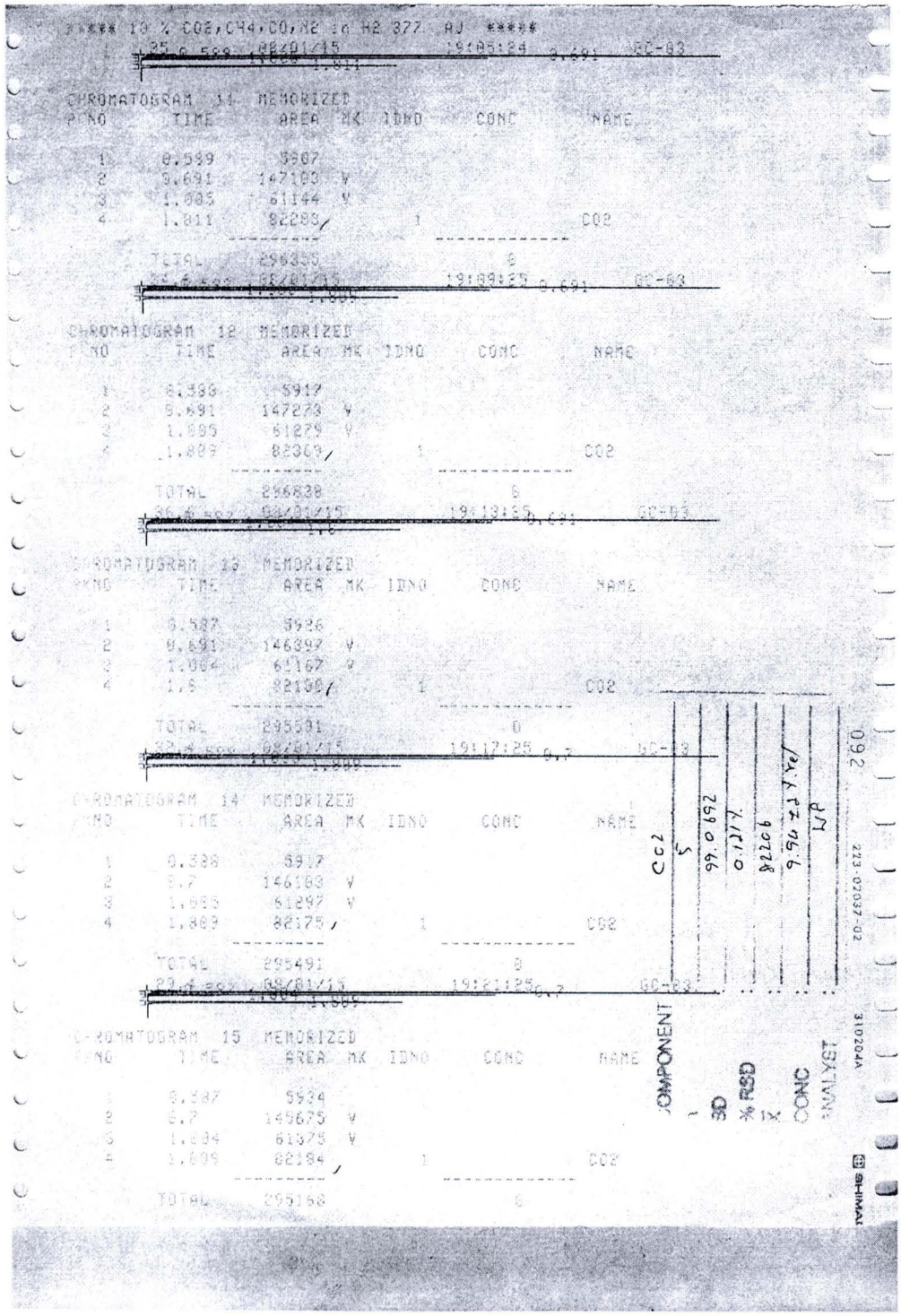
COMPONENT: CO_2
n: 5
SD: 9046.45
% RSD: 0.0727
X̄: 10.6908
CONC: 9.95532.0107
ANALYST: WP

SHIMADZU 223-02037-02 3102044 090

- Standard mixed gas (**59.8% H_2, 10.0% N_2, 10.1% CO, 10.1% CH_4,** 9.5% CO_2)



- Standard mixed gas (59.8% H_2, 10.0% N_2, 10.1% CO, 10.1% CH_4, **9.5% CO_2**)



2. Chromatogram of best condition at 1st, 2nd, 3rd, 4th adsorption cycle.
   - Reference standard **200.2±1.0 ppm CO, 200.0±1.0 ppm CH_4**, 200.1±1.0 ppm CO_2 in N2

0803192

S t a t i s t i c R e p o r t

Sequence table: C:\HPCHEM\1\DATA\090319_2.S
Data directory path: C:\HPCHEM\1\DATA\1010325
Operator: Seksan

Method file name: C:\HPCHEM\1\METHODS\ACC-ME~1\ACC-ME~2.M

Run #	Location	Inj #	Inj. Date/Time	File Name	Sample Name
1	Vial 1	1	19/3/2008 10:31:15 AM	08031920.D	ALVY644
2	Vial 1	2	19/3/2008 10:39:55 AM	08031921.D	ALVY644
3	Vial 1	3	19/3/2008 10:48:35 AM	08031922.D	ALVY644
4	Vial 1	4	19/3/2008 10:57:15 AM	08031923.D	ALVY644
5	Vial 1	5	19/3/2008 11:05:56 AM	08031924.D	ALVY644
6	Vial 1	6	19/3/2008 11:14:38 AM	08031925.D	ALVY644

