APPENDIX A

The experimental data for Absorption of Carbon Dioxide in Biogas by Monoethanolamine Solution

Table A.1 The data from experimental in CO_2 absorption by MEA concentration of 0.05, height to diameter ratio of 1.4 and inlet biogas flow rates of 1, 3 and 5 liter/min.

time(min)	1.0 lite/min			3.0 lite/min			5.0 lite/min		
	$\%C_{CO_2 i}$	$\%C_{CO_2 0}$	$\%C_{CH_4}$	$\%C_{CO_2 i}$	$\%C_{CO_2 0}$	$\%C_{CH_4}$	$\%C_{CO_2 i}$	$\%C_{CO_2 0}$	$\%C_{CH_4}$
0.0	25.2	25.2	71.2	24.0	24.0	74.8	25.5	25.5	74.3
1.0	25.2	8.7	86.8	24.0	10.8	85.3	25.5	11.8	84.5
2.0	25.2	8.8	86.9	24.0	10.8	85.4	25.5	11.8	84.7
3.0	25.2	8.8	87.0	24.0	10.8	85.5	25.5	12.2	84.8
4.0	25.2	8.9	87.2	24.0	11.0	85.6	25.5	12.7	84.6
5.0	25.2	9.0	87.4	24.0	11.2	85.5	25.5	13.2	84.1
6.0	25.2	9.2	87.2	24.0	11.6	85.2	25.5	13.8	83.4
7.0	25.2	9.4	87.0	24.0	12.0	84.9	25.5	14.4	82.6
8.0	25.2	9.6	86.9	24.0	12.4	84.5	25.5	15.7	81.6
9.0	25.2	9.7	86.6	24.0	12.8	84.4	25.5	18.0	79.4
10.0	25.2	10.0	86.4	24.0	13.2	83.6	25.5	20.0	77.6
11.0	25.2	10.2	86.2	24.0	14.1	82.9	25.5	21.2	75.8
12.0	25.2	10.5	85.9	24.0	15.6	81.5	25.5	22.2	74.8
13.0	25.2	11.2	85.5	24.0	17.2	80.1	25.5	22.7	74.5
14.0	25.2	11.9	85.2	24.0	19.0	77.5	25.5	22.9	74.3
15.0	25.2	12.9	84.4	24.0	21.0	75.9	25.5	23.1	74.3
16.0	25.2	14.0	83.5	24.0	21.8	75.4	25.5	23.2	74.3
17.0	25.2	16.2	82.5	24.0	22.5	75.2	0.0	0.0	0.0
18.0	25.2	17.4	81.3	24.0	23.2	75.1	0.0	0.0	0.0
19.0	25.2	18.6	80.1	24.0	23.5	74.9	0.0	0.0	0.0
20.0	25.2	19.7	78.8	24.0	23.7	74.9	0.0	0.0	0.0
21.0	25.2	20.8	77.8	24.0	23.8	74.8	0.0	0.0	0.0
22.0	25.2	21.9	76.7	0.0	0.0	0.0	0.0	0.0	0.0
23.0	25.2	23.0	75.7	0.0	0.0	0.0	0.0	0.0	0.0
24.0	25.2	23.7	74.8	0.0	0.0	0.0	0.0	0.0	0.0
25.0	25.2	24.3	74.1	0.0	0.0	0.0	0.0	0.0	0.0
26.0	25.2	24.5	73.4	0.0	0.0	0.0	0.0	0.0	0.0
27.0	25.2	24.7	73.0	0.0	0.0	0.0	0.0	0.0	0.0
28.0	25.2	24.9	72.8	0.0	0.0	0.0	0.0	0.0	0.0
29.0	25.2	25.0	72.5	0.0	0.0	0.0	0.0	0.0	0.0
30.0	25.2	25.0	72.3	0.0	0.0	0.0	0.0	0.0	0.0
31.0	25.2	25.1	72.2	0.0	0.0	0.0	0.0	0.0	0.0
32.0	25.2	25.1	72.1	0.0	0.0	0.0	0.0	0.0	0.0

Table A.2 The data from experimental in CO_2 absorption by MEA concentration of 0.05, height to diameter ratio of 3.3 and inlet biogas flow rates of 1, 3 and 5 liter/min

time(min)	1.0 lite/min			3.0 lite/min			5.0 lite/min		
	$\%C_{CO_2 i}$	$\%C_{CO_2 0}$	$\%C_{CH_4}$	$\%C_{CO_2 i}$	$\%C_{CO_2 0}$	$\%C_{CH_4}$	$\%C_{CO_2 i}$	$\%C_{CO_2 0}$	$\%C_{CH_4}$
0.0	24.5	24.5	74.5	24.0	24.0	74.4	25.8	25.8	71.7
1.0	24.5	6.7	89.2	24.0	10.4	84.0	25.8	11.4	84.6
2.0	24.5	6.7	89.3	24.0	10.4	84.0	25.8	11.4	84.6
3.0	24.5	6.7	89.3	24.0	10.6	84.1	25.8	11.4	84.6
4.0	24.5	6.8	89.3	24.0	10.6	84.2	25.8	11.4	84.6
5.0	24.5	6.8	89.4	24.0	10.8	84.2	25.8	11.6	84.5
6.0	24.5	6.9	89.4	24.0	10.9	84.5	25.8	12.1	84.3
7.0	24.5	6.9	89.5	24.0	11.0	84.3	25.8	12.5	84.1
8.0	24.5	6.9	89.5	24.0	11.5	84.3	25.8	13.3	83.6
9.0	24.5	6.9	89.7	24.0	11.9	84.1	25.8	15.2	82.3
10.0	24.5	7.1	89.6	24.0	12.7	83.8	25.8	16.7	80.3
11.0	24.5	7.2	89.6	24.0	13.8	82.6	25.8	19.6	78.2
12.0	24.5	7.4	89.5	24.0	15.0	81.5	25.8	21.9	76.3
13.0	24.5	7.5	89.3	24.0	17.5	79.8	25.8	23.3	75.1

time(min)	1.0 lite/min			3.0 lite/min			5.0 lite/min		
	$\%C_{CO_2 i}$	$\%C_{CO_2 o}$	$\%C_{CH_4}$	$\%C_{CO_2 i}$	$\%C_{CO_2 o}$	$\%C_{CH_4}$	$\%C_{CO_2 i}$	$\%C_{CO_2 o}$	$\%C_{CH_4}$
14.0	24.5	7.7	89.2	24.0	19.2	78.7	25.8	23.9	74.3
15.0	24.5	8.0	89.0	24.0	20.8	78.1	25.8	24.5	73.8
16.0	24.5	8.2	88.8	24.0	21.4	77.2	25.8	25.0	73.2
17.0	24.5	8.7	88.3	24.0	21.9	76.4	25.8	25.3	72.8
18.0	24.5	9.2	87.9	24.0	22.7	75.8	25.8	25.6	72.2
19.0	24.5	10.2	86.8	24.0	23.2	75.1	25.8	25.7	71.9
20.0	24.5	11.5	85.5	24.0	23.6	74.8	0.0	0.0	0.0
21.0	24.5	13.2	84.0	24.0	23.8	74.5	0.0	0.0	0.0
22.0	24.5	14.8	82.4	24.0	23.9	74.4	0.0	0.0	0.0
23.0	24.5	16.8	80.9	24.0	24.0	74.3	0.0	0.0	0.0
24.0	24.5	18.6	79.3	0.0	0.0	0.0	0.0	0.0	0.0
25.0	24.5	20.0	77.4	0.0	0.0	0.0	0.0	0.0	0.0
26.0	24.5	21.7	76.7	0.0	0.0	0.0	0.0	0.0	0.0
27.0	24.5	22.5	76.2	0.0	0.0	0.0	0.0	0.0	0.0
28.0	24.5	23.2	75.8	0.0	0.0	0.0	0.0	0.0	0.0
29.0	24.5	23.9	75.4	0.0	0.0	0.0	0.0	0.0	0.0
30.0	24.5	24.3	74.7	0.0	0.0	0.0	0.0	0.0	0.0
31.0	24.5	24.5	74.5	0.0	0.0	0.0	0.0	0.0	0.0

Table A.3 The data from experimental in CO_2 absorption by MEA concentration of 0.05, height to diameter ratio of 6.5 and inlet biogas flow rates of 1, 3 and 5 liter/min.

time(min)	1.0 lite/min			3.0 lite/min			5.0 lite/min		
	$\%C_{CO_2 i}$	$\%C_{CO_2 o}$	$\%C_{CH_4}$	$\%C_{CO_2 i}$	$\%C_{CO_2 o}$	$\%C_{CH_4}$	$\%C_{CO_2 i}$	$\%C_{CO_2 o}$	$\%C_{CH_4}$
0.0	24.1	24.1	74.9	24.1	24.1	74.6	23.9	23.9	74.2
1.0	24.1	2.0	91.2	24.1	4.5	89.8	23.9	5.1	88.9
2.0	24.1	2.0	91.2	24.1	4.4	89.9	23.9	5.2	88.9
3.0	24.1	2.0	91.4	24.1	4.4	90.0	23.9	5.3	89.0
4.0	24.1	2.0	91.4	24.1	4.3	90.1	23.9	5.5	88.8
5.0	24.1	2.0	91.6	24.1	4.3	90.0	23.9	5.9	88.2
6.0	24.1	2.0	91.7	24.1	4.6	89.9	23.9	6.5	87.6
7.0	24.1	2.0	91.8	24.1	4.9	89.4	23.9	7.1	86.8
8.0	24.1	2.0	92.0	24.1	5.2	89.0	23.9	8.0	85.9
9.0	24.1	2.1	91.8	24.1	5.6	88.7	23.9	9.7	84.1
10.0	24.1	2.2	91.6	24.1	6.4	87.7	23.9	13.0	81.1
11.0	24.1	2.5	91.5	24.1	7.4	86.8	23.9	16.1	78.5
12.0	24.1	2.7	91.3	24.1	9.3	84.9	23.9	18.4	76.8
13.0	24.1	2.8	91.0	24.1	12.8	81.7	23.9	19.8	76.0
14.0	24.1	3.0	91.0	24.1	14.9	79.9	23.9	20.9	75.4
15.0	24.1	3.3	90.7	24.1	16.8	78.2	23.9	22.0	75.1
16.0	24.1	3.3	90.6	24.1	18.3	76.9	23.9	23.0	74.7
17.0	24.1	3.8	90.2	24.1	19.7	76.0	23.9	23.5	74.4
18.0	24.1	4.1	89.8	24.1	20.5	75.7	23.9	23.8	74.2
19.0	24.1	4.5	89.5	24.1	21.3	75.4	0.0	0.0	0.0
20.0	24.1	5.0	89.0	24.1	22.5	75.0	0.0	0.0	0.0
21.0	24.1	5.6	88.3	24.1	23.0	74.8	0.0	0.0	0.0
22.0	24.1	6.7	87.3	24.1	23.5	74.6	0.0	0.0	0.0
23.0	24.1	7.4	86.6	24.1	23.9	74.6	0.0	0.0	0.0
24.0	24.1	8.1	86.1	24.1	24.0	74.5	0.0	0.0	0.0
25.0	24.1	9.5	84.6	24.1	24.1	74.5	0.0	0.0	0.0
26.0	24.1	11.0	83.0	0.0	0.0	0.0	0.0	0.0	0.0
27.0	24.1	12.5	81.5	0.0	0.0	0.0	0.0	0.0	0.0
28.0	24.1	13.9	80.2	0.0	0.0	0.0	0.0	0.0	0.0
29.0	24.1	16.0	79.0	0.0	0.0	0.0	0.0	0.0	0.0
30.0	24.1	17.2	77.9	0.0	0.0	0.0	0.0	0.0	0.0
31.0	24.1	18.9	77.2	0.0	0.0	0.0	0.0	0.0	0.0
32.0	24.1	20.2	76.8	0.0	0.0	0.0	0.0	0.0	0.0
33.0	24.1	21.3	76.1	0.0	0.0	0.0	0.0	0.0	0.0
34.0	24.1	22.2	75.7	0.0	0.0	0.0	0.0	0.0	0.0
35.0	24.1	22.8	75.4	0.0	0.0	0.0	0.0	0.0	0.0
36.0	24.1	23.4	75.2	0.0	0.0	0.0	0.0	0.0	0.0
37.0	24.1	23.7	75.3	0.0	0.0	0.0	0.0	0.0	0.0
38.0	24.1	23.9	75.1	0.0	0.0	0.0	0.0	0.0	0.0
39.0	24.1	24.0	75.0	0.0	0.0	0.0	0.0	0.0	0.0
40.0	24.1	24.1	75.0	0.0	0.0	0.0	0.0	0.0	0.0

Table A.4 The data from experimental in CO_2 absorption by MEA concentration of 0.10, height to diameter ratio of 1.4 and inlet biogas flow rates of 1, 3 and 5 liter/min

time(min)	1.0 lite/min			3.0 lite/min			5.0 lite/min		
	$\%C_{CO2i}$	$\%C_{CO2o}$	$\%C_{CH4}$	$\%C_{CO2i}$	$\%C_{CO2o}$	$\%C_{CH4}$	$\%C_{CO2i}$	$\%C_{CO2o}$	$\%C_{CH4}$
0.0	24.3	24.3	74.0	23.0	23.0	74.9	24.5	24.5	74.0
1.0	24.3	4.3	92.5	23.0	4.6	90.0	24.5	5.7	90.7
2.0	24.3	4.3	92.5	23.0	4.6	91.1	24.5	5.7	90.7
3.0	24.3	4.2	92.6	23.0	4.6	91.2	24.5	5.9	90.5
4.0	24.3	4.1	92.7	23.0	4.5	91.3	24.5	6.1	90.3
5.0	24.3	4.1	92.7	23.0	4.4	91.4	24.5	6.2	90.2
6.0	24.3	4.1	92.7	23.0	4.3	91.5	24.5	6.4	90.0
7.0	24.3	4.0	92.8	23.0	4.5	91.3	24.5	7.0	89.4
8.0	24.3	4.0	92.8	23.0	4.6	91.2	24.5	7.8	88.6
9.0	24.3	3.9	92.9	23.0	4.8	91.0	24.5	8.7	87.7
10.0	24.3	3.8	93.0	23.0	5.5	89.8	24.5	9.7	86.7
11.0	24.3	3.8	93.0	23.0	6.2	89.6	24.5	10.5	85.9
12.0	24.3	3.8	93.0	23.0	6.8	89.0	24.5	11.3	85.1
13.0	24.3	3.8	93.0	23.0	7.6	88.2	24.5	12.1	84.3
14.0	24.3	3.8	93.0	23.0	8.2	87.6	24.5	13.6	82.8
15.0	24.3	3.9	92.9	23.0	8.8	87.0	24.5	14.5	81.9
16.0	24.3	3.9	92.9	23.0	9.5	86.3	24.5	15.7	80.7
17.0	24.3	4.0	92.8	23.0	10.4	85.4	24.5	17.0	79.4
18.0	24.3	4.1	92.7	23.0	11.1	84.7	24.5	18.9	77.5
19.0	24.3	4.3	92.5	23.0	11.8	84.0	24.5	20.8	75.6
20.0	24.3	4.5	92.3	23.0	12.3	83.5	24.5	21.5	74.9
21.0	24.3	4.9	91.9	23.0	13.6	82.2	24.5	22.1	74.5
22.0	24.3	5.3	91.5	23.0	14.6	81.2	24.5	22.7	74.2
23.0	24.3	5.5	91.3	23.0	16.0	79.8	24.5	23.2	74.2
24.0	24.3	6.1	90.7	23.0	17.3	78.5	24.5	23.8	74.1
25.0	24.3	6.4	90.4	23.0	18.2	77.6	24.5	24.2	74.0
26.0	24.3	6.8	90.0	23.0	19.6	76.2	24.5	24.5	74.0
27.0	24.3	7.1	89.7	23.0	20.4	75.6	0.0	0.0	0.0
28.0	24.3	7.3	89.5	23.0	20.9	75.4	0.0	0.0	0.0
29.0	24.3	7.5	89.3	23.0	21.5	75.2	0.0	0.0	0.0
30.0	24.3	8.1	88.7	23.0	22.0	75.1	0.0	0.0	0.0
31.0	24.3	8.3	88.5	23.0	22.4	75.0	0.0	0.0	0.0
32.0	24.3	8.4	88.4	23.0	22.8	74.9	0.0	0.0	0.0
33.0	24.3	8.9	87.9	23.0	23.0	74.9	0.0	0.0	0.0
34.0	24.3	9.8	87.0	0.0	0.0	0.0	0.0	0.0	0.0
35.0	24.3	10.3	86.5	0.0	0.0	0.0	0.0	0.0	0.0
36.0	24.3	10.8	86.0	0.0	0.0	0.0	0.0	0.0	0.0
37.0	24.3	11.3	85.5	0.0	0.0	0.0	0.0	0.0	0.0
38.0	24.3	11.6	85.2	0.0	0.0	0.0	0.0	0.0	0.0
39.0	24.3	12.0	84.8	0.0	0.0	0.0	0.0	0.0	0.0
40.0	24.3	12.4	84.4	0.0	0.0	0.0	0.0	0.0	0.0
41.0	24.3	13.3	83.5	0.0	0.0	0.0	0.0	0.0	0.0
42.0	24.3	13.7	83.1	0.0	0.0	0.0	0.0	0.0	0.0
43.0	24.3	14.4	82.4	0.0	0.0	0.0	0.0	0.0	0.0
44.0	24.3	15.3	81.5	0.0	0.0	0.0	0.0	0.0	0.0
45.0	24.3	16.2	80.6	0.0	0.0	0.0	0.0	0.0	0.0
46.0	24.3	17.1	79.7	0.0	0.0	0.0	0.0	0.0	0.0
47.0	24.3	17.4	79.4	0.0	0.0	0.0	0.0	0.0	0.0
48.0	24.3	18.8	78.0	0.0	0.0	0.0	0.0	0.0	0.0
49.0	24.3	19.3	77.5	0.0	0.0	0.0	0.0	0.0	0.0
50.0	24.3	19.8	77.0	0.0	0.0	0.0	0.0	0.0	0.0
51.0	24.3	20.8	76.0	0.0	0.0	0.0	0.0	0.0	0.0
52.0	24.3	21.9	74.9	0.0	0.0	0.0	0.0	0.0	0.0
53.0	24.3	23.0	74.5	0.0	0.0	0.0	0.0	0.0	0.0
54.0	24.3	24.4	74.3	0.0	0.0	0.0	0.0	0.0	0.0
55.0	24.3	24.4	74.2	0.0	0.0	0.0	0.0	0.0	0.0
56.0	24.3	24.3	74.1	0.0	0.0	0.0	0.0	0.0	0.0
57.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
58.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table A.5 The data from experimental in CO_2 absorption by MEA concentration of 0.10, height to diameter ratio of 3.3 and inlet biogas flow rates of 1, 3 and 5 liter/min.