Compound: Carbon Monoxide (Signal: FID2 B,)

Run #	Peak area [pA*s]
1	3028.98657
2	3019.94775
3	3025.14648
4	3026.46021
5	3023.67651
6	3022.66846
Mean:	3024.48100
S.D.:	3.13506
RSD :	0.10366
95% CI:	3.29005

Compound: Methane (Signal: FID2 B,)

Run #	Peak area [pA*s]
1	2962.26831
2	2970.05029
3	2973.38647
4	2975.57593
5	2974.85132
6	2974.67041
Mean:	2971.80046
S.D.:	5.06436
RSD :	0.17041
95% CI:	5.31472

Compound: Carbon Dioxide (Signal: FID2 B,)

Run #	Peak area [pA*s]
1	2976.14307
2	2984.67700
3	2988.66309
4	2991.15161
5	2990.35596

- Reference standard 1.6±0.1 ppm CO, 1.7±0.1 ppm CH_4, **1.6±0.1 ppm CO_2 in N2**

0810100

Statistic Report

Sequence table: C:\HPCHEM\1\DATA\081010_0.S
Data directory path: C:\HPCHEM\1\DATA\1009261
Operator: Seksan

Method file name: C:\HPCHEM\1\METHODS\ACC-ME~1\ACC-ME~2.M

Run #	Location	Inj #	Inj. Date/Time	File Name	Sample Name
1	Vial 1	1	10/10/2008 8:34:41 AM	08101000.D	ALWA7148
2	Vial 1	2	10/10/2008 8:43:21 AM	08101001.D	ALWA7148
3	Vial 1	3	10/10/2008 8:52:02 AM	08101002.D	ALWA7148
4	Vial 1	4	10/10/2008 9:00:43 AM	08101003.D	ALWA7148
5	Vial 1	5	10/10/2008 9:09:24 AM	08101004.D	ALWA7148
6	Vial 1	6	10/10/2008 9:18:06 AM	08101005.D	ALWA7148

Compound: Carbon Monoxide (Signal: FID2 B,)

Run #	Peak area [pA*s]
1	16.62586
2	15.67266
3	15.98224
4	15.61271
5	15.58857
6	25.61274
Mean:	17.51580
S.D.:	3.98591
RSD :	22.75609
95% CI:	4.18296

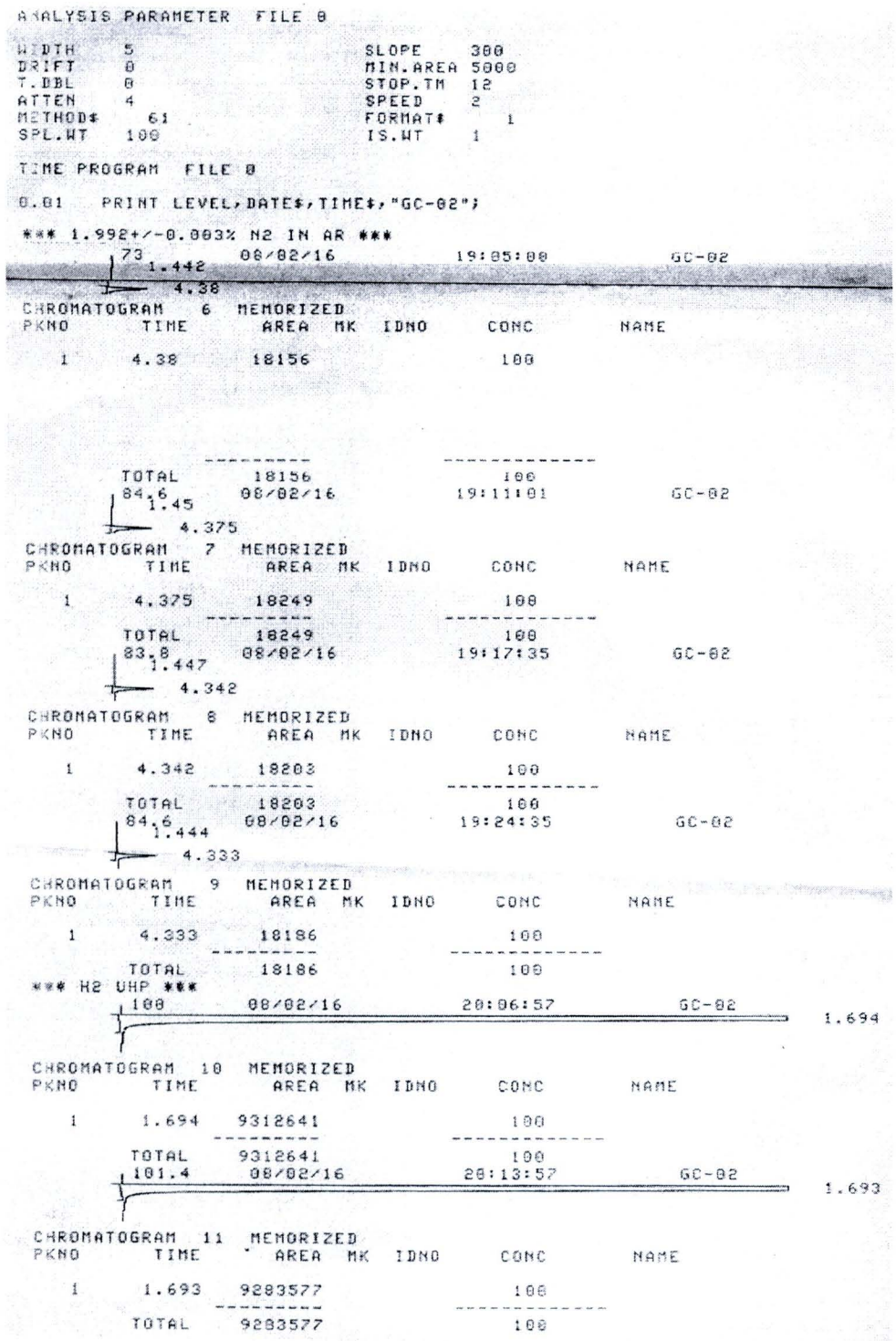
Compound: Methane (Signal: FID2 B,)

Run #	Peak area [pA*s]
1	16.84346
2	16.83319
3	16.84682
4	16.91287
5	16.88065
6	16.87641
Mean:	16.86557
S.D.:	0.02990
RSD :	0.17731
95% CI:	0.03138

Compound: Carbon Dioxide (Signal: FID2 B,)

Run #	Peak area [pA*s]
1	17.63055
2	16.79604
3	16.55412
4	16.45318
5	16.43300

- Reference standard 1.992+/-0.003% N_2 in Ar
- H_2 UHP



- Chromatogram of output gas by best condition at 1st adsorption cycle.

- Carbon monoxide, methane , carbon dioxide

0802160
Statistic Report

Sequence table: C:\HPCHEM\080216_0.S
Data directory path: C:\HPCHEM\1\DATA\SANGSOM
Operator: Sangsom

Method file name: C:\HPCHEM\1\METHODS\ACC-ME~1\ACC-ME~2.M

Run #	Location	Inj #	Inj. Date/Time	File Name	Sample Name
1	Vial 1	1	16/2/2008 6:29:02 PM	08021600.D	BETA 1ST
2	Vial 1	2	16/2/2008 6:37:44 PM	08021601.D	BETA 1ST

Compound: Carbon Monoxide (Signal: FID2 B,)

Run #	Peak area [pA*s]
1	279860.18750
2	279629.06250
Mean:	279744.62500
S.D.:	163.43005
RSD :	0.05842
95% CI:	1468.36068

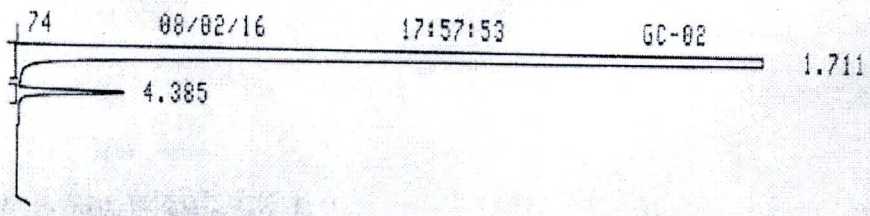
Compound: Methane (Signal: FID2 B,)

Run #	Peak area [pA*s]
1	4336.78955
2	4334.28174
Mean:	4335.53564
S.D.:	1.77329
RSD :	0.04090
95% CI:	15.93239

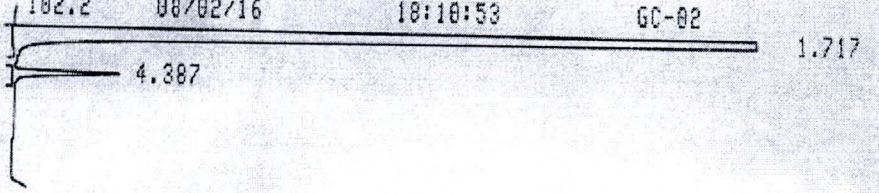
Statistic results for compound Carbon Dioxide not available.

- Hydrogen and nitrogen

```
ANALYSIS PARAMETER  FILE 0

WIDTH     5                 SLOPE     300
DRIFT     0                 MIN.AREA  5000
T.DBL     0                 STOP.TM   12
ATTEN     4                 SPEED     2
METHOD$     61              FORMAT$       1
SPL.WT    100               IS.WT     1

TIME PROGRAM  FILE 0

0.01   PRINT LEVEL,DATE$,TIME$,"GC-02";
```


```
CHROMATOGRAM   1  MEMORIZED
PKNO      TIME       AREA  MK  IDNO      CONC        NAME

   1     1.711    9011848                99.512
   2     4.385      44193                 0.488
                 ---------             ----------
         TOTAL    9056040                  100
```



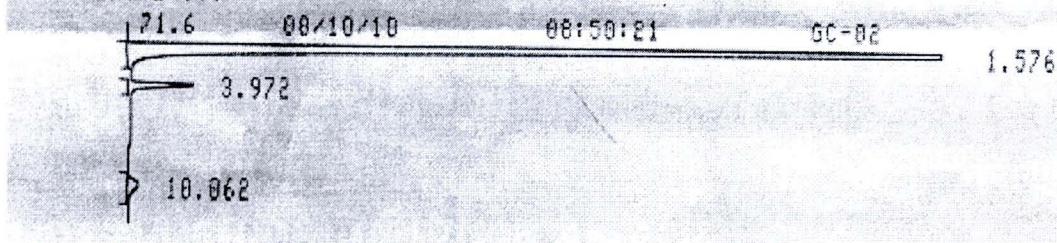

```
CHROMATOGRAM   2  MEMORIZED
PKNO      TIME       AREA  MK  IDNO      CONC        NAME

   1     1.717    9017927                99.511
   2     4.387      44316                 0.489
                 ---------             ----------
         TOTAL    9062243                  100
```