time(min)	1.0 lite/min			3.0 lite/min			5.0 lite/min		
	$\%C_{CO2i}$	$\%C_{CO2o}$	$\%C_{CH4}$	$\%C_{CO2i}$	$\%C_{CO2o}$	$\%C_{CH4}$	$\%C_{CO2i}$	$\%C_{CO2o}$	$\%C_{CH4}$
0.0	25.3	25.3	70.8	25.1	25.1	73.5	25.7	25.7	72.4
1.0	25.3	3.5	92.6	25.1	7.2	91.4	25.7	8.1	90.0
2.0	25.3	3.4	92.7	25.1	7.1	91.5	25.7	7.9	90.2
3.0	25.3	3.4	92.7	25.1	7.0	91.6	25.7	7.8	90.3
4.0	25.3	3.3	92.8	25.1	7.0	91.6	25.7	7.7	90.4
5.0	25.3	3.2	92.9	25.1	6.9	91.7	25.7	7.7	90.4
6.0	25.3	3.1	93.0	25.1	6.8	91.8	25.7	7.8	90.3
7.0	25.3	3.1	93.0	25.1	6.8	91.8	25.7	7.9	90.2
8.0	25.3	3.1	93.0	25.1	6.8	91.8	25.7	8.3	89.8
9.0	25.3	2.9	93.2	25.1	7.1	91.5	25.7	9.1	89.0
10.0	25.3	2.8	93.3	25.1	7.4	91.2	25.7	9.9	88.2
11.0	25.3	2.7	93.4	25.1	7.8	90.8	25.7	10.6	87.5
12.0	25.3	2.7	93.4	25.1	8.2	90.4	25.7	11.6	86.5
13.0	25.3	2.6	93.5	25.1	8.6	90.0	25.7	12.7	85.4
14.0	25.3	2.6	93.5	25.1	9.0	89.6	25.7	13.4	84.7
15.0	25.3	2.6	93.5	25.1	9.5	89.1	25.7	14.0	84.1
16.0	25.3	2.8	93.3	25.1	10.0	88.6	25.7	15.2	82.9
17.0	25.3	2.9	93.2	25.1	11.0	87.6	25.7	16.6	81.5
18.0	25.3	3.0	93.1	25.1	12.1	86.5	25.7	18.6	79.5
19.0	25.3	3.2	92.9	25.1	12.8	85.8	25.7	19.7	78.4
20.0	25.3	3.4	92.7	25.1	13.6	85.0	25.7	21.5	76.6
21.0	25.3	3.6	92.5	25.1	15.0	83.6	25.7	22.8	75.3
22.0	25.3	3.8	92.3	25.1	16.9	81.7	25.7	23.5	74.6
23.0	25.3	4.1	92.0	25.1	17.8	80.8	25.7	24.6	73.5
24.0	25.3	4.3	91.8	25.1	19.0	79.6	25.7	25.4	72.7
25.0	25.3	4.6	91.5	25.1	22.1	76.5	25.7	25.7	72.4
26.0	25.3	5.1	91.0	25.1	23.4	75.2	0.0	0.0	0.0
27.0	25.3	5.3	90.8	25.1	24.4	74.2	0.0	0.0	0.0
28.0	25.3	5.7	90.4	25.1	24.8	73.8	0.0	0.0	0.0
29.0	25.3	6.1	90.0	25.1	25.0	73.6	0.0	0.0	0.0
30.0	25.3	6.5	89.6	25.1	25.1	73.5	0.0	0.0	0.0
31.0	25.3	7.1	89.0	0.0	0.0	0.0	0.0	0.0	0.0
32.0	25.3	7.6	88.5	0.0	0.0	0.0	0.0	0.0	0.0
33.0	25.3	7.9	88.2	0.0	0.0	0.0	0.0	0.0	0.0
34.0	25.3	8.3	87.8	0.0	0.0	0.0	0.0	0.0	0.0
35.0	25.3	8.9	87.2	0.0	0.0	0.0	0.0	0.0	0.0
36.0	25.3	9.5	86.6	0.0	0.0	0.0	0.0	0.0	0.0
37.0	25.3	9.9	86.2	0.0	0.0	0.0	0.0	0.0	0.0
38.0	25.3	10.4	85.7	0.0	0.0	0.0	0.0	0.0	0.0
39.0	25.3	11.0	85.1	0.0	0.0	0.0	0.0	0.0	0.0
40.0	25.3	11.6	84.5	0.0	0.0	0.0	0.0	0.0	0.0
41.0	25.3	12.2	83.9	0.0	0.0	0.0	0.0	0.0	0.0
42.0	25.3	13.3	82.8	0.0	0.0	0.0	0.0	0.0	0.0
43.0	25.3	14.5	81.6	0.0	0.0	0.0	0.0	0.0	0.0
44.0	25.3	15.6	80.5	0.0	0.0	0.0	0.0	0.0	0.0
45.0	25.3	16.6	79.5	0.0	0.0	0.0	0.0	0.0	0.0
46.0	25.3	17.7	78.4	0.0	0.0	0.0	0.0	0.0	0.0
47.0	25.3	18.8	77.3	0.0	0.0	0.0	0.0	0.0	0.0
48.0	25.3	19.9	76.2	0.0	0.0	0.0	0.0	0.0	0.0
49.0	25.3	21.0	75.1	0.0	0.0	0.0	0.0	0.0	0.0
50.0	25.3	21.9	74.2	0.0	0.0	0.0	0.0	0.0	0.0
51.0	25.3	22.8	73.3	0.0	0.0	0.0	0.0	0.0	0.0
52.0	25.3	24.0	72.1	0.0	0.0	0.0	0.0	0.0	0.0
53.0	25.3	24.7	71.4	0.0	0.0	0.0	0.0	0.0	0.0
54.0	25.3	25.2	70.9	0.0	0.0	0.0	0.0	0.0	0.0
55.0	25.3	25.3	70.8	0.0	0.0	0.0	0.0	0.0	0.0

Table A.6 The data from experimental in CO_2 absorption by MEA concentration of 0.10, height to diameter ratio of 6.5 and inlet biogas flow rates of 1, 3 and 5 liter/min.

time(min)	1.0 lite/min			3.0 lite/min			5.0 lite/min		
	$\%C_{CO2i}$	$\%C_{CO2o}$	$\%C_{CH4}$	$\%C_{CO2i}$	$\%C_{CO2o}$	$\%C_{CH4}$	$\%C_{CO2i}$	$\%C_{CO2o}$	$\%C_{CH4}$
0.0	23.9	23.9	74.1	20.5	20.5	76.1	24.8	24.8	73.8
1.0	23.9	2.6	92.8	20.5	5.6	91.9	24.8	5.8	91.4
2.0	23.9	2.5	92.9	20.5	5.6	92.0	24.8	5.7	91.4
3.0	23.9	2.3	93.1	20.5	5.6	92.1	24.8	5.6	91.5
4.0	23.9	2.3	93.1	20.5	5.5	92.2	24.8	5.5	91.6
5.0	23.9	2.1	93.3	20.5	5.5	92.3	24.8	5.2	91.8
6.0	23.9	2.1	93.3	20.5	5.4	92.4	24.8	5.2	91.8
7.0	23.9	2.1	93.3	20.5	5.3	92.5	24.8	5.2	91.8
8.0	23.9	1.9	93.5	20.5	5.2	92.6	24.8	5.2	91.8
9.0	23.9	1.9	93.5	20.5	5.0	92.7	24.8	5.3	91.7
10.0	23.9	1.9	93.5	20.5	4.8	92.8	24.8	5.6	91.4
11.0	23.9	1.8	93.6	20.5	4.7	93.0	24.8	6.0	91.0
12.0	23.9	1.8	93.6	20.5	4.6	93.3	24.8	6.3	90.7
13.0	23.9	1.7	93.7	20.5	4.5	93.4	24.8	6.8	90.2
14.0	23.9	1.7	93.7	20.5	4.6	93.3	24.8	7.8	89.2
15.0	23.9	1.5	93.9	20.5	4.7	93.2	24.8	8.7	88.3
16.0	23.9	1.5	93.9	20.5	4.8	93.1	24.8	9.8	87.2
17.0	23.9	1.5	93.9	20.5	4.9	93.0	24.8	11.9	85.6
18.0	23.9	1.4	94.0	20.5	5.1	92.8	24.8	14.0	84.5
19.0	23.9	1.3	94.1	20.5	5.5	92.4	24.8	16.6	83.3
20.0	23.9	1.3	94.1	20.5	5.6	92.3	24.8	17.9	81.5
21.0	23.9	1.2	94.2	20.5	6.0	91.9	24.8	19.9	80.4
22.0	23.9	1.2	94.2	20.5	6.3	91.6	24.8	21.2	79.1
23.0	23.9	1.3	94.1	20.5	6.7	91.2	24.8	22.0	77.9
24.0	23.9	1.4	94.0	20.5	7.0	90.9	24.8	22.7	77.0
25.0	23.9	1.4	94.0	20.5	7.4	90.5	24.8	23.3	76.1
26.0	23.9	1.6	93.8	20.5	7.9	90.0	24.8	23.7	75.0
27.0	23.9	1.7	93.7	20.5	8.0	89.9	24.8	24.0	74.2
28.0	23.9	1.8	93.6	20.5	8.4	89.5	24.8	24.7	74.0
29.0	23.9	1.9	93.5	20.5	8.8	89.1	24.8	24.8	73.8
30.0	23.9	2.0	93.4	20.5	9.3	88.6	0.0	0.0	0.0
31.0	23.9	2.2	93.2	20.5	9.6	88.3	0.0	0.0	0.0
32.0	23.9	2.4	93.0	20.5	10.1	87.8	0.0	0.0	0.0
33.0	23.9	2.4	93.0	20.5	10.8	87.1	0.0	0.0	0.0
34.0	23.9	2.5	92.9	20.5	11.6	86.3	0.0	0.0	0.0
35.0	23.9	2.6	92.8	20.5	12.5	85.4	0.0	0.0	0.0
36.0	23.9	3.0	92.6	20.5	13.6	84.3	0.0	0.0	0.0
37.0	23.9	3.5	92.3	20.5	14.9	83.0	0.0	0.0	0.0
38.0	23.9	4.1	92.1	20.5	16.1	81.8	0.0	0.0	0.0
39.0	23.9	4.4	91.9	20.5	17.1	80.8	0.0	0.0	0.0
40.0	23.9	4.8	91.3	20.5	18.2	79.7	0.0	0.0	0.0
41.0	23.9	5.3	91.0	20.5	19.1	78.8	0.0	0.0	0.0
42.0	23.9	5.8	90.6	20.5	19.8	77.8	0.0	0.0	0.0
43.0	23.9	6.6	90.1	20.5	20.2	77.4	0.0	0.0	0.0
44.0	23.9	7.3	89.6	20.5	20.4	76.7	0.0	0.0	0.0
45.0	23.9	8.4	88.8	20.5	20.5	76.1	0.0	0.0	0.0
46.0	23.9	9.0	88.1	20.5	20.5	76.1	0.0	0.0	0.0
47.0	23.9	9.5	87.0	0.0	0.0	0.0	0.0	0.0	0.0
48.0	23.9	10.1	86.0	0.0	0.0	0.0	0.0	0.0	0.0
49.0	23.9	10.7	84.7	0.0	0.0	0.0	0.0	0.0	0.0
50.0	23.9	11.7	83.7	0.0	0.0	0.0	0.0	0.0	0.0
51.0	23.9	12.6	82.8	0.0	0.0	0.0	0.0	0.0	0.0
52.0	23.9	13.6	81.8	0.0	0.0	0.0	0.0	0.0	0.0
53.0	23.9	14.7	80.7	0.0	0.0	0.0	0.0	0.0	0.0
54.0	23.9	15.6	79.8	0.0	0.0	0.0	0.0	0.0	0.0
55.0	23.9	16.1	79.3	0.0	0.0	0.0	0.0	0.0	0.0
56.0	23.9	16.9	78.5	0.0	0.0	0.0	0.0	0.0	0.0
57.0	23.9	17.9	77.9	0.0	0.0	0.0	0.0	0.0	0.0
58.0	23.9	18.4	77.2	0.0	0.0	0.0	0.0	0.0	0.0
59.0	23.9	18.9	76.8	0.0	0.0	0.0	0.0	0.0	0.0
60.0	23.9	19.6	76.0	0.0	0.0	0.0	0.0	0.0	0.0
61.0	23.9	20.1	75.2	0.0	0.0	0.0	0.0	0.0	0.0
62.0	23.9	21.0	74.8	0.0	0.0	0.0	0.0	0.0	0.0
63.0	23.9	22.0	74.7	0.0	0.0	0.0	0.0	0.0	0.0
64.0	23.9	22.8	74.5	0.0	0.0	0.0	0.0	0.0	0.0
65.0	23.9	23.5	74.3	0.0	0.0	0.0	0.0	0.0	0.0
66.0	23.9	23.9	74.1	0.0	0.0	0.0	0.0	0.0	0.0

Table A.7 The data from experimental in CO_2 absorption by MEA concentration of 0.20, height to diameter ratio of 1.4 and inlet biogas flow rates of 1, 3 and 5 liter/min.

time(min)	1.0 lite/min			3.0 lite/min			5.0 lite/min		
	$\%C_{CO2i}$	$\%C_{CO2o}$	$\%C_{CH4}$	$\%C_{CO2i}$	$\%C_{CO2o}$	$\%C_{CH4}$	$\%C_{CO2i}$	$\%C_{CO2o}$	$\%C_{CH4}$
0.0	27.8	27.8	70.5	26.0	26.0	70.7	24.6	24.6	70.0
1.0	27.8	6.8	93.1	26.0	2.2	94.5	24.6	2.1	92.5
2.0	27.8	6.8	93.1	26.0	2.2	94.6	24.6	1.9	92.7
3.0	27.8	6.7	93.1	26.0	2.2	94.7	24.6	1.7	92.9
4.0	27.8	6.6	93.2	26.0	2.1	94.8	24.6	1.5	93.1
5.0	27.8	6.5	93.4	26.0	2.0	94.9	24.6	1.2	93.4
6.0	27.8	6.3	93.7	26.0	1.9	95.0	24.6	1.1	93.5
7.0	27.8	6.1	93.9	26.0	1.8	95.1	24.6	0.9	93.7
8.0	27.8	5.9	94.1	26.0	1.7	95.2	24.6	0.7	93.9
9.0	27.8	5.7	94.3	26.0	1.7	95.2	24.6	0.6	94.0
10.0	27.8	5.5	94.5	26.0	1.5	95.4	24.6	0.9	93.7
11.0	27.8	5.3	94.7	26.0	1.4	95.5	24.6	1.3	93.3
12.0	27.8	5.2	94.8	26.0	1.4	95.5	24.6	2.6	92.0
13.0	27.8	5.1	94.9	26.0	1.7	95.2	24.6	3.3	91.3
14.0	27.8	5.0	95.0	26.0	2.2	94.6	24.6	4.2	90.4
15.0	27.8	4.9	95.1	26.0	2.9	94.0	24.6	5.0	89.6
16.0	27.8	4.8	95.2	26.0	3.2	93.7	24.6	5.8	88.8
17.0	27.8	4.8	95.2	26.0	3.5	93.4	24.6	6.6	88.0
18.0	27.8	4.8	95.2	26.0	3.9	93.0	24.6	7.4	87.2
19.0	27.8	4.8	95.2	26.0	4.5	92.4	24.6	8.1	86.5
20.0	27.8	4.8	95.2	26.0	4.9	92.0	24.6	9.0	85.6
21.0	27.8	4.8	95.2	26.0	5.3	91.6	24.6	10.0	84.6
22.0	27.8	4.8	95.2	26.0	5.8	91.1	24.6	10.4	84.2
23.0	27.8	4.8	95.2	26.0	6.6	90.3	24.6	11.0	83.6
24.0	27.8	4.8	95.2	26.0	7.5	89.4	24.6	11.6	83.0
25.0	27.8	4.8	95.2	26.0	8.3	88.6	24.6	12.6	82.0
26.0	27.8	4.8	95.2	26.0	8.7	88.2	24.6	13.5	81.1
27.0	27.8	4.8	95.2	26.0	9.1	87.8	24.6	15.4	79.2
28.0	27.8	4.8	95.2	26.0	9.9	87.0	24.6	15.5	79.1
29.0	27.8	4.8	95.2	26.0	10.1	86.8	24.6	16.9	77.7
30.0	27.8	4.8	95.2	26.0	10.6	86.3	24.6	17.7	76.9
31.0	27.8	4.8	95.2	26.0	11.5	85.4	24.6	18.4	76.2
32.0	27.8	4.9	95.1	26.0	11.8	85.1	24.6	19.2	75.4
33.0	27.8	5.0	95.0	26.0	12.6	84.3	24.6	20.1	74.5
34.0	27.8	5.0	95.0	26.0	13.2	83.7	24.6	21.2	73.4
35.0	27.8	5.1	94.9	26.0	14.0	82.9	24.6	21.9	72.7
36.0	27.8	5.3	94.7	26.0	14.8	82.1	24.6	22.9	71.7
37.0	27.8	5.6	94.4	26.0	15.5	81.4	24.6	23.7	70.9
38.0	27.8	6.1	93.9	26.0	16.1	80.8	24.6	24.0	70.6
39.0	27.8	6.1	93.9	26.0	17.2	79.7	24.6	24.3	70.3
40.0	27.8	6.3	93.7	26.0	18.3	78.6	24.6	24.6	70.0
41.0	27.8	6.6	93.4	26.0	19.0	77.9	24.6	24.6	70.0
42.0	27.8	6.6	93.4	26.0	20.1	76.8	0.0	0.0	0.0
43.0	27.8	7.1	92.9	26.0	20.9	76.0	0.0	0.0	0.0
44.0	27.8	7.4	92.6	26.0	21.8	75.1	0.0	0.0	0.0
45.0	27.8	7.5	92.5	26.0	22.8	74.3	0.0	0.0	0.0
46.0	27.8	7.5	92.5	26.0	23.7	73.6	0.0	0.0	0.0
47.0	27.8	7.7	92.3	26.0	24.2	72.9	0.0	0.0	0.0
48.0	27.8	8.1	91.9	26.0	24.7	72.0	0.0	0.0	0.0
49.0	27.8	8.2	91.8	26.0	25.3	71.4	0.0	0.0	0.0
50.0	27.8	8.4	91.6	26.0	25.7	71.0	0.0	0.0	0.0
51.0	27.8	8.9	91.1	26.0	25.9	70.8	0.0	0.0	0.0
52.0	27.8	9.0	91.0	0.0	0.0	0.0	0.0	0.0	0.0
53.0	27.8	9.4	90.6	0.0	0.0	0.0	0.0	0.0	0.0
54.0	27.8	9.4	90.6	0.0	0.0	0.0	0.0	0.0	0.0
55.0	27.8	10.0	90.0	0.0	0.0	0.0	0.0	0.0	0.0
56.0	27.8	10.1	89.9	0.0	0.0	0.0	0.0	0.0	0.0
57.0	27.8	10.3	89.7	0.0	0.0	0.0	0.0	0.0	0.0
58.0	27.8	10.6	89.4	0.0	0.0	0.0	0.0	0.0	0.0
59.0	27.8	10.9	89.1	0.0	0.0	0.0	0.0	0.0	0.0
60.0	27.8	11.3	88.7	0.0	0.0	0.0	0.0	0.0	0.0
61.0	27.8	11.5	88.5	0.0	0.0	0.0	0.0	0.0	0.0
62.0	27.8	11.8	88.2	0.0	0.0	0.0	0.0	0.0	0.0
63.0	27.8	12.4	87.6	0.0	0.0	0.0	0.0	0.0	0.0
64.0	27.8	12.6	87.5	0.0	0.0	0.0	0.0	0.0	0.0
65.0	27.8	13.0	87.0	0.0	0.0	0.0	0.0	0.0	0.0
66.0	27.8	13.5	86.5	0.0	0.0	0.0	0.0	0.0	0.0
67.0	27.8	14.0	86.0	0.0	0.0	0.0	0.0	0.0	0.0

time(min)	1.0 lite/min			3.0 lite/min			5.0 lite/min		
	$\%C_{CO2i}$	$\%C_{CO2o}$	$\%C_{CH4}$	$\%C_{CO2i}$	$\%C_{CO2o}$	$\%C_{CH4}$	$\%C_{CO2i}$	$\%C_{CO2o}$	$\%C_{CH4}$
68.0	27.8	14.3	85.7	0.0	0.0	0.0	0.0	0.0	0.0
69.0	27.8	14.9	85.1	0.0	0.0	0.0	0.0	0.0	0.0
70.0	27.8	15.1	84.9	0.0	0.0	0.0	0.0	0.0	0.0
71.0	27.8	15.6	84.4	0.0	0.0	0.0	0.0	0.0	0.0
72.0	27.8	16.3	83.7	0.0	0.0	0.0	0.0	0.0	0.0
73.0	27.8	16.9	83.1	0.0	0.0	0.0	0.0	0.0	0.0
74.0	27.8	17.6	82.4	0.0	0.0	0.0	0.0	0.0	0.0
75.0	27.8	18.1	81.9	0.0	0.0	0.0	0.0	0.0	0.0
76.0	27.8	18.8	81.2	0.0	0.0	0.0	0.0	0.0	0.0
77.0	27.8	20.2	79.8	0.0	0.0	0.0	0.0	0.0	0.0
78.0	27.8	20.6	79.4	0.0	0.0	0.0	0.0	0.0	0.0
79.0	27.8	21.0	79.0	0.0	0.0	0.0	0.0	0.0	0.0
80.0	27.8	21.4	78.6	0.0	0.0	0.0	0.0	0.0	0.0
81.0	27.8	22.0	78.0	0.0	0.0	0.0	0.0	0.0	0.0
82.0	27.8	22.2	77.8	0.0	0.0	0.0	0.0	0.0	0.0
83.0	27.8	23.4	76.6	0.0	0.0	0.0	0.0	0.0	0.0
84.0	27.8	24.0	76.0	0.0	0.0	0.0	0.0	0.0	0.0
85.0	27.8	24.7	75.3	0.0	0.0	0.0	0.0	0.0	0.0
86.0	27.8	25.6	74.2	0.0	0.0	0.0	0.0	0.0	0.0
87.0	27.8	26.4	73.0	0.0	0.0	0.0	0.0	0.0	0.0
88.0	27.8	26.8	72.1	0.0	0.0	0.0	0.0	0.0	0.0
89.0	27.8	27.2	71.5	0.0	0.0	0.0	0.0	0.0	0.0
90.0	27.8	27.4	71.1	0.0	0.0	0.0	0.0	0.0	0.0
91.0	27.8	27.5	70.9	0.0	0.0	0.0	0.0	0.0	0.0
92.0	27.8	27.6	70.7	0.0	0.0	0.0	0.0	0.0	0.0
93.0	27.8	27.7	70.5	0.0	0.0	0.0	0.0	0.0	0.0

Table A.8 The data from experimental in CO_2 absorption by MEA concentration of 0.20, height to diameter ratio of 3.3 and inlet biogas flow rates of 1, 3 and 5 liter/min

time(min)	1.0 lite/min			3.0 lite/min			5.0 lite/min		
	$\%C_{CO2i}$	$\%C_{CO2o}$	$\%C_{CH4}$	$\%C_{CO2i}$	$\%C_{CO2o}$	$\%C_{CH4}$	$\%C_{CO2i}$	$\%C_{CO2o}$	$\%C_{CH4}$
0.0	28.5	28.5	70.5	25.5	25.1	73.5	25.5	25.5	72.4
1.0	28.5	2.6	93.4	25.5	3.2	92.8	25.5	1.6	92.9
2.0	28.5	2.5	93.5	25.5	3.1	92.9	25.5	1.6	92.9
3.0	28.5	2.4	93.6	25.5	3.0	93.0	25.5	1.5	93.0
4.0	28.5	2.4	93.6	25.5	3.0	93.0	25.5	1.5	93.0
5.0	28.5	2.4	93.6	25.5	2.9	93.1	25.5	1.4	93.1
6.0	28.5	2.3	93.7	25.5	2.9	93.1	25.5	1.4	93.1
7.0	28.5	2.3	93.7	25.5	2.8	93.2	25.5	1.4	93.1
8.0	28.5	2.3	93.7	25.5	2.6	93.4	25.5	1.5	93.0
9.0	28.5	2.2	93.8	25.5	2.5	93.5	25.5	1.5	93.0
10.0	28.5	2.2	93.8	25.5	2.4	93.6	25.5	1.9	92.6
11.0	28.5	2.2	93.8	25.5	2.4	93.6	25.5	2.3	92.2
12.0	28.5	2.1	93.9	25.5	2.5	93.5	25.5	2.6	91.9
13.0	28.5	2.0	94.0	25.5	2.5	93.5	25.5	2.8	91.7
14.0	28.5	1.9	94.1	25.5	2.6	93.4	25.5	3.5	91.0
15.0	28.5	1.7	94.3	25.5	2.6	93.4	25.5	3.8	90.7
16.0	28.5	1.6	94.4	25.5	2.8	93.2	25.5	5.0	89.5
17.0	28.5	1.4	94.6	25.5	2.8	93.2	25.5	5.9	88.6
18.0	28.5	1.3	94.7	25.5	2.8	93.2	25.5	6.4	88.1
19.0	28.5	1.2	94.8	25.5	3.0	93.0	25.5	6.7	87.8
20.0	28.5	1.2	94.8	25.5	3.4	92.6	25.5	7.5	87.0
21.0	28.5	1.2	94.8	25.5	3.9	92.1	25.5	8.1	86.4
22.0	28.5	1.0	95.0	25.5	4.4	91.6	25.5	8.7	85.8
23.0	28.5	1.0	95.0	25.5	4.9	91.1	25.5	9.7	84.8
24.0	28.5	1.0	95.0	25.5	5.7	90.3	25.5	10.4	84.1
25.0	28.5	0.7	95.3	25.5	6.2	89.8	25.5	11.2	82.6
26.0	28.5	0.9	95.1	25.5	6.4	89.6	25.5	12.0	82.2
27.0	28.5	1.1	94.9	25.5	7.4	88.6	25.5	13.5	81.0
28.0	28.5	1.1	94.9	25.5	7.6	88.4	25.5	15.0	80.2
29.0	28.5	1.1	94.9	25.5	8.2	87.8	25.5	17.7	79.2
30.0	28.5	1.1	94.9	25.5	8.8	87.2	25.5	19.2	78.2
31.0	28.5	1.1	94.9	25.5	9.4	86.6	25.5	20.7	77.2
32.0	28.5	1.1	94.9	25.5	9.7	86.3	25.5	21.9	76.7
33.0	28.5	1.2	94.8	25.5	10.9	85.1	25.5	22.9	75.7
34.0	28.5	1.4	94.6	25.5	11.5	84.5	25.5	24.0	73.2
35.0	28.5	1.5	94.5	25.5	12.1	83.9	25.5	25.1	72.8
36.0	28.5	1.6	94.4	25.5	13.7	82.3	25.5	25.3	72.6