- Cromatogram of output gas by best condition at 2nd adsorption cycle.
  - Carbon monoxide, methane and carbon dioxide

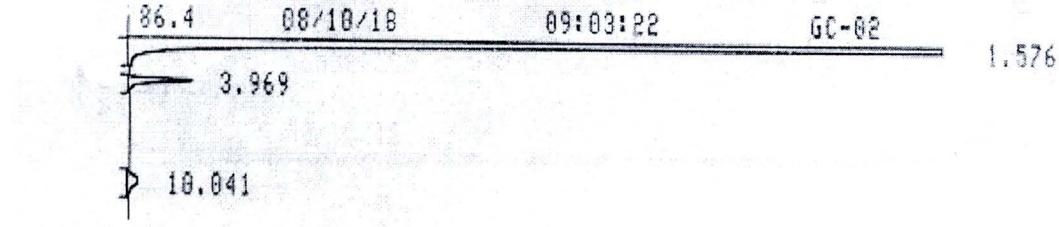
```
Sequence table:      C:\HPCHEM\1\DATA\081015_1.S
Data directory path: C:\HPCHEM\1\DATA\SANGSOM
Operator:            Sangsom

Method file name:    C:\HPCHEM\1\METHODS\ACC-ME~1\ACC-ME~2.M

Run Location Inj     Inj. Date/Time      File Name   Sample Name
 #           #
---|--------|---|----------------------|---------|----------------
  1 Vial 1     1 15/10/2008 7:51:07 AM    08101510.D HEAT 2
  2 Vial 1     2 15/10/2008 7:59:49 AM    08101511.D HEAT 2


Compound: Carbon Monoxide (Signal: FID2 B, )

Run              Peak area
 #                 [pA*s]
---|--------------------
  1        369251.12500
  2        368955.12500
-------------------------
Mean:      369103.12500
S.D.:         209.30361
RSD :           0.05671
95% CI:      1880.51817

Compound: Methane (Signal: FID2 B, )

Run              Peak area
 #                 [pA*s]
---|--------------------
  1          4697.45215
  2          4694.64307
-------------------------
Mean:        4696.04761
S.D.:           1.98632
RSD :           0.04230
95% CI:        17.84638

Compound: Carbon Dioxide (Signal: FID2 B, )

Run              Peak area
 #                 [pA*s]
---|--------------------
  1             2.60465
  2             2.75388
-------------------------
Mean:           2.67927
S.D.:           0.10552
RSD :           3.93855
95% CI:         0.94810
```

- Hydrogen and nitrogen

```
ANALYSIS PARAMETER  FILE 0

WIDTH    5                  SLOPE    300
DRIFT    0                  MIN.AREA 5000
T.DBL    0                  STOP.TM  12.5
ATTEN    4                  SPEED    2
METHOD$    61               FORMAT$     1
SPL.WT   100                IS.WT    1

TIME PROGRAM  FILE 0

0.01   PRINT LEVEL,DATE$,TIME$,"GC-02";

*** HEAT 2 ***
```




```
CHROMATOGRAM   1  MEMORIZED
PKNO      TIME      AREA  MK  IDNO     CONC       NAME

   1     1.576   3848325                99.1708
   2     3.972     21948                 0.5656
   3    10.062     10230                 0.2636
              ---------           ------------
         TOTAL   3880503               100
```




```
CHROMATOGRAM   2  MEMORIZED
PKNO      TIME      AREA  MK  IDNO     CONC       NAME

   1     1.576   3847815                99.1562
   2     3.969     22232                 0.5729
   3    10.041     10511                 0.2709
              ---------           ------------
         TOTAL   3880558               100
```

- Chromatogram of output gas by best condition at 3rd adsorption cycle.
  - Carbon monoxide, methane and carbon dioxide

0810230

Statistic Report

Sequence table: C:\HPCHEM\1\DATA\081023_0.S
Data directory path: C:\HPCHEM\1\DATA\SANGSOM
Operator: Sangsom

Method file name: C:\HPCHEM\1\METHODS\ACC-ME~1\ACC-ME~2.M

Run #	Location	Inj #	Inj. Date/Time	File Name	Sample Name
1	Vial 1	1	23/10/2008 12:09:21 PM	08102300.D	HEAT3
2	Vial 1	2	23/10/2008 12:18:02 PM	08102301.D	HEAT3

Compound: Carbon Monoxide (Signal: FID2 B,)

Run #	Peak area [pA*s]
1	330418.81250
2	330107.96875
Mean:	330263.39062
S.D.:	219.79972
RSD :	0.06655
95% CI:	1974.82202

Compound: Methane (Signal: FID2 B,)

Run #	Peak area [pA*s]
1	3998.82910
2	3994.14673
Mean:	3996.48792
S.D.:	3.31094
RSD :	0.08285
95% CI:	29.74759

Statistic results for compound Carbon Dioxide not available.