time(min)	1.0 lite/min			3.0 lite/min			5.0 lite/min		
	$\%C_{CO2i}$	$\%C_{CO2o}$	$\%C_{CH4}$	$\%C_{CO2i}$	$\%C_{CO2o}$	$\%C_{CH4}$	$\%C_{CO2i}$	$\%C_{CO2o}$	$\%C_{CH4}$
37.0	28.5	2.0	94.0	25.5	14.3	81.7	25.5	25.5	72.4
38.0	28.5	2.2	93.8	25.5	15.0	80.9	0.0	0.0	0.0
39.0	28.5	2.3	93.7	25.5	15.9	79.9	0.0	0.0	0.0
40.0	28.5	2.4	93.6	25.5	16.7	79.1	0.0	0.0	0.0
41.0	28.5	3.2	92.8	25.5	17.5	78.6	0.0	0.0	0.0
42.0	28.5	3.6	92.4	25.5	18.5	77.5	0.0	0.0	0.0
43.0	28.5	3.7	92.3	25.5	20.5	76.7	0.0	0.0	0.0
44.0	28.5	3.8	92.2	25.5	21.7	75.7	0.0	0.0	0.0
45.0	28.5	3.9	92.1	25.5	22.5	74.9	0.0	0.0	0.0
46.0	28.5	4.3	91.7	25.5	23.7	74.0	0.0	0.0	0.0
47.0	28.5	4.7	91.3	25.5	24.5	73.8	0.0	0.0	0.0
48.0	28.5	4.7	91.3	25.5	25.0	73.6	0.0	0.0	0.0
49.0	28.5	4.7	91.3	25.5	25.1	73.5	0.0	0.0	0.0
50.0	28.5	5.2	90.8	25.5	25.2	73.5	0.0	0.0	0.0
51.0	28.5	5.5	90.5	0.0	0.0	0.0	0.0	0.0	0.0
52.0	28.5	5.7	90.3	0.0	0.0	0.0	0.0	0.0	0.0
53.0	28.5	6.0	90.0	0.0	0.0	0.0	0.0	0.0	0.0
54.0	28.5	6.2	89.8	0.0	0.0	0.0	0.0	0.0	0.0
55.0	28.5	6.3	89.7	0.0	0.0	0.0	0.0	0.0	0.0
56.0	28.5	6.4	89.6	0.0	0.0	0.0	0.0	0.0	0.0
57.0	28.5	6.5	89.5	0.0	0.0	0.0	0.0	0.0	0.0
58.0	28.5	6.7	89.3	0.0	0.0	0.0	0.0	0.0	0.0
59.0	28.5	7.1	88.9	0.0	0.0	0.0	0.0	0.0	0.0
60.0	28.5	7.6	88.4	0.0	0.0	0.0	0.0	0.0	0.0
61.0	28.5	7.9	88.1	0.0	0.0	0.0	0.0	0.0	0.0
62.0	28.5	8.3	87.7	0.0	0.0	0.0	0.0	0.0	0.0
63.0	28.5	8.6	87.4	0.0	0.0	0.0	0.0	0.0	0.0
64.0	28.5	9.0	87.0	0.0	0.0	0.0	0.0	0.0	0.0
65.0	28.5	9.4	86.6	0.0	0.0	0.0	0.0	0.0	0.0
66.0	28.5	9.9	86.1	0.0	0.0	0.0	0.0	0.0	0.0
67.0	28.5	10.6	85.4	0.0	0.0	0.0	0.0	0.0	0.0
68.0	28.5	11.5	84.5	0.0	0.0	0.0	0.0	0.0	0.0
69.0	28.5	12.0	84.0	0.0	0.0	0.0	0.0	0.0	0.0
70.0	28.5	12.6	83.4	0.0	0.0	0.0	0.0	0.0	0.0
71.0	28.5	13.1	82.9	0.0	0.0	0.0	0.0	0.0	0.0
72.0	28.5	13.7	82.3	0.0	0.0	0.0	0.0	0.0	0.0
73.0	28.5	14.5	81.5	0.0	0.0	0.0	0.0	0.0	0.0
74.0	28.5	15.0	81.3	0.0	0.0	0.0	0.0	0.0	0.0
75.0	28.5	15.6	80.9	0.0	0.0	0.0	0.0	0.0	0.0
76.0	28.5	16.2	80.4	0.0	0.0	0.0	0.0	0.0	0.0
77.0	28.5	17.0	79.8	0.0	0.0	0.0	0.0	0.0	0.0
78.0	28.5	18.1	79.3	0.0	0.0	0.0	0.0	0.0	0.0
79.0	28.5	18.6	78.6	0.0	0.0	0.0	0.0	0.0	0.0
80.0	28.5	19.2	77.9	0.0	0.0	0.0	0.0	0.0	0.0
81.0	28.5	19.4	77.4	0.0	0.0	0.0	0.0	0.0	0.0
82.0	28.5	19.7	76.8	0.0	0.0	0.0	0.0	0.0	0.0
83.0	28.5	20.2	76.6	0.0	0.0	0.0	0.0	0.0	0.0
84.0	28.5	20.8	76.3	0.0	0.0	0.0	0.0	0.0	0.0
85.0	28.5	21.2	75.8	0.0	0.0	0.0	0.0	0.0	0.0
86.0	28.5	22.4	75.2	0.0	0.0	0.0	0.0	0.0	0.0
87.0	28.5	22.8	74.8	0.0	0.0	0.0	0.0	0.0	0.0
88.0	28.5	23.5	74.4	0.0	0.0	0.0	0.0	0.0	0.0
89.0	28.5	24.7	73.8	0.0	0.0	0.0	0.0	0.0	0.0
90.0	28.5	25.8	72.7	0.0	0.0	0.0	0.0	0.0	0.0
91.0	28.5	26.2	72.1	0.0	0.0	0.0	0.0	0.0	0.0
92.0	28.5	27.1	71.4	0.0	0.0	0.0	0.0	0.0	0.0
93.0	28.5	27.6	70.9	0.0	0.0	0.0	0.0	0.0	0.0
94.0	28.5	28.0	70.8	0.0	0.0	0.0	0.0	0.0	0.0
95.0	28.5	28.3	70.6	0.0	0.0	0.0	0.0	0.0	0.0
96.0	28.5	28.5	70.5	0.0	0.0	0.0	0.0	0.0	0.0

Table A.9 The data from experimental in CO_2 absorption by MEA concentration of 0.20, height to diameter ratio of 6.5 and inlet biogas flow rates of 1, 3 and 5 liter/min

time(min)	1.0 lite/min			3.0 lite/min			5.0 lite/min		
	$\%C_{CO2i}$	$\%C_{CO2o}$	$\%C_{CH4}$	$\%C_{CO2i}$	$\%C_{CO2o}$	$\%C_{CH4}$	$\%C_{CO2i}$	$\%C_{CO2o}$	$\%C_{CH4}$
0.0	28.5	28.5	70.6	27.5	27.5	71.5	25.9	25.9	73.2
1.0	28.5	2.7	93.4	27.5	2.6	93.5	25.9	3.7	93.3
2.0	28.5	2.7	93.4	27.5	2.6	93.5	25.9	3.7	93.3
3.0	28.5	2.7	93.4	27.5	2.5	93.6	25.9	3.7	93.3
4.0	28.5	2.7	93.4	27.5	2.5	93.6	25.9	3.7	93.3
5.0	28.5	2.7	93.4	27.5	2.5	93.6	25.9	3.6	93.4
6.0	28.5	2.7	93.4	27.5	2.3	93.8	25.9	3.6	93.4
7.0	28.5	2.5	93.6	27.5	2.3	93.8	25.9	3.6	93.4
8.0	28.5	2.5	93.6	27.5	2.3	93.8	25.9	3.6	93.4
9.0	28.5	2.5	93.6	27.5	2.1	94.0	25.9	3.4	93.6
10.0	28.5	2.5	93.6	27.5	1.9	94.2	25.9	3.4	93.6
11.0	28.5	2.5	93.6	27.5	1.9	94.2	25.9	3.4	93.6
12.0	28.5	2.3	93.8	27.5	1.9	94.2	25.9	3.2	93.8
13.0	28.5	2.3	93.8	27.5	1.9	94.2	25.9	3.2	93.8
14.0	28.5	2.1	94.0	27.5	1.9	94.2	25.9	2.9	94.1
15.0	28.5	1.9	94.2	27.5	1.8	94.3	25.9	2.9	94.1
16.0	28.5	1.7	94.4	27.5	1.8	94.3	25.9	2.7	94.3
17.0	28.5	1.6	94.5	27.5	1.9	94.2	25.9	2.8	94.2
18.0	28.5	1.6	94.5	27.5	2.0	94.1	25.9	3.1	93.9
19.0	28.5	1.3	94.8	27.5	2.1	94.0	25.9	3.3	93.7
20.0	28.5	1.3	94.8	27.5	2.6	93.8	25.9	3.8	93.2
21.0	28.5	1.0	95.1	27.5	2.7	93.4	25.9	4.0	93.0
22.0	28.5	1.0	95.1	27.5	2.9	93.3	25.9	4.4	92.6
23.0	28.5	0.7	95.4	27.5	3.2	93.3	25.9	4.9	92.1
24.0	28.5	1.0	95.1	27.5	3.6	93.0	25.9	5.8	91.6
25.0	28.5	0.9	95.2	27.5	4.0	92.7	25.9	7.4	91.0
26.0	28.5	0.9	95.2	27.5	4.2	92.5	25.9	8.5	90.6
27.0	28.5	0.9	95.2	27.5	4.6	92.3	25.9	9.3	90.1
28.0	28.5	0.9	95.2	27.5	4.9	92.1	25.9	10.1	89.6
29.0	28.5	0.9	95.2	27.5	5.3	91.9	25.9	11.1	88.5
30.0	28.5	0.9	95.2	27.5	5.6	91.5	25.9	12.0	87.7
31.0	28.5	0.9	95.2	27.5	5.9	91.2	25.9	13.0	86.9
32.0	28.5	0.9	95.2	27.5	6.5	90.8	25.9	13.9	85.9
33.0	28.5	0.9	95.2	27.5	7.0	90.5	25.9	14.8	85.0
34.0	28.5	0.9	95.2	27.5	7.6	90.2	25.9	15.6	84.0
35.0	28.5	0.9	95.2	27.5	8.1	89.6	25.9	16.9	83.1
36.0	28.5	0.9	95.2	27.5	8.7	89.1	25.9	17.6	82.2
37.0	28.5	1.0	95.1	27.5	9.7	88.5	25.9	18.4	81.4
38.0	28.5	1.2	94.9	27.5	10.4	88.0	25.9	19.7	80.1
39.0	28.5	1.2	94.9	27.5	11.0	87.4	25.9	20.2	79.4
40.0	28.5	1.2	94.9	27.5	12.1	86.4	25.9	20.8	78.6
41.0	28.5	1.5	94.6	27.5	13.1	85.7	25.9	21.5	77.9
42.0	28.5	1.5	94.6	27.5	14.2	85.1	25.9	22.2	77.3
43.0	28.5	1.6	94.5	27.5	15.1	84.0	25.9	22.9	76.8
44.0	28.5	1.8	94.3	27.5	16.0	83.0	25.9	23.9	76.2
45.0	28.5	1.9	94.2	27.5	16.9	81.9	25.9	24.8	75.7
46.0	28.5	2.0	94.1	27.5	18.1	81.0	25.9	25.2	75.1
47.0	28.5	2.1	94.0	27.5	19.1	80.1	25.9	25.4	74.6
48.0	28.5	2.5	93.6	27.5	20.1	79.2	25.9	25.5	73.7
49.0	28.5	2.1	94.0	27.5	21.0	78.0	25.9	25.5	73.5
50.0	28.5	2.4	93.7	27.5	21.8	77.0	25.9	25.7	73.3
51.0	28.5	2.6	93.5	27.5	22.5	76.0	0.0	0.0	0.0
52.0	28.5	2.8	93.3	27.5	23.2	75.1	0.0	0.0	0.0
53.0	28.5	2.9	93.2	27.5	24.0	74.3	0.0	0.0	0.0
54.0	28.5	3.1	93.0	27.5	24.8	73.6	0.0	0.0	0.0
55.0	28.5	3.3	92.8	27.5	25.7	72.9	0.0	0.0	0.0
56.0	28.5	3.5	92.6	27.5	26.4	72.1	0.0	0.0	0.0
57.0	28.5	4.0	92.1	27.5	27.0	71.9	0.0	0.0	0.0
58.0	28.5	3.9	92.2	27.5	27.3	71.5	0.0	0.0	0.0
59.0	28.5	4.1	92.0	0.0	0.0	0.0	0.0	0.0	0.0
60.0	28.5	4.3	91.8	0.0	0.0	0.0	0.0	0.0	0.0
61.0	28.5	4.6	91.5	0.0	0.0	0.0	0.0	0.0	0.0
62.0	28.5	5.1	91.0	0.0	0.0	0.0	0.0	0.0	0.0
63.0	28.5	5.4	90.7	0.0	0.0	0.0	0.0	0.0	0.0
64.0	28.5	5.6	90.5	0.0	0.0	0.0	0.0	0.0	0.0
65.0	28.5	6.0	90.1	0.0	0.0	0.0	0.0	0.0	0.0
66.0	28.5	6.5	89.6	0.0	0.0	0.0	0.0	0.0	0.0
67.0	28.5	6.8	89.3	0.0	0.0	0.0	0.0	0.0	0.0

time(min)	1.0 lite/min			3.0 lite/min			5.0 lite/min		
	$\%C_{CO2i}$	$\%C_{CO2o}$	$\%C_{CH4}$	$\%C_{CO2i}$	$\%C_{CO2o}$	$\%C_{CH4}$	$\%C_{CO2i}$	$\%C_{CO2o}$	$\%C_{CH4}$
68.0	28.5	7.3	88.8	0.0	0.0	0.0	0.0	0.0	0.0
69.0	28.5	7.7	88.4	0.0	0.0	0.0	0.0	0.0	0.0
70.0	28.5	8.3	88.1	0.0	0.0	0.0	0.0	0.0	0.0
71.0	28.5	8.8	87.8	0.0	0.0	0.0	0.0	0.0	0.0
72.0	28.5	9.2	87.3	0.0	0.0	0.0	0.0	0.0	0.0
73.0	28.5	9.7	86.9	0.0	0.0	0.0	0.0	0.0	0.0
74.0	28.5	10.1	86.4	0.0	0.0	0.0	0.0	0.0	0.0
75.0	28.5	10.4	86.0	0.0	0.0	0.0	0.0	0.0	0.0
76.0	28.5	11.0	85.7	0.0	0.0	0.0	0.0	0.0	0.0
77.0	28.5	11.7	85.1	0.0	0.0	0.0	0.0	0.0	0.0
78.0	28.5	12.0	84.4	0.0	0.0	0.0	0.0	0.0	0.0
79.0	28.5	12.8	84.2	0.0	0.0	0.0	0.0	0.0	0.0
80.0	28.5	13.8	83.5	0.0	0.0	0.0	0.0	0.0	0.0
81.0	28.5	14.8	82.9	0.0	0.0	0.0	0.0	0.0	0.0
82.0	28.5	15.4	82.6	0.0	0.0	0.0	0.0	0.0	0.0
83.0	28.5	16.5	82.1	0.0	0.0	0.0	0.0	0.0	0.0
84.0	28.5	17.2	81.5	0.0	0.0	0.0	0.0	0.0	0.0
85.0	28.5	18.0	81.3	0.0	0.0	0.0	0.0	0.0	0.0
86.0	28.5	18.6	81.0	0.0	0.0	0.0	0.0	0.0	0.0
87.0	28.5	19.0	80.2	0.0	0.0	0.0	0.0	0.0	0.0
88.0	28.5	19.6	79.5	0.0	0.0	0.0	0.0	0.0	0.0
89.0	28.5	20.2	78.9	0.0	0.0	0.0	0.0	0.0	0.0
90.0	28.5	21.0	78.0	0.0	0.0	0.0	0.0	0.0	0.0
91.0	28.5	22.0	77.6	0.0	0.0	0.0	0.0	0.0	0.0
92.0	28.5	22.9	76.9	0.0	0.0	0.0	0.0	0.0	0.0
93.0	28.5	23.8	76.1	0.0	0.0	0.0	0.0	0.0	0.0
94.0	28.5	24.6	75.1	0.0	0.0	0.0	0.0	0.0	0.0
95.0	28.5	25.6	74.7	0.0	0.0	0.0	0.0	0.0	0.0
96.0	28.5	26.2	73.5	0.0	0.0	0.0	0.0	0.0	0.0
97.0	28.5	26.9	72.4	0.0	0.0	0.0	0.0	0.0	0.0
98.0	28.5	27.7	71.5	0.0	0.0	0.0	0.0	0.0	0.0
99.0	28.5	28.2	71.0	0.0	0.0	0.0	0.0	0.0	0.0
100.0	28.5	28.4	70.6	0.0	0.0	0.0	0.0	0.0	0.0

The experimental data for Used MEA Solution Regeneration

Table A.10 The pH of used solution regeneration in 1st time.