- Hydrogen and nitrogen

ANALYSIS PARAMETER FILE 0

WIDTH	5	SLOPE	300
DRIFT	0	MIN.AREA	5000
T.DBL	0	STOP.TM	12.5
ATTEN	4	SPEED	2
METHOD#	61	FORMAT#	1
SPL.WT	100	IS.WT	1

TIME PROGRAM FILE 0

0.01 PRINT LEVEL,DATE$,TIME$,"GC-02";

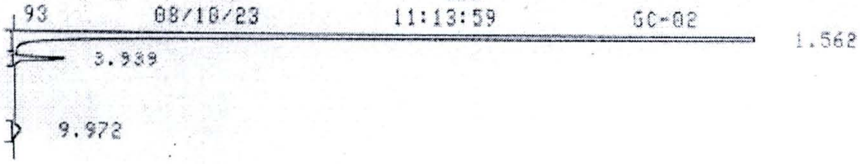
*** HEAT 3 ***

84.2 08/10/23 11:00:59 GC-02

CHROMATOGRAM 1 MEMORIZED

PKNO	TIME	AREA	MK	IDNO	CONC	NAME
1	1.565	3848695			99.2939	
2	3.946	19475			0.5024	
3	9.987	7893			0.2036	
	TOTAL	3876062			100	

93 08/10/23 11:13:59 GC-02



CHROMATOGRAM 2 MEMORIZED

PKNO	TIME	AREA	MK	IDNO	CONC	NAME
1	1.562	3860871			99.2912	
2	3.939	19481			0.501	
3	9.972	8081			0.2078	
	TOTAL	3888432			100	

87.8 08/10/23 11:26:59 GC-02

CHROMATOGRAM 3 MEMORIZED

PKNO	TIME	AREA	MK	IDNO	CONC	NAME
1	1.565	3851357			99.3026	
2	3.94	19666			0.5071	
3	9.978	7382			0.1903	
	TOTAL	3878405			100	

- Chromatogram of output gas by best condition at 4nd adsorption cycle.

Carbon monoxide, methane and carbon dioxide

0810250

Statistic Report

Sequence table: C:\HPCHEM\1\DATA\081025_0.S
Data directory path: C:\HPCHEM\1\DATA\SANGSOM
Operator: Sangsom

Method file name: C:\HPCHEM\1\METHODS\ACC-ME~1\ACC-ME~2.M

Run #	Location	Inj #	Inj. Date/Time	File Name	Sample Name
1	Vial 1	1	26/10/2008 11:23:49 AM	08102500.D	HEAT 4
2	Vial 1	2	26/10/2008 11:32:31 AM	08102501.D	HEAT 4

Compound: Carbon Monoxide (Signal: FID2 B,)

Run #	Peak area [pA*s]
1	310594.28125
2	310156.71875
Mean:	310375.50000
S.D.:	309.40341
RSD :	0.09969
95% CI:	2779.87915

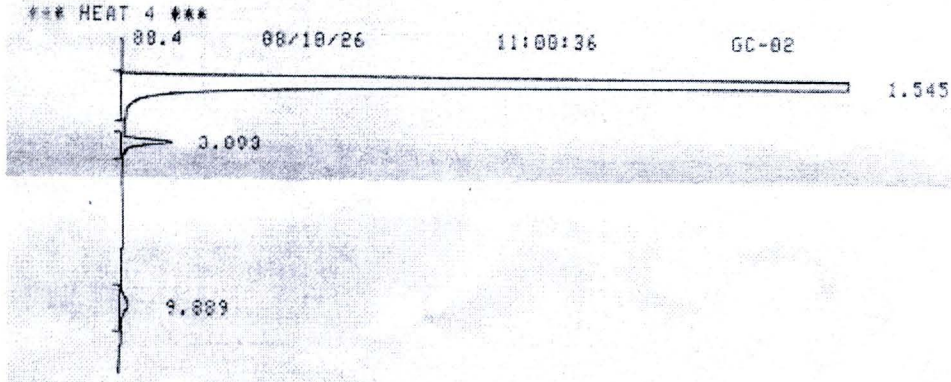
Compound: Methane (Signal: FID2 B,)

Run #	Peak area [pA*s]
1	3930.42139
2	3928.19312
Mean:	3929.30725
S.D.:	1.57563
RSD :	0.04010
95% CI:	14.15644

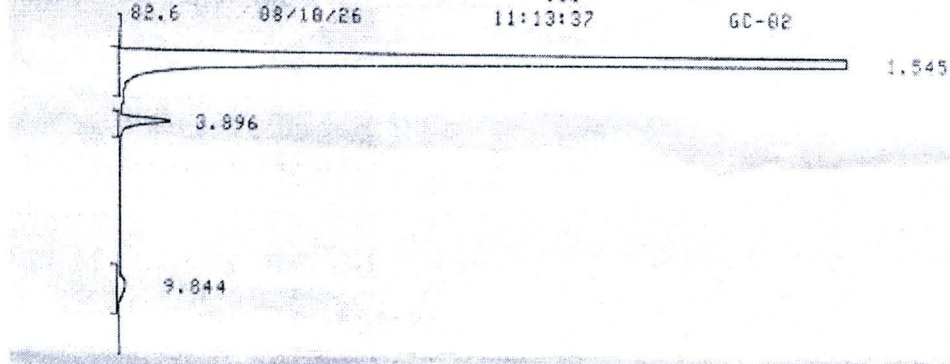
Statistic results for compound Carbon Dioxide not available.