Time	Heating without ultrasonic wave method					Heating with ultrasonic wave method				
	98°C	90°C	80°C	70°C	60°C	50°C	90°C	80°C	70°C	60°C
0.0	7.7	7.6	7.6	7.6	7.5	7.5	7.6	7.6	7.7	7.6
3.0	7.9	7.9	7.9	7.9	7.8	7.7	7.9	7.9	7.9	7.8
6.0	8.2	8.1	8.1	8.1	8.0	7.8	8.3	8.3	8.3	7.9
9.0	8.3	8.5	8.5	8.4	8.2	7.9	8.5	8.5	8.5	8.0
12.0	8.5	8.5	8.5	8.5	8.5	8.0	8.7	8.5	8.6	8.3
15.0	8.8	8.6	8.6	8.5	8.6	8.0	8.9	8.7	8.7	8.4
18.0	9.0	8.8	8.6	8.5	8.6	8.0	9.0	8.9	8.8	8.5
21.0	9.3	9.0	8.8	8.6	8.6	8.0	9.1	9.0	8.8	8.4
24.0	9.6	9.1	8.9	8.6	8.6	8.1	9.2	9.2	8.8	8.5
27.0	9.8	9.3	9.1	8.7	8.6	8.1	9.3	9.3	8.8	8.5
30.0	9.9	9.4	9.2	8.7	8.6	8.1	9.5	9.4	8.8	8.5
33.0	10.0	9.5	9.3	8.7	8.6	8.2	9.6	9.5	8.8	8.4
36.0	10.0	9.5	9.3	8.7	8.6	8.2	9.7	9.6	8.8	8.6
39.0	10.1	9.6	9.3	8.7	8.6	8.3	9.7	9.6	8.9	8.6
42.0	10.2	9.6	9.3	8.7	8.6	8.2	9.9	9.7	8.9	8.6
45.0	10.3	9.6	9.3	8.7	8.6	8.2	9.9	9.7	8.9	8.6
48.0	10.3	9.7	9.3	8.7	8.6	8.3	10.0	9.8	8.9	8.6
51.0	10.3	9.7	9.3	8.7	8.6	8.3	10.0	9.8	9.0	8.7
54.0	10.3	9.7	9.3	8.7	8.6	8.3	10.0	9.8	9.0	8.6
57.0	10.3	9.7	9.3	8.7	8.6	8.3	10.1	9.8	9.0	8.6
60.0	10.3	9.7	9.3	8.7	8.6	8.3	10.1	9.9	9.0	8.7
63.0	10.3	9.7	9.3	8.7	8.6	8.3	10.1	9.9	9.0	8.7
66.0	10.3	9.8	9.4	8.7	8.6	8.3	10.2	10.0	9.1	8.7
69.0	10.3	9.8	9.4	8.7	8.6	8.3	10.2	10.0	9.1	8.7
72.0	10.3	9.8	9.4	8.7	8.6	8.3	10.2	10.0	9.1	8.7
75.0	10.3	9.8	9.4	8.7	8.6	8.3	10.2	10.0	9.1	8.7

Table A.11 The data from experimental in 1st, 2nd and 3rd CO_2 absorption by fresh and reused MEA solution at height to diameter ratio of 6.5 and inlet biogas flow rates of 5 liter/min; Regeneration by 98ºC Heating

time(min)	1st				2nd				3rd			
	pH	$\%C_{CO2i}$	$\%C_{CO2o}$	$\%C_{CH4}$	pH	$\%C_{CO2i}$	$\%C_{CO2o}$	$\%C_{CH4}$	pH	$\%C_{CO2i}$	$\%C_{CO2o}$	$\%C_{CH4}$
0.0	10.9	19.5	19.5	78.0	10.3	19.5	19.5	78.0	10.2	19.5	19.5	78.0
1.0		19.5	0.6	92.4		19.5	0.6	92.4		19.5	0.8	92.2
2.0	10.5	19.5	0.6	92.4	9.9	19.5	0.6	92.4	9.8	19.5	0.8	92.2
3.0		19.5	0.6	92.4		19.5	0.6	92.4		19.5	0.9	92.1
4.0	10.3	19.5	0.6	92.4	9.6	19.5	0.6	92.4	9.5	19.5	0.9	92.1
5.0		19.5	0.6	92.4		19.5	0.6	92.4		19.5	0.9	92.1
6.0	10.0	19.5	0.6	92.4	9.3	19.5	0.6	92.4	9.1	19.5	1.1	91.9
7.0		19.5	0.6	92.4		19.5	0.6	92.4		19.5	1.3	91.7
8.0	9.9	19.5	0.6	92.4	9.1	19.5	0.9	92.1	8.7	19.5	1.5	91.5
9.0		19.5	0.6	92.4		19.5	0.9	92.1		19.5	2.0	91.0
10.0	9.7	19.5	0.6	92.4	8.9	19.5	0.9	92.1	8.5	19.5	2.3	90.7
11.0		19.5	0.6	92.4		19.5	0.9	92.1		19.5	2.5	90.5
12.0	9.5	19.5	0.5	92.5	8.7	19.5	1.5	91.5	8.4	19.5	3.0	90.0
13.0		19.5	0.5	92.5		19.5	1.7	91.3		19.5	3.8	89.2
14.0	9.4	19.5	0.5	92.5	8.5	19.5	2.0	91.0	8.3	19.5	4.1	88.9
15.0		19.5	0.5	92.5		19.5	2.0	91.0		19.5	5.0	88.0
16.0	9.2	19.5	0.5	92.5	8.4	19.5	2.4	90.6	8.0	19.5	6.5	86.5
17.0		19.5	0.5	92.5		19.5	2.7	90.3		19.5	8.2	84.8
18.0	9.1	19.5	0.5	92.5	8.3	19.5	3.4	89.6	7.7	19.5	9.5	83.5
19.0		19.5	0.6	92.4		19.5	4.5	88.5		19.5	10.7	82.3
20.0	9.0	19.5	0.6	92.4	8.0	19.5	5.3	87.7	7.6	19.5	12.0	81.4
21.0		19.5	0.6	92.4		19.5	6.1	86.9		19.5	13.5	80.5
22.0	8.9	19.5	0.6	92.4	7.8	19.5	7.5	85.5	7.6	19.5	14.6	79.9
23.0		19.5	0.6	92.4		19.5	8.6	84.4		19.5	15.0	79.8
24.0	8.8	19.5	0.7	92.3	7.7	19.5	9.7	83.3				
25.0		19.5	0.7	92.3		19.5	10.8	82.2				
26.0	8.8	19.5	0.7	92.3	7.7	19.5	12.0	81.0				
27.0		19.5	0.8	92.2		19.5	12.9	80.1				
28.0	8.7	19.5	0.8	92.2	7.6	19.5	13.8	79.2				
29.0		19.5	0.9	92.1		19.5	14.4	78.6				
30.0	8.6	19.5	1.4	91.6	7.6	19.5	14.8	78.2				
31.0		19.5	2.0	91.0		19.5	14.9	78.1				
32.0	8.5	19.5	2.4	90.6	7.6	19.5	15.0	78.0				
33.0		19.5	2.9	90.1								
34.0	8.4	19.5	3.4	89.6								
35.0		19.5	4.5	88.5								
36.0	8.3	19.5	5.3	87.7								
37.0		19.5	6.1	86.9								
38.0	8.1	19.5	7.1	85.9								
39.0		19.5	8.0	85.0								
40.0	8.0	19.5	9.0	84.0								
41.0		19.5	9.9	83.1								
42.0	7.9	19.5	10.8	82.2								
43.0		19.5	11.6	81.4								
44.0	7.7	19.5	12.9	80.1								
45.0		19.5	13.6	79.4								
46.0	7.7	19.5	14.6	78.6								
47.0		19.5	14.9	77.9								
48.0		19.5	15.0	78.0								

Table A.12 The data from experimental in 1st, 2nd and 3rd CO_2 absorption by fresh and reused MEA solution at height to diameter ratio of 6.5 and inlet biogas flow rates of 5 liter/min; Regeneration by 90ºC Heating with 20 kHz ultrasonic wave

Time	1st				2nd				3rd			
(min)	pH	$\%C_{CO2i}$	$\%C_{CO2o}$	$\%C_{CH4}$	pH	$\%C_{CO2i}$	$\%C_{CO2o}$	$\%C_{CH4}$	pH	$\%C_{CO2i}$	$\%C_{CO2o}$	$\%C_{CH4}$
0.0	11.0	19.5	19.5	78.0	10.2	19.5	19.5	78.0	10.1	19.5	19.5	78.0
1.0		19.5	0.8	92.2		19.5	0.9	92.1		19.5	1.1	91.9
2.0	10.5	19.5	0.8	92.2	9.9	19.5	0.9	92.1	9.7	15.0	1.1	91.9
3.0		19.5	0.8	92.2		19.5	0.8	92.2		15.0	1.1	91.9
4.0	10.2	19.5	0.8	92.2	9.6	19.5	0.8	92.2	9.2	15.0	1.1	91.9
5.0		19.5	0.8	92.2		19.5	0.8	92.2		15.0	1.1	91.9
6.0	9.9	19.5	0.8	92.2	9.2	19.5	0.7	92.3	8.8	15.0	1.2	91.8
7.0		19.5	0.7	92.3		19.5	0.7	92.3		15.0	1.6	91.4
8.0	9.8	19.5	0.7	92.3	8.9	19.5	0.9	92.1	8.6	15.0	1.9	91.1
9.0		19.5	0.7	92.3		19.5	0.9	92.1		15.0	2.3	90.7
10.0	9.6	19.5	0.7	92.3	8.8	19.5	0.9	92.1	8.5	15.0	3.0	90.0
11.0		19.5	0.7	92.3		19.5	0.9	92.1		15.0	4.3	88.7
12.0	9.4	19.5	0.7	92.3	8.6	19.5	1.5	91.5	8.4	15.0	5.0	88.0
13.0		19.5	0.7	92.3		19.5	2.0	91.0		15.0	5.8	87.2
14.0	9.3	19.5	0.7	92.3	8.5	19.5	2.5	90.5	8.2	15.0	6.6	86.4
15.0		19.5	0.7	92.3		19.5	2.8	90.2		15.0	8.0	85.0
16.0	9.1	19.5	0.6	92.4	8.4	19.5	3.5	89.5	8.0	15.0	9.1	83.9
17.0		19.5	0.6	92.4		19.5	3.8	89.2		15.0	9.9	83.1
18.0	9.0	19.5	0.6	92.4	8.3	19.5	4.9	88.1	7.7	15.0	11.0	82.0
19.0		19.5	0.6	92.4		19.5	6.0	87.0		15.0	12.5	80.5
20.0	8.9	19.5	0.6	92.4	8.1	19.5	6.8	86.2	7.6	15.0	13.4	79.6
21.0		19.5	0.6	92.4		19.5	7.6	85.4		15.0	14.3	78.7
22.0	8.9	19.5	0.6	92.4	8.0	19.5	9.0	84.0	7.6	15.0	14.9	78.1
23.0		19.5	0.7	92.3		19.5	10.4	82.6		15.0	15.0	78.0
24.0	8.9	19.5	0.7	92.3	7.8	19.5	11.5	81.5				
25.0		19.5	0.8	92.2		19.5	12.6	80.4				
26.0	8.8	19.5	0.8	92.2	7.6	19.5	13.8	79.2				
27.0		19.5	0.9	92.1		19.5	14.7	78.3				
28.0	8.7	19.5	0.9	92.1	7.6	19.5	15.0	78.0				
29.0		19.5	0.9	92.1								
30.0	8.6	19.5	0.9	92.1								
31.0		19.5	1.5	91.5								
32.0	8.5	19.5	2.0	91.0								
33.0		19.5	2.5	90.5								
34.0	8.4	19.5	2.8	90.2								
35.0		19.5	3.5	89.5								
36.0	8.3	19.5	4.8	88.2								
37.0		19.5	5.6	87.4								
38.0	8.1	19.5	7.4	85.6								
39.0		19.5	8.3	84.7								
40.0	8.0	19.5	9.5	83.5								
41.0		19.5	10.4	82.6								
42.0	7.9	19.5	11.3	81.7								
43.0		19.5	12.1	80.9								
44.0	7.7	19.5	13.4	79.6								
45.0		19.5	13.6	79.4								
46.0	7.6	19.5	14.2	78.8								
47.0		19.5	14.9	78.1								
48.0		19.5	14.8	78.2								

Table A.13 The data from experimental in 1st, 2nd and 3rd CO_2 absorption by fresh and reused MEA solution at height to diameter ratio of 6.5 and inlet biogas flow rates of 5 liter/min; Regeneration by 80ºC Heating with 20 kHz ultrasonic wave

Time	1st				2nd				3rd			
(min)	pH	$\%C_{CO2i}$	$\%C_{CO2o}$	$\%C_{CH4}$	pH	$\%C_{CO2i}$	$\%C_{CO2o}$	$\%C_{CH4}$	pH	$\%C_{CO2i}$	$\%C_{CO2o}$	$\%C_{CH4}$
0.0	11.0	19.5	19.5	78.0	10.0	19.5	19.5	78.0	9.9	19.5	19.5	78.0
1.0		19.5	0.9	92.1		19.5	1.5	91.5		19.5	2.2	90.8
2.0	10.5	19.5	0.9	92.1	9.8	19.5	1.5	91.5	9.6	19.5	2.2	90.8
3.0		19.5	0.9	92.1		19.5	1.5	91.5		19.5	2.4	90.6
4.0	10.2	19.5	0.9	92.1	9.4	19.5	1.3	91.7	9.1	19.5	2.2	90.8
5.0		19.5	0.9	92.1		19.5	1.3	91.7		19.5	2.2	90.8
6.0	9.9	19.5	0.9	92.1	9.1	19.5	1.3	91.7	8.7	19.5	2.2	90.8
7.0		19.5	0.9	92.1		19.5	0.9	92.1		19.5	2.5	90.5
8.0	9.7	19.5	0.9	92.1	8.8	19.5	0.9	92.1	8.5	19.5	2.8	90.2
9.0		19.5	0.9	92.1		19.5	1.5	91.5		19.5	3.5	89.5
10.0	9.5	19.5	0.9	92.1	8.7	19.5	1.5	91.5	8.3	19.5	4.2	88.8
11.0		19.5	0.9	92.1		19.5	2.0	91.0		19.5	5.5	87.5
12.0	9.3	19.5	0.8	92.2	8.6	19.5	2.2	90.8	8.2	19.5	6.2	86.8
13.0		19.5	0.8	92.2		19.5	2.9	90.1		19.5	7.0	86.0
14.0	9.2	19.5	0.8	92.2	8.4	19.5	3.3	89.7	8.0	19.5	7.8	85.2
15.0		19.5	0.8	92.2		19.5	3.7	89.3		19.5	9.3	83.7
16.0	9.1	19.5	0.8	92.2	8.2	19.5	4.7	88.3	7.8	19.5	10.4	82.6
17.0		19.5	0.8	92.2		19.5	5.9	87.1		19.5	10.9	82.1
18.0	9.0	19.5	0.8	92.2	8.1	19.5	7.0	86.0	7.6	19.5	11.7	81.3
19.0		19.5	0.8	92.2		19.5	7.5	85.5		19.5	13.6	79.4
20.0	8.9	19.5	0.8	92.2	8.0	19.5	8.8	84.2	7.6	19.5	14.7	78.3
21.0		19.5	0.8	92.2		19.5	9.6	83.4		19.5	15.2	77.8
22.0	8.9	19.5	0.8	92.2	7.8	19.5	11.1	81.9				
23.0		19.5	0.8	92.2		19.5	12.0	81.0				
24.0	8.8	19.5	0.8	92.2	7.7	19.5	13.0	80.0				
25.0		19.5	0.9	92.1		19.5	14.0	79.0				
26.0	8.7	19.5	0.9	92.1	7.6	19.5	14.5	78.5				
27.0		19.5	0.9	92.1		19.5	15.0	78.0				
28.0	8.6	19.5	0.9	92.1	7.5	19.5	15.0	78.0				
29.0		19.5	1.0	92.0								
30.0	8.5	19.5	1.5	91.5								
31.0		19.5	1.6	91.4								
32.0	8.4	19.5	1.9	91.1								
33.0		19.5	2.4	90.6								
34.0	8.4	19.5	3.0	90.0								
35.0		19.5	3.8	89.2								
36.0	8.3	19.5	4.8	88.2								
37.0		19.5	5.5	87.5								
38.0	8.1	19.5	7.7	85.3								
39.0		19.5	8.9	84.1								
40.0	8.0	19.5	9.5	83.5								
41.0		19.5	10.4	82.6								
42.0	7.9	19.5	11.5	81.5								
43.0		19.5	12.0	81.0								
44.0	7.7	19.5	13.0	80.0								
45.0		19.5	13.5	79.5								
46.0	7.6	19.5	14.3	78.7								

APPENDIX B

The experimental data for 80 % Biomethane Adsorption on Activated Carbons

Gas Composition

Gas	% Concentration	mol fraction
CH_4	79.5	0.59
CO_2	20.5	0.41
O_2	0.0	0.00
Total	100.0	1.00

Activated carbon weight

Item		**Coal**	**Coconut Shell**	
A/C Weight	before degassing	897	1,286	g
A/C Weight	degassing	891	1,282	g

Table B.1 The data from experimental in 80% biomethane adsorption on coal and coconut shell activated carbon at temperature of 10-25°C, Pressure of 0-8 bar.

Coal				Coconut shell			
Temp (°C)	Pressure (MPa)	mmol/$g_{(A/C)}$	g/$g_{(A/C)}$	Temp (°C)	Pressure (MPa)	mmol/$g_{(A/C)}$	g/$g_{(A/C)}$
10.00	0.0000	0.0000	0.0000	10.00	0.0000	0.0000	0.0000
9.50	0.2063	0.4115	0.0089	9.38	0.2263	0.2787	0.0060
9.75	0.4013	0.7253	0.0157	9.18	0.4041	0.4671	0.0101
10.34	0.6013	1.0370	0.0224	10.55	0.6113	0.6812	0.0147
10.00	0.7890	1.3024	0.0282	10.00	0.8304	0.8542	0.0185
15.00	0.0000	0.0000	0.0000	15.00	0.0000	0.0000	0.0000
14.14	0.2218	0.4053	0.0088	15.00	0.2362	0.2768	0.0060
14.14	0.4163	0.7208	0.0156	15.00	0.4203	0.4639	0.0100
14.14	0.6413	1.0207	0.0221	15.04	0.6363	0.6758	0.0146
15.00	0.8641	1.2711	0.0275	15.00	0.8721	0.8446	0.0183
20.00	0.0000	0.0000	0.0000	20.00	0.0000	0.0000	0.0000
20.00	0.2332	0.4018	0.0087	20.00	0.2493	0.2744	0.0059
20.00	0.4432	0.7116	0.0154	20.00	0.4415	0.4591	0.0099
19.98	0.6813	1.0071	0.0218	20.41	0.6813	0.6643	0.0144
20.40	0.8913	1.2656	0.0274	20.10	0.9113	0.8363	0.0181
25.00	0.0000	0.0000	0.0000	25.00	0.0000	0.0000	0.0000
25.14	0.2463	0.3974	0.0086	25.09	0.2638	0.2702	0.0058
24.55	0.4753	0.6991	0.0151	25.00	0.4713	0.4514	0.0098
24.36	0.7263	0.9899	0.0214	24.11	0.7263	0.6518	0.0141
25.00	0.9163	1.2602	0.0273	25.00	0.9513	0.8278	0.0179

The experimental data for 90 % Biomethane Adsorption on Activated Carbons

Gas Composition

Gas	% Concentration	mol fraction
CH_4	90.0	0.77
CO_2	10.0	0.23
O_2	0.0	0.00
Total	100.0	1.00

Activated carbon weight

Item		**Coal**	**Coconut Shell**	
A/C Weight	before degassing	947	1,400	g
A/C Weight	degassing	941	1,396	g

Table B.2 The data from experimental in 90% biomethane adsorption on coal and coconut shell activated carbon at temperature of 10-25ºC, Pressure of 0-8 bar.

Coal				Coconut shell			
Temp (ºC)	Pressure (MPa)	mmol/$g_{(A/C)}$	g/$g_{(A/C)}$	Temp (ºC)	Pressure (MPa)	mmol/$g_{(A/C)}$	g/$g_{(A/C)}$
10.00	0	0	0.0000	10.00	0	0	0
9.75	0.21	0.29	0.0055	10.20	0.21	0.16	0.0030
9.75	0.41	0.53	0.0100	10.80	0.43	0.31	0.0059
10.40	0.60	0.72	0.0136	10.55	0.59	0.41	0.0078
10.20	0.79	0.91	0.0171	9.77	0.79	0.50	0.0094
15.00	0.00	0.00	0.0000	15.00	0.00	0.00	0.0000
15.00	0.22	0.29	0.0054	15.80	0.22	0.16	0.0030
14.80	0.42	0.53	0.0100	15.40	0.45	0.31	0.0058
15.60	0.61	0.72	0.0136	15.40	0.63	0.40	0.0076
15.00	0.85	0.89	0.0168	15.00	0.81	0.50	0.0093
20.00	0.00	0.00	0.0000	20.00	0.00	0.00	0.0000
20.70	0.23	0.29	0.0054	20.10	0.23	0.16	0.0029
19.50	0.45	0.52	0.0098	20.10	0.47	0.31	0.0058
20.70	0.65	0.71	0.0134	20.60	0.66	0.40	0.0075
20.44	0.88	0.88	0.0166	20.00	0.84	0.49	0.0092
25.00	0.00	0.00	0.0000	25.00	0.00	0.00	0.0000
25.20	0.24	0.28	0.0053	25.10	0.24	0.15	0.0029
25.10	0.48	0.51	0.0096	25.80	0.49	0.30	0.0057
24.80	0.68	0.70	0.0132	25.50	0.68	0.39	0.0074
25.00	0.92	0.87	0.0163	25.00	0.89	0.48	0.0091

Table B.3 The data from experimental in 80% biomethane desorption on coal activated carbon at temperature of 25-55°C

Adsorber Temperature (°C)	Desorbed Gas (g)	Gas in Space (g)	Remain gas on AC (g)	% gas Remain on AC	% gas desorption
1st desorption Total gas in Adsorber = 30 g Gas on AC =24.3329 g					
25.0	20.5339	0.9661	8.5000	34.99	65.01
35.4	21.2258	0.9645	7.8097	32.15	67.85
44.9	21.6483	0.9596	7.3921	30.43	69.57
55.0	22.3748	0.9545	6.6707	27.46	72.54
2nd desorption Total gas in Adsorber = 29 g Gas on AC =22.3962 g					
25.5	20.0223	0.9697	8.0080	35.76	64.24
36.5	20.9400	0.9680	7.0920	31.67	68.33
46.0	21.4207	0.9593	6.6200	29.56	70.44
54.3	21.7771	0.9548	6.2681	27.99	72.01
3rd desorption Total gas in Adsorber = 27 g Gas on AC =21.4013 g					
25.5	18.4804	0.9622	7.5574	35.31	64.69
35.0	19.5056	0.9622	6.5322	30.52	69.48
44.0	20.3806	0.9551	5.6643	26.47	73.53
54.8	21.3273	0.9520	4.7207	22.06	77.94

Table B.4 The data from experimental in 80% biomethane desorption on coconut shell activated carbon at temperature of 25-55ºC

Adsorber Temperature (ºC)	Desorbed Gas (g)	Gas in Space (g)	Remain gas on AC (g)	% gas Remain on AC	% gas desorption
1st desorption Total gas in Adsorber = 30 g Gas on AC =22.3962 g					
25.0	17.9142	0.8426	11.2432	37.48	62.52
35.4	18.5177	0.8412	10.6412	35.47	64.53
44.9	18.8861	0.8369	10.2770	34.26	65.74
55.0	19.5197	0.8325	9.6478	32.16	67.84
2nd desorption Total gas in Adsorber = 30 g Gas on AC =22.3962 g					
25.5	17.7096	0.8392	11.4513	38.17	64.24
36.5	18.6808	0.8392	10.4800	34.93	68.33
46.0	19.4011	0.8330	9.7659	32.55	70.44
54.3	19.7943	0.8303	9.3754	31.25	72.01
3rd desorption Total gas in Adsorber = 30 g Gas on AC =22.3961 g					
25.5	17.4540	0.8341	11.7119	39.04	60.96
35.0	18.3918	0.8281	10.7801	35.93	64.07
44.0	19.4496	0.8333	9.7171	32.39	67.61
54.8	21.4591	0.8311	7.7098	25.70	74.30

APPENDIX C

Testing Reports on Surface and Porous Analyses of Coal and Coconut Shell Activated Carbons

ภาควิชาเคมีอุตสาหกรรม คณะวิทยาศาสตร์ มหาวิทยาลัยเชียงใหม่ 50202
INDUSTRIAL CHEMISTRY DEPARTMENT, FACULTY OF SCIENCE, CHIANG MAI UNIVERSITY
Tel. +66-053-943401, 943405 Fax. +66-053-892262

ผลการวิเคราะห์

ตารางที่ 1 ผลการวิเคราะห์พื้นที่ผิวของตัวอย่าง

ตัวอย่าง Sample ID	พื้นที่ผิวจำเพาะ, S (m^2/g), BET Theory	BET C-constant	เอกสาร หมายเลข
1. Coal	1418.18	5.461×10^2	COAL0114.RAW
2. Coconut	1301.14	1.854×10^3	COCO0157.RAW

ตารางที่ 2 ผลการวิเคราะห์รูพรุนของตัวอย่าง

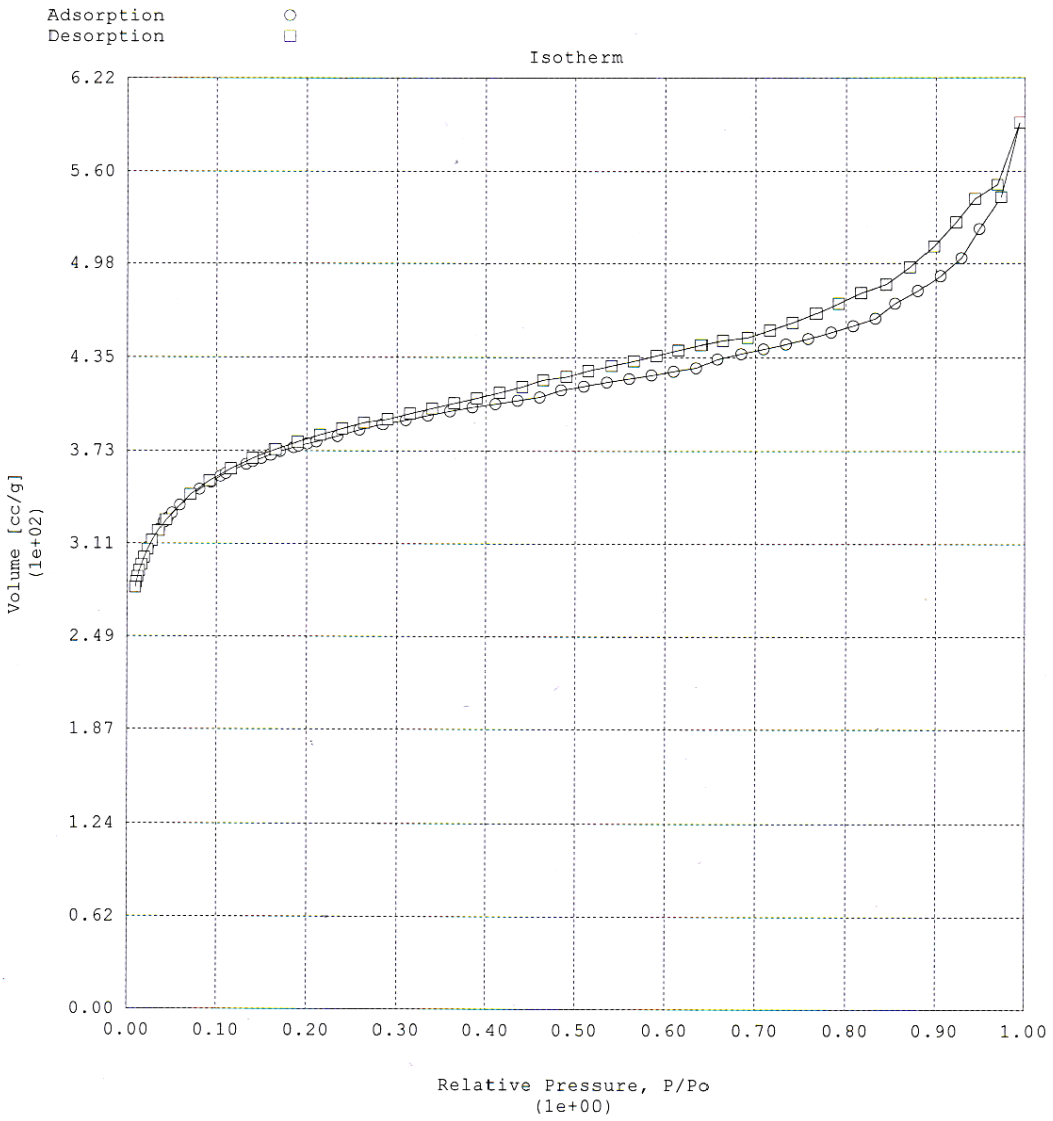
ตัวอย่าง Sample ID	ปริมาตรรูพรุน, V_p, (cc/g)	รัศมีเฉลี่ยของรูพรุน (Å)	รูพรุนมีขนาดรัศมีเล็กกว่า (Å)	เอกสาร หมายเลข
1. Coal	0.916	12.92	1663.1	COAL0114.RAW
2. Coconut	0.585	8.98	15919.2	COCO0157.RAW

ผู้วิเคราะห์

(นางนงคราญ ไชยวงค์)
นักวิทยาศาสตร์ (ชำนาญการพิเศษ)
6 มกราคม 2557

Quantachrome Corporation
Quantachrome Autosorb Automated Gas Sorption System Report
Autosorb for Windows™ Version 1.11

Sample ID	1.Coal				
Description	black pellet - 02-01-57				
Comments					
Sample Weight	0.0296 g				
Adsorbate	Nitrogen	**Outgas Temp**	120.0 °C	**Operator**	Nongkhran
Cross-Sec Area	16.2 Å²/molecule	**Outgas Time**	7.0 hrs	**Analysis Time**	467.1 min
NonIdeality	6.580E-05	**P/Po Toler**	3	**End of Run**	01/01/102 00:15
Molecular Wt	28.0134 g/mol	**Equil Time**	2	**File Name**	COAL0114.RAW
				Station #	1



Quantachrome Corporation
Quantachrome Autosorb Automated Gas Sorption System Report
Autosorb for Windows® Version 1.11

Sample ID	1.Coal				
Description	black pellet - 02-01-57				
Comments					
Sample Weight	0.0296 g				
Adsorbate	Nitrogen	Outgas Temp	120 °C	Operator	Nongkhran
Cross-Sec Area	16.2 Å²/molec	Outgas Time	7.0 hrs	Analysis Time	467.1 min
NonIdeality	6.580E-05	P/Po Toler	3	End of Run	01/01/102 00:15
Molecular Wt	28.0134 g/mol	Equil Time	2	File Name	COAL0114.RAW
Station #	1				

MULTIPOINT BET

P/Po	Volume [cc/g] STP	1/(W((Po/P)-1))
1.0115e-02	284.2094	2.877E-02
2.4219e-02	308.6317	6.434E-02
3.5545e-02	320.4561	9.202E-02
5.0145e-02	331.6892	1.273E-01
5.8987e-02	337.0912	1.488E-01

Area = 1.418E+03 m²/g

Slope = 2.451E+00

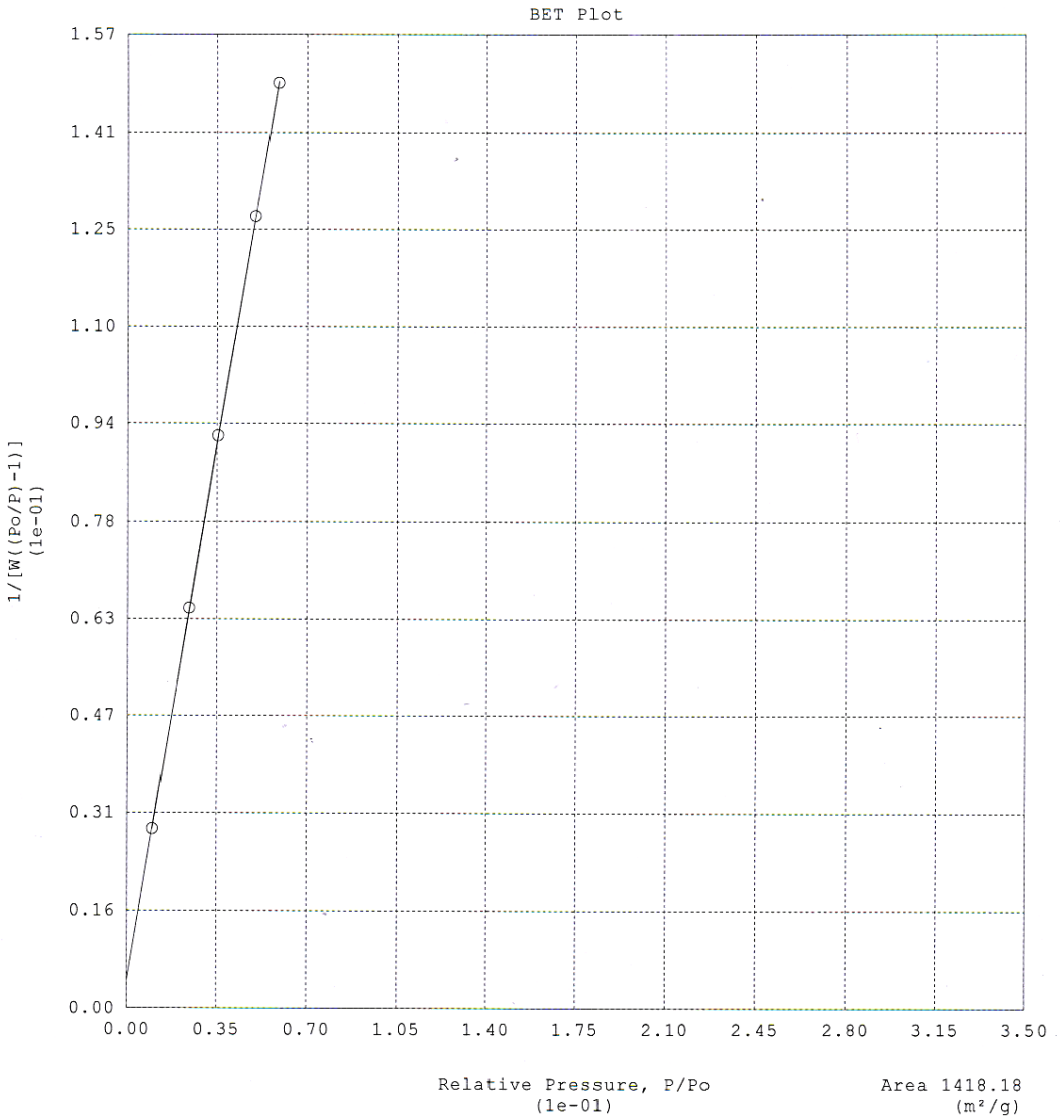
Y - Intercept = 4.497E-03

Correlation Coefficient = 0.999959

C = 5.461E+02

Quantachrome Corporation
Quantachrome Autosorb Automated Gas Sorption System Report
Autosorb for Windows™ Version 1.11