- Hydrogen and nitrogen

```
ANALYSIS PARAMETER  FILE 0

WIDTH     5                    SLOPE     300
DRIFT     0                    MIN.AREA  5000
T.DBL     0                    STOP.TM   12.5
ATTEN     4                    SPEED     5
METHOD$    61                  FORMAT$      1
SPL.WT   100                   IS.WT     1

TIME PROGRAM  FILE 0

0.01   PRINT LEVEL,DATE$,TIME$,"GC-02";

*** HEAT 4 ***
```




```
CHROMATOGRAM   1  MEMORIZED
PKNO      TIME       AREA  MK  IDNO      CONC        NAME

   1     1.545    3767079                99.2937
   2     3.893      19199                 0.506
   3     9.889       7598                0.2003
                 ---------              ---------
         TOTAL    3793875                  100
```




```
CHROMATOGRAM   2  MEMORIZED
PKNO      TIME       AREA  MK  IDNO      CONC        NAME

   1     1.545    3796125                99.2902
   2     3.896      18957                 0.4958
   3     9.844       8180                0.2139
                 ---------              ---------
         TOTAL    3823261                  100
```

APPENDIX B

1. N_2 adsorption / desorption isotherm of zeolite 13X

[Adsorption / desorption isotherm]

File Name	13X(1).DAT
Date of measurement	17/4/2009
Time of measurement	7:14:11
COMMENT1	13X(1)
COMMENT2	
COMMENT3	
COMMENT4	
Serial number	154
Version	

Sample weight	3.99E-02	[g]
Standard volume	9.043	[cm^3]
Dead volume	12.98	[cm^3 g^{-1}]
Equilibrium time	100	[sec]
Adsorptive	N2	
Apparatus temperature	0	[C]
Adsorption temperature	77	[K]

Saturated vapor pressure	100.98	[kPa]
Adsorption cross section area	0.162	[nm^2]
File name of walladsorption		
Wall adsorption correction value 1		
Wall adsorption correction value 2		
Number of adsorption data	44	
Number of desorption data	26	

No	*pi* /kPa	*pe* /kPa	*pe*2 /kPa	p_0 /kPa	p/p_0	V_a/cm^3(STP) g^{-1}
ADS						
1	0	0.0040601	0	101.26	0.000040096	12.914
2	0	0.0040601	0	101.28	0.000040088	23.784
3	0	0.0081201	0	101.28	0.000080175	34.584
4	0	0.01218	0	101.28	0.00012026	45.351
5	0	0.0203	0	101.27	0.00020045	56.124
6	0	0.0203	0	101.25	0.00020049	66.816
7	0	0.02842	0	101.23	0.00028075	77.485
8	0	0.036541	0	101.22	0.00036101	88.044
9	0	0.1015	0	101.22	0.0010028	98.119
10	0	0.3289	0	101.19	0.0032499	107.03

11	0	0.8161	0	101.21	0.0080631	113.65
12	0	1.4007	0	101.22	0.013838	117.72
13	0	2.1112	0	101.21	0.02086	120.84
14	0	3.9829	0	101.17	0.039368	125.89
15	0	5.6922	0	101.21	0.056241	128.89
16	0	7.3162	0	101.17	0.072316	131.15
17	0	8.5627	0	101.16	0.084645	132.66
18	0	10.844	0	101.19	0.1072	135
19	0	13.39	0	101.14	0.1324	137.26
20	0	14.75	0	101.12	0.1459	138.31
21	0	16.236	0	101.15	0.1605	139.49
22	0	18.201	0	101.2	0.1799	140.87
23	0	22.428	0	101.2	0.2216	143.73
24	0	25.57	0	101.17	0.2527	145.72
25	0	30.491	0	101.18	0.3014	148.69
26	0	35.558	0	101.13	0.3516	151.51
27	0	40.629	0	101.19	0.4015	154.36
28	0	45.647	0	101.16	0.4512	157.33
29	0	50.674	0	101.22	0.5006	160.43
30	0	55.745	0	101.16	0.5511	163.74
31	0	60.747	0	101.15	0.6006	167.18
32	0	65.753	0	101.1	0.6504	170.85
33	0	71.019	0	101.12	0.7023	174.94
34	0	75.777	0	101.07	0.7497	179.05
35	0	81.055	0	101.06	0.802	184.39
36	0	85.809	0	101.01	0.8495	190.73
37	0	89.882	0	100.98	0.8901	199.17
38	0	90.925	0	101.02	0.9001	202.25
39	0	95.627	0	100.91	0.9476	226.89
40	0	96.264	0	100.97	0.9534	232.78
41	0	97.847	0	100.94	0.9694	254.96
42	0	98.887	0	100.85	0.9805	284.49
43	0	99.402	0	100.8	0.9861	310.3
44	0	99.715	0	100.78	0.9894	332.63
DES						
1	0	98.574	0	100.73	0.9786	303.99
2	0	97.912	0	100.76	0.9717	281.64
3	0	97.372	0	100.75	0.9665	269.02
4	0	96.016	0	100.73	0.9532	246.42
5	0	95.383	0	100.75	0.9467	240.11
6	0	91.636	0	100.75	0.9095	211.36