Sample ID	1.Coal				
Description	black pellet - 02-01-57				
Comments					
Sample Weight	0.0296 g				
Adsorbate	Nitrogen	**Outgas Temp**	120.0 °C	**Operator**	Nongkhran
Cross-Sec Area	16.2 Å²/molecule	**Outgas Time**	7.0 hrs	**Analysis Time**	467.1 min
NonIdeality	6.580E-05	**P/Po Toler**	3	**End of Run**	01/01/102 00:15
Molecular Wt	28.0134 g/mol	**Equil Time**	2	**File Name**	COAL0114.RAW
				Station #	1



Quantachrome Corporation
Quantachrome Autosorb Automated Gas Sorption System Report
Autosorb for Windows® Version 1.11

Sample ID	1.Coal				
Description	black pellet - 02-01-57				
Comments					
Sample Weight	0.0296 g				
Adsorbate	Nitrogen	Outgas Temp	120 °C	Operator	Nongkhran
Cross-Sec Area	16.2 Å²/molec	Outgas Time	7.0 hrs	Analysis Time	467.1 min
NonIdeality	6.580E-05	P/Po Toler	3	End of Run	01/01/102 00:15
Molecular Wt	28.0134 g/mol	Equil Time	2	File Name	COAL0114.RAW
Station #	1				

TOTAL PORE VOLUME

Total pore volume = 9.164E-01 cc/g for

pores smaller than 1663.1 Å (Radius),

at P/Po = 0.99421

Quantachrome Corporation
Quantachrome Autosorb Automated Gas Sorption System Report
Autosorb for Windows® Version 1.11

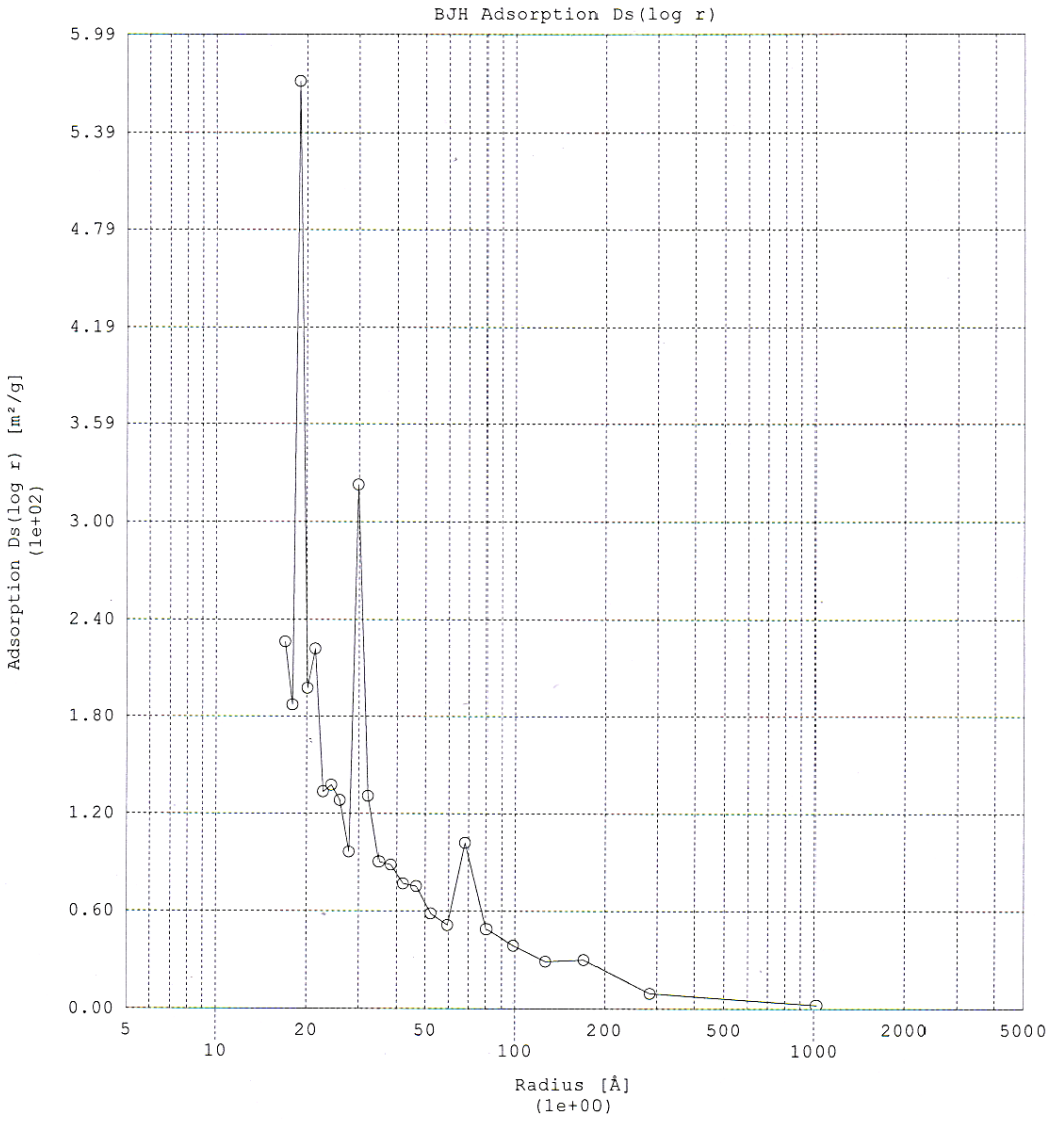
Sample ID	1.Coal				
Description	black pellet - 02-01-57				
Comments					
Sample Weight	0.0296 g				
Adsorbate	Nitrogen	Outgas Temp	120 °C	Operator	Nongkhran
Cross-Sec Area	16.2 Å²/molec	Outgas Time	7.0 hrs	Analysis Time	467.1 min
NonIdeality	6.580E-05	P/Po Toler	3	End of Run	01/01/102 00:15
Molecular Wt	28.0134 g/mol	Equil Time	2	File Name	COAL0114.RAW
Station #	1				

AVERAGE PORE SIZE

Average Pore Radius = 1.292E+01 Å

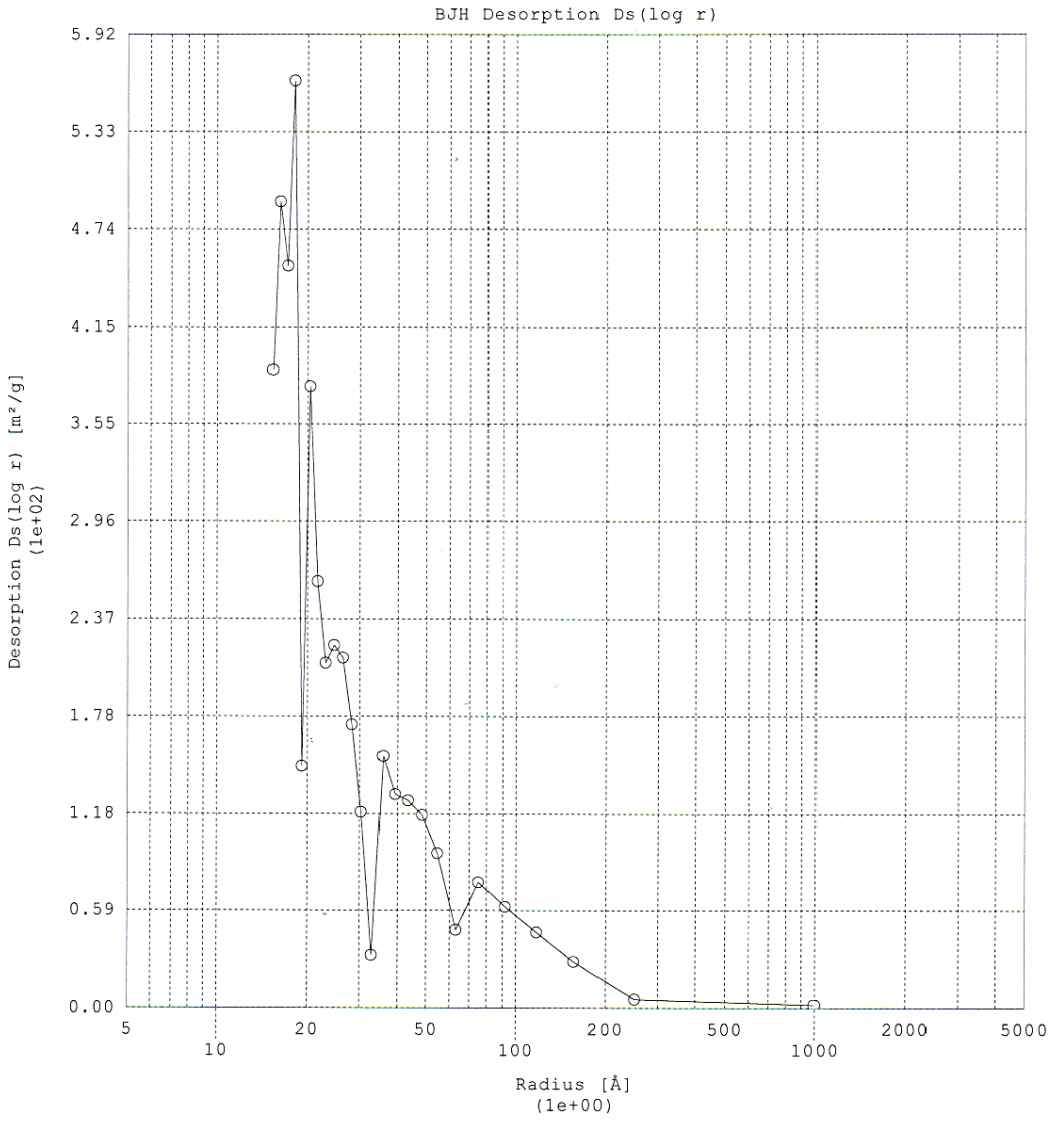
Quantachrome Corporation
Quantachrome Autosorb Automated Gas Sorption System Report
Autosorb for Windows™ Version 1.11

Sample ID	1.Coal				
Description	black pellet - 02-01-57				
Comments					
Sample Weight	0.0296 g				
Adsorbate	Nitrogen	**Outgas Temp**	120.0 °C	**Operator**	Nongkhran
Cross-Sec Area	16.2 Å²/molecule	**Outgas Time**	7.0 hrs	**Analysis Time**	467.1 min
NonIdeality	6.580E-05	**P/Po Toler**	3	**End of Run**	01/01/102 00:15
Molecular Wt	28.0134 g/mol	**Equil Time**	2	**File Name**	COAL0114.RAW
				Station #	1



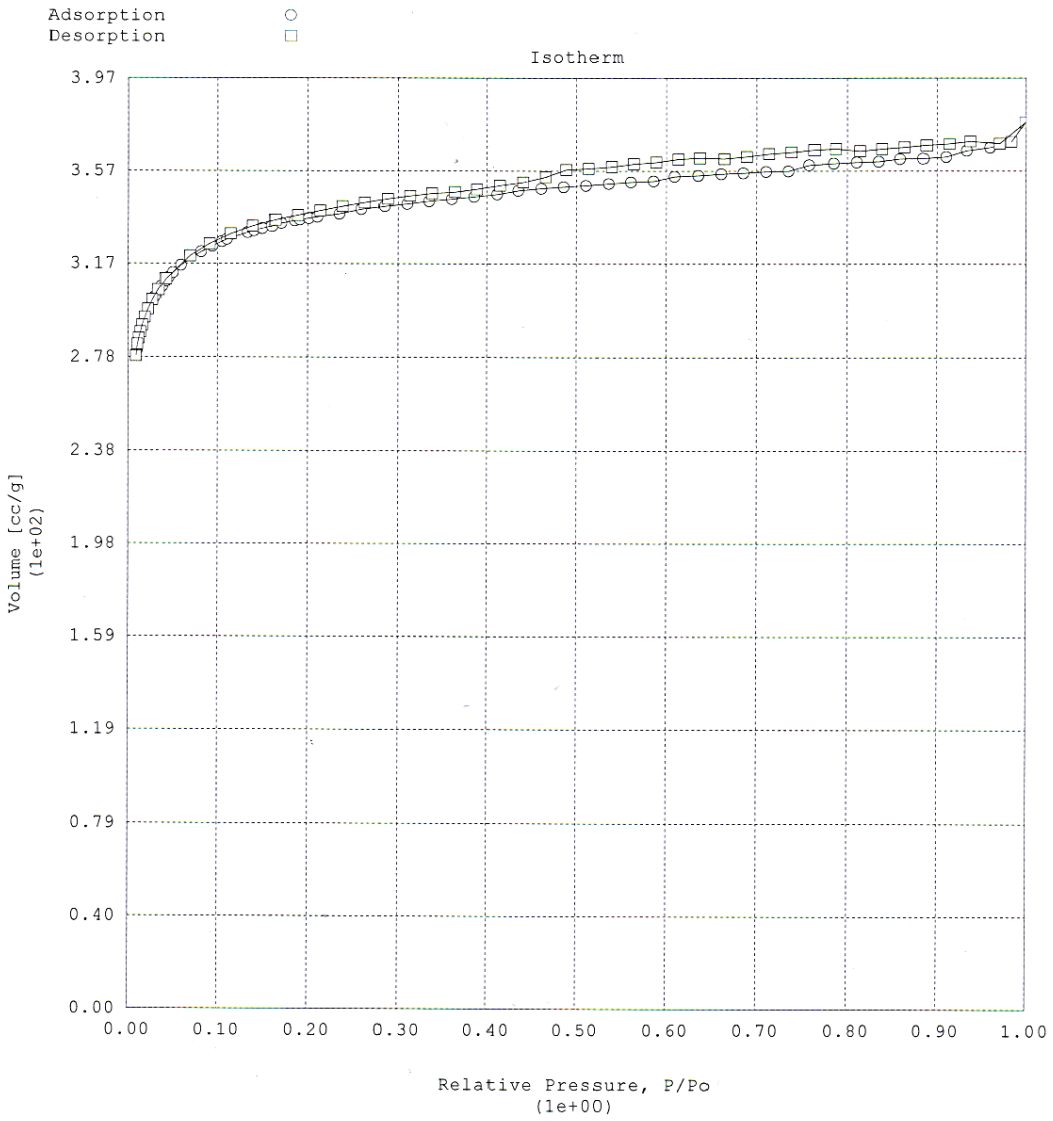
Quantachrome Corporation
Quantachrome Autosorb Automated Gas Sorption System Report
Autosorb for Windows™ Version 1.11

Sample ID	1.Coal				
Description	black pellet - 02-01-57				
Comments					
Sample Weight	0.0296 g				
Adsorbate	Nitrogen	**Outgas Temp**	120.0 °C	**Operator**	Nongkhran
Cross-Sec Area	16.2 Å²/molecule	**Outgas Time**	7.0 hrs	**Analysis Time**	467.1 min
NonIdeality	6.580E-05	**P/Po Toler**	3	**End of Run**	01/01/102 00:15
Molecular Wt	28.0134 g/mol	**Equil Time**	2	**File Name**	COAL0114.RAW
				Station #	1



Quantachrome Corporation
Quantachrome Autosorb Automated Gas Sorption System Report
Autosorb for Windows™ Version 1.11

Sample ID	2.Coconut				
Description	black pellet - 03-01-57				
Comments					
Sample Weight	0.0454 g				
Adsorbate	Nitrogen	**Outgas Temp**	120.0 °C	**Operator**	Nongkhran
Cross-Sec Area	16.2 Å²/molecule	**Outgas Time**	7.0 hrs	**Analysis Time**	447.8 min
NonIdeality	6.580E-05	**P/Po Toler**	3	**End of Run**	01/01/102 07:53
Molecular Wt	28.0134 g/mol	**Equil Time**	2	**File Name**	COCO0157.RAW
				Station #	1