7	0	90.21	0	100.73	0.8956	205.39
8	0	86.934	0	100.71	0.8632	195.3
9	0	85.545	0	100.68	0.8497	192.31
10	0	81.108	0	100.72	0.8053	185.68
11	0	80.409	0	100.72	0.7983	184.8
12	0	75.314	0	100.67	0.7481	179.96
13	0	70.511	0	100.7	0.7002	176.4
14	0	65.448	0	100.68	0.6501	173
15	0	60.288	0	100.66	0.5989	170.25
16	0	55.184	0	100.68	0.5481	167.88
17	0	50.162	0	100.7	0.4981	165.56
18	0	45.688	0	100.69	0.4537	159.47
19	0	45.237	0	100.7	0.4492	158.59
20	0	40.097	0	100.73	0.3981	153.55
21	0	35.172	0	100.76	0.3491	150.67
22	0	30.113	0	100.76	0.2989	147.81
23	0	25.067	0	100.75	0.2488	144.93
24	0	20.04	0	100.75	0.1989	141.82
25	0	15.022	0	100.76	0.1491	138.41
26	0	10.045	0	100.76	0.099692	134.2

[BET plot]

File Name	Zip_bag(1).DAT
Date of measurement	17/4/2009
Time of measurement	7:14:11
COMMENT1	13X(1)
COMMENT2	
COMMENT3	
COMMENT4	
Serial number	154
Version	

Sample weight	3.99E-02	[g]	
Standard volume	9.043	[cm^3]	
Dead volume	12.98	[$cm^3\ g^{-1}$]	
Equilibrium time	100	[sec]	
Adsorptive	N2		

Saturated vapor pressure	100.98	[kPa]
Adsorption cross section area	0.162	[nm^2]
File name of walladsorption		
Wall adsorption correction value 1		
Wall adsorption correction value 2		

Apparatus temperature	0 [C]
Adsorption temperature	77 [K]

Number of adsorption data	44
Number of desorption data	26

Starting point	4	
End point	17	
Slore	0.0081965	
Intercept	2.7811E-06	
Correlation coefficient	1	
Vm	121.96	[cm^3(STP) g^{-1}]
$a_{s,BET}$	530.84	[m^2 g^{-1}]
C	2948.2	
Total pore volume (p/p_0=0.989)	0.5142	[cm^3 g^{-1}]
Average pore diameter	3.8746	[nm]

No	p/p_0	$p/V_a(p_0-p)$
1	0.000040096	0.000003105
2	0.000040088	1.6856E-06
3	0.000080175	2.3184E-06
4	0.00012026	2.6521E-06
5	0.00020045	3.5723E-06
6	0.00020049	3.0013E-06
7	0.00028075	3.6243E-06
8	0.00036101	4.1018E-06
9	0.0010028	0.00001023
10	0.0032499	0.000030464
11	0.0080631	0.000071524
12	0.013838	0.0001192
13	0.02086	0.0001763
14	0.039368	0.00032554
15	0.056241	0.00046236
16	0.072316	0.00059438
17	0.084645	0.00069706
18	0.1072	0.00088909
19	0.1324	0.0011117
20	0.1459	0.0012347
21	0.1605	0.0013707

22	0.1799	0.0015567
23	0.2216	0.0019809
24	0.2527	0.0023211
25	0.3014	0.0029009
26	0.3516	0.0035791
27	0.4015	0.0043462
28	0.4512	0.0052264

2. N_2 adsorption / desorption isotherm of beta zeolite

[Adsorption / desorption isotherm]

File Name	Beta zeolite(1).DAT
Date of measurement	17/4/2009
Time of measurement	4:50:34
COMMENT1	Beta zeolite(1)
COMMENT2	
COMMENT3	
COMMENT4	
Serial number	154
Version	

Sample weight	3.58E-02 [g]
Standard volume	9.043 [cm^3]
Dead volume	12.005 [$cm^3 g^{-1}$]
Equilibrium time	100 [sec]
Adsorptive	N2
Apparatus temperature	0 [C]
Adsorption temperature	77 [K]

Saturated vapor pressure	101.08 [kPa]
Adsorption cross section area	0.162 [nm^2]
File name of walladsorption	
Wall adsorption correction value 1	
Wall adsorption correction value 2	
Number of adsorption data	42
Number of desorption data	20

No	*pi* /kPa	*pe* /kPa	*pe*2 /kPa	p_0 /kPa	p/p_0	V_a/cm^3(STP) g^{-1}
ADS						
1	0	0.01626	0	101.27	0.00016056	13.505
2	0	0.01626	0	101.27	0.00016056	24.909
3	0	0.01626	0	101.25	0.00016059	36.384
4	0	0.02439	0	101.29	0.00024079	47.754