Quantachrome Corporation
Quantachrome Autosorb Automated Gas Sorption System Report
Autosorb for Windows® Version 1.11

Sample ID	2.Coconut				
Description	black pellet - 03-01-57				
Comments					
Sample Weight	0.0454 g				
Adsorbate	Nitrogen	Outgas Temp	120 °C	Operator	Nongkhran
Cross-Sec Area	16.2 Å²/molec	Outgas Time	7.0 hrs	Analysis Time	447.8 min
NonIdeality	6.580E-05	P/Po Toler	3	End of Run	01/01/102 07:53
Molecular Wt	28.0134 g/mol	Equil Time	2	File Name	COCO0157.RAW
Station #	1				

MULTIPOINT BET

P/Po	Volume [cc/g] STP	1/(W((Po/P)-1))
1.0106e-02	280.4207	2.913E-02
3.0338e-02	303.2269	8.256E-02
4.5523e-02	311.5507	1.225E-01
5.9276e-02	316.6366	1.592E-01
8.1940e-02	322.3304	2.216E-01

Area = 1.301E+03 m²/g

Slope = 2.675E+00

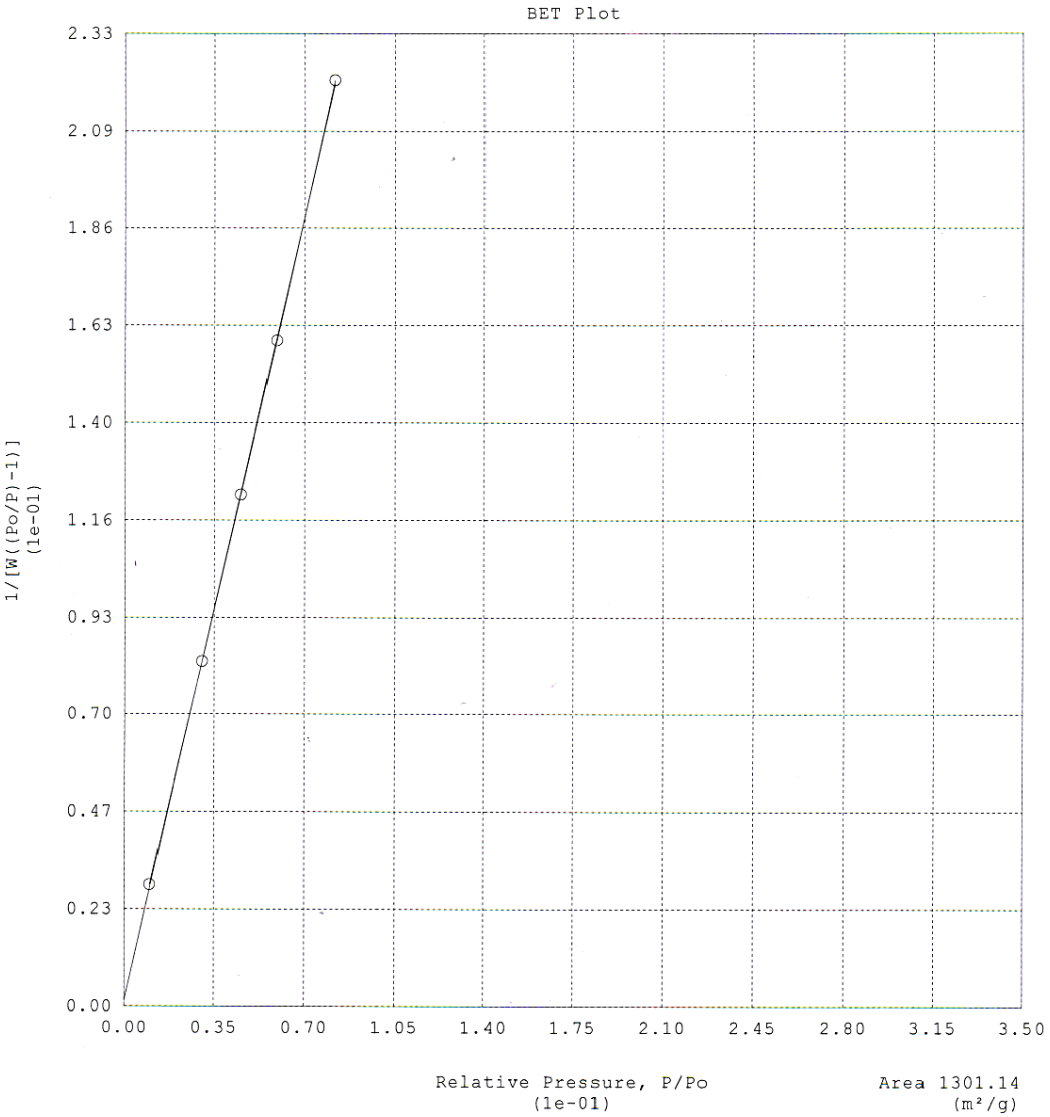
Y - Intercept = 1.443E-03

Correlation Coefficient = 0.999944

C = 1.854E+03

Quantachrome Corporation
Quantachrome Autosorb Automated Gas Sorption System Report
Autosorb for Windows™ Version 1.11

Sample ID	2.Coconut				
Description	black pellet - 03-01-57				
Comments					
Sample Weight	0.0454 g				
Adsorbate	Nitrogen	**Outgas Temp**	120.0 °C	**Operator**	Nongkhran
Cross-Sec Area	16.2 Å²/molecule	**Outgas Time**	7.0 hrs	**Analysis Time**	447.8 min
NonIdeality	6.580E-05	**P/Po Toler**	3	**End of Run**	01/01/102 07:53
Molecular Wt	28.0134 g/mol	**Equil Time**	2	**File Name**	COCO0157.RAW
				Station #	1



Quantachrome Corporation
Quantachrome Autosorb Automated Gas Sorption System Report
Autosorb for Windows® Version 1.11

Sample ID	2.Coconut				
Description	black pellet - 03-01-57				
Comments					
Sample Weight	0.0454 g				
Adsorbate	Nitrogen	Outgas Temp	120 °C	Operator	Nongkhran
Cross-Sec Area	16.2 Å²/molec	Outgas Time	7.0 hrs	Analysis Time	447.8 min
NonIdeality	6.580E-05	P/Po Toler	3	End of Run	01/01/102 07:53
Molecular Wt	28.0134 g/mol	Equil Time	2	File Name	COCO0157.RAW
Station #	1				

TOTAL PORE VOLUME

Total pore volume = 5.845E-01 cc/g for

pores smaller than 15919.2 Å (Radius),

at P/Po = 0.99940

Quantachrome Corporation
Quantachrome Autosorb Automated Gas Sorption System Report
Autosorb for Windows® Version 1.11

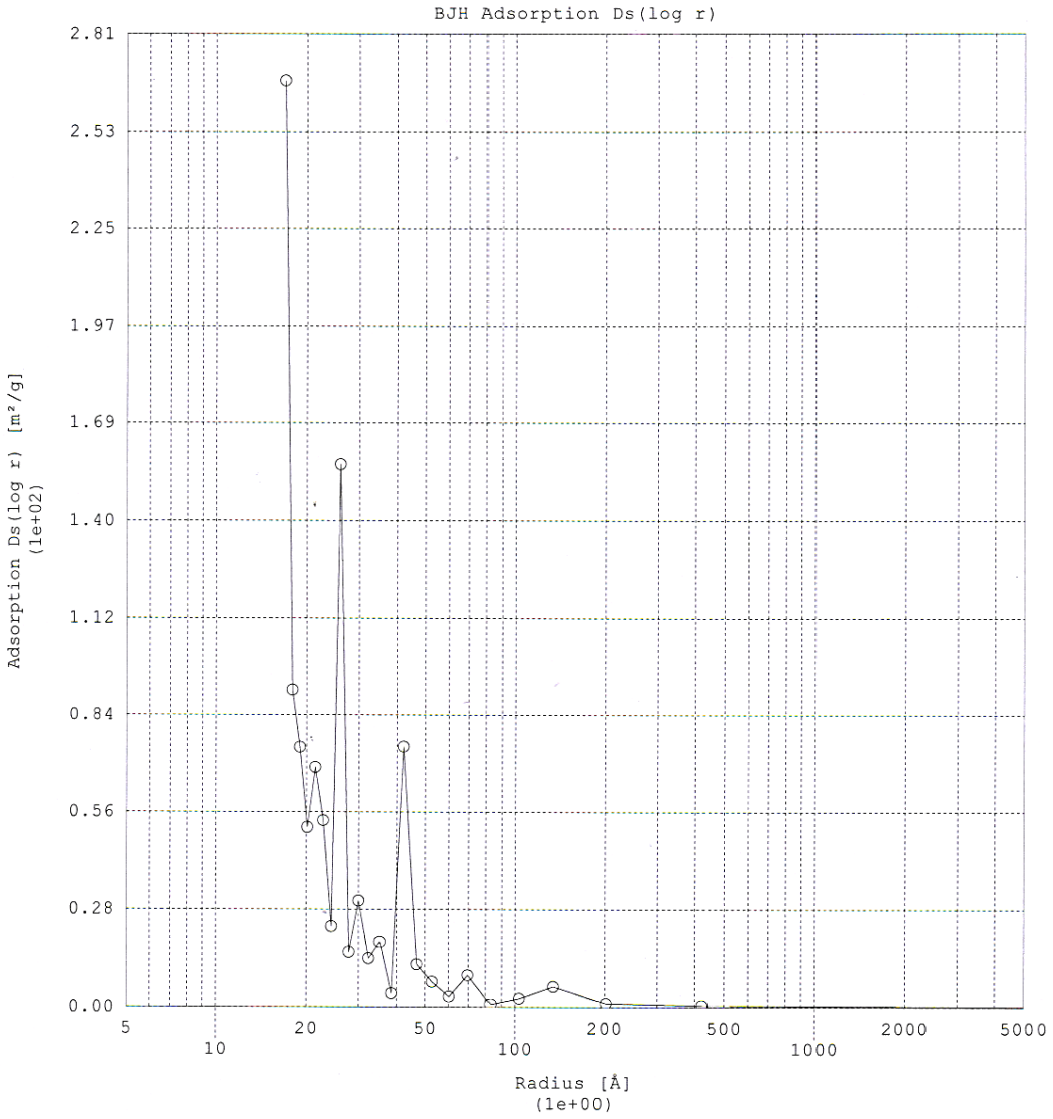
Sample ID	2.Coconut				
Description	black pellet - 03-01-57				
Comments					
Sample Weight	0.0454 g				
Adsorbate	Nitrogen	Outgas Temp	120 °C	Operator	Nongkhran
Cross-Sec Area	16.2 Å²/molec	Outgas Time	7.0 hrs	Analysis Time	447.8 min
NonIdeality	6.580E-05	P/Po Toler	3	End of Run	01/01/102 07:53
Molecular Wt	28.0134 g/mol	Equil Time	2	File Name	COCO0157.RAW
Station #	1				

AVERAGE PORE SIZE

Average Pore Radius = 8.984E+00 Å

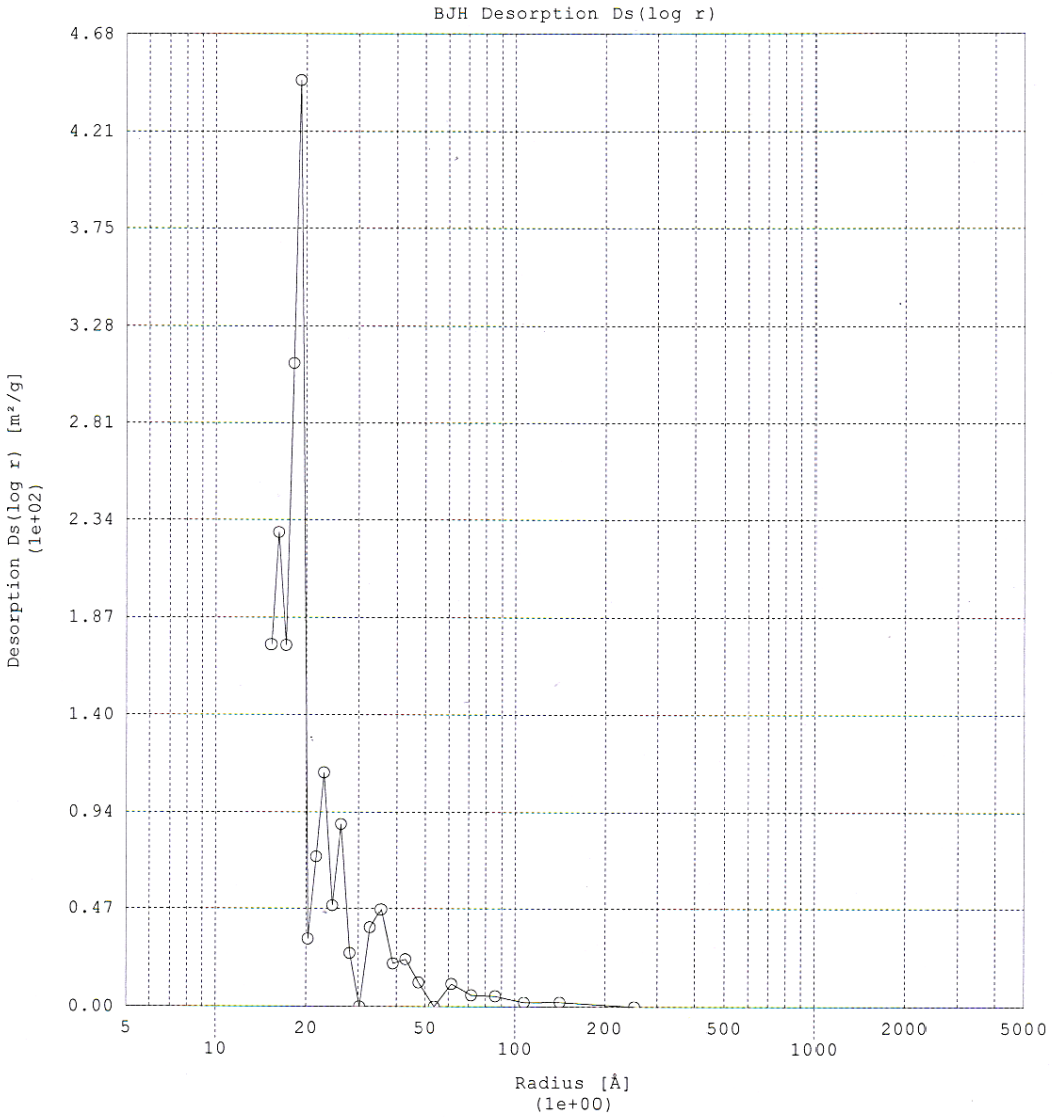
Quantachrome Corporation
Quantachrome Autosorb Automated Gas Sorption System Report
Autosorb for Windows™ Version 1.11

Sample ID	2.Coconut				
Description	black pellet - 03-01-57				
Comments					
Sample Weight	0.0454 g				
Adsorbate	Nitrogen	**Outgas Temp**	120.0 °C	**Operator**	Nongkhran
Cross-Sec Area	16.2 Å²/molecule	**Outgas Time**	7.0 hrs	**Analysis Time**	447.8 min
NonIdeality	6.580E-05	**P/Po Toler**	3	**End of Run**	01/01/102 07:53
Molecular Wt	28.0134 g/mol	**Equil Time**	2	**File Name**	COCO0157.RAW
				Station #	1



Quantachrome Corporation
Quantachrome Autosorb Automated Gas Sorption System Report
Autosorb for Windows™ Version 1.11

Sample ID	2.Coconut				
Description	black pellet - 03-01-57				
Comments					
Sample Weight	0.0454 g				
Adsorbate	Nitrogen	**Outgas Temp**	120.0 °C	**Operator**	Nongkhran
Cross-Sec Area	16.2 Å²/molecule	**Outgas Time**	7.0 hrs	**Analysis Time**	447.8 min
NonIdeality	6.580E-05	**P/Po Toler**	3	**End of Run**	01/01/102 07:53
Molecular Wt	28.0134 g/mol	**Equil Time**	2	**File Name**	COCO0157.RAW
				Station #	1



CURRICULUM VITAE

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