5	0	0.01626	0	101.27	0.00016056	59.2
6	0	0.020325	0	101.25	0.00020074	70.592
7	0	0.012195	0	101.23	0.00012047	82.022
8	0	0.01626	0	101.25	0.00016059	93.398
9	0	0.020325	0	101.21	0.00020082	104.75
10	0	0.028455	0	101.21	0.00028115	116.17
11	0	0.020325	0	101.21	0.00020082	127.48
12	0	0.028455	0	101.21	0.00028115	138.68
13	0	0.126	0	101.19	0.0012454	149.2
14	0	0.7154	0	101.2	0.0070697	156.65
15	0	2.1626	0	101.19	0.021372	160.24
16	0	3.9797	0	101.21	0.039321	162.04
17	0	5.6667	0	101.19	0.056001	163.06
18	0	7.252	0	101.12	0.071717	163.77
19	0	8.7927	0	101.2	0.086884	164.33
20	0	10.829	0	101.16	0.107	164.9
21	0	13.35	0	101.2	0.1319	165.55
22	0	14.923	0	101.12	0.1476	165.92
23	0	16.439	0	101.19	0.1625	166.24
24	0	18.459	0	101.19	0.1824	166.63
25	0	22.439	0	101.19	0.2218	167.31
26	0	25.52	0	101.2	0.2522	167.85
27	0	30.5	0	101.13	0.3016	168.64
28	0	35.541	0	101.17	0.3513	169.4
29	0	40.589	0	101.19	0.4011	170.18
30	0	45.667	0	101.19	0.4513	170.95
31	0	50.715	0	101.17	0.5013	171.73
32	0	55.744	0	101.19	0.5509	172.59
33	0	60.784	0	101.15	0.6009	173.52
34	0	65.788	0	101.16	0.6503	174.58
35	0	70.805	0	101.21	0.6996	175.82
36	0	76.215	0	101.15	0.7535	177.62
37	0	81.207	0	101.2	0.8024	179.75
38	0	86.097	0	101.18	0.8509	183.03
39	0	91.199	0	101.19	0.9013	188.81
40	0	96.374	0	101.03	0.9539	203.33
41	0	98.414	0	101.09	0.9735	215.96
42	0	100.12	0	101.02	0.9911	239.83
DES						
1	0	97.549	0	101	0.9658	219.37
2	0	95.248	0	100.96	0.9434	208.26

3	0	90.443	0	100.93	0.8961	194.19
4	0	86.207	0	100.96	0.8539	188.27
5	0	85.634	0	100.96	0.8482	187.65
6	0	80.756	0	100.96	0.7999	184.2
7	0	75.54	0	100.9	0.7487	181.61
8	0	70.37	0	100.85	0.6978	179.8
9	0	65.614	0	100.83	0.6507	178.5
10	0	60.528	0	100.81	0.6004	177.3
11	0	55.435	0	100.83	0.5498	176.29
12	0	50.394	0	100.79	0.5	174.19
13	0	45.211	0	100.81	0.4485	171.58
14	0	40.301	0	100.8	0.3998	170.58
15	0	35.215	0	100.8	0.3494	169.69
16	0	30.146	0	100.79	0.2991	168.94
17	0	25.102	0	100.78	0.2491	168.18
18	0	20.073	0	100.75	0.1992	167.37
19	0	15.053	0	100.75	0.1494	166.42
20	0	10.077	0	100.69	0.1001	165.21

[BET plot]

File Name	Plastic Bottle(1).DAT
Date of measurement	17/4/2009
Time of measurement	4:50:34
COMMENT1	Plastic Bottle(1)
COMMENT2	
COMMENT3	
COMMENT4	
Serial number	154
Version	

Sample weight	3.58E-02 [g]
Standard volume	9.043 [cm^3]
Dead volume	12.005 [$cm^3\ g^{-1}$]
Equilibrium time	100 [sec]
Adsorptive	N2
Apparatus temperature	0 [C]

Saturated vapor pressure	101.08 [kPa]
Adsorption cross section area	0.162 [nm^2]
File name of walladsorption	
Wall adsorption correction value 1	
Wall adsorption correction value 2	
Number of adsorption data	42

Adsorption temperature	77 [K]

Number of desorption data	20

Starting point	5	
End point	16	
Slore	0.0063913	
Intercept	6.7173E-07	
Correlation coefficient	1	
Vm	156.45	[cm^3(STP) g^{-1}]
$a_{s,BET}$	680.93	[m^2 g^{-1}]
C	9515.7	
Total pore volume (p/p_0=0.990)	0.3684	[cm^3 g^{-1}]
Average pore diameter	2.1644	[nm]

No	p/p_0	$p/V_a(p_0-p)$
1	0.00016056	0.000011891
2	0.00016056	6.4469E-06
3	0.00016059	4.4145E-06
4	0.00024079	5.0436E-06
5	0.00016056	2.7126E-06
6	0.00020074	2.8442E-06
7	0.00012047	1.4689E-06
8	0.00016059	1.7197E-06
9	0.00020082	1.9175E-06
10	0.00028115	2.4208E-06
11	0.00020082	1.5756E-06
12	0.00028115	2.0279E-06
13	0.0012454	8.3575E-06
14	0.0070697	0.000045452
15	0.021372	0.00013629
16	0.039321	0.0002526
17	0.056001	0.00036381
18	0.071717	0.00047174
19	0.086884	0.00057903
20	0.107	0.00072699
21	0.1319	0.00091793
22	0.1476	0.0010434

23	0.1625	0.0011668
24	0.1824	0.001339
25	0.2218	0.001703
26	0.2522	0.002009
27	0.3016	0.0025606
28	0.3513	0.0031968
29	0.4011	0.0039357
30	0.4513	0.0048113

VITA

Miss Sangsom Chongsotichat was born on January 7, 1979 in Bangkok, Thailand. She graduate at Suksanaree School in 1997. She received the Bachelor Degree of Science in chemistry, Srinakarinwirot University in 2001. She continued her Master study in Program of Petrochemistry and Polymer Science, Faculty of Science, Chulalongkorn University in 2005 and completed the program in 2009.