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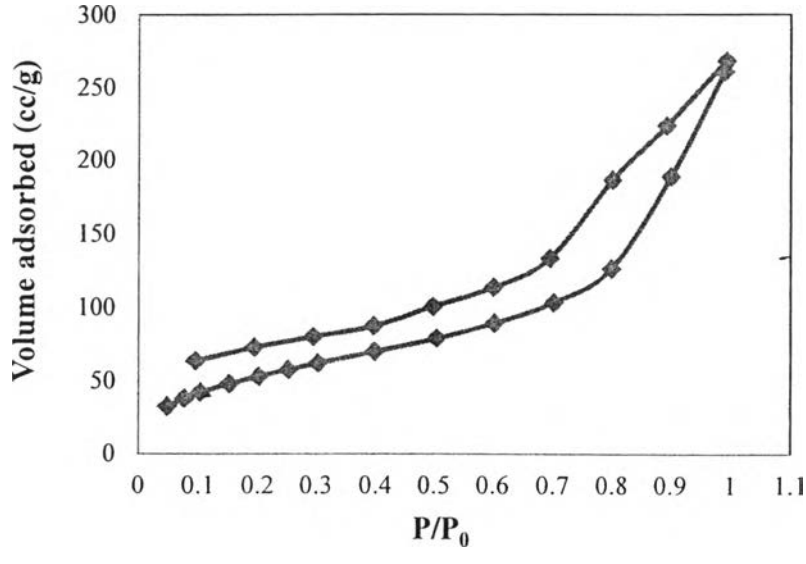
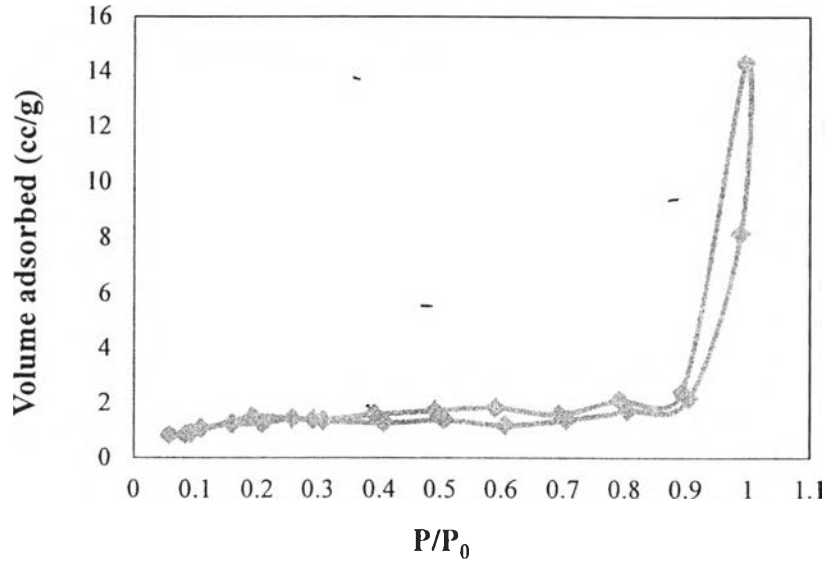
APPENDICES

Appendix A Experimental Data

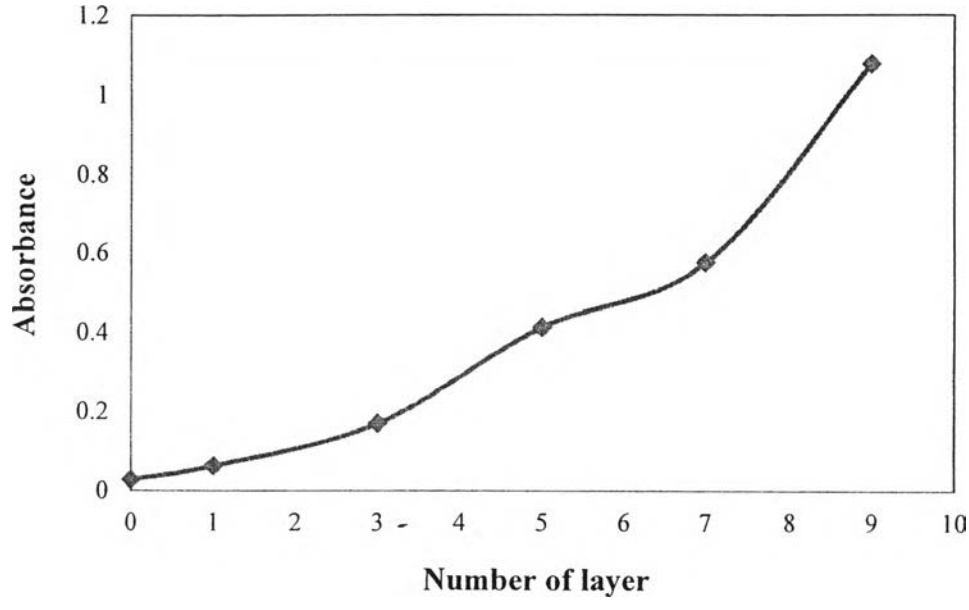


(B)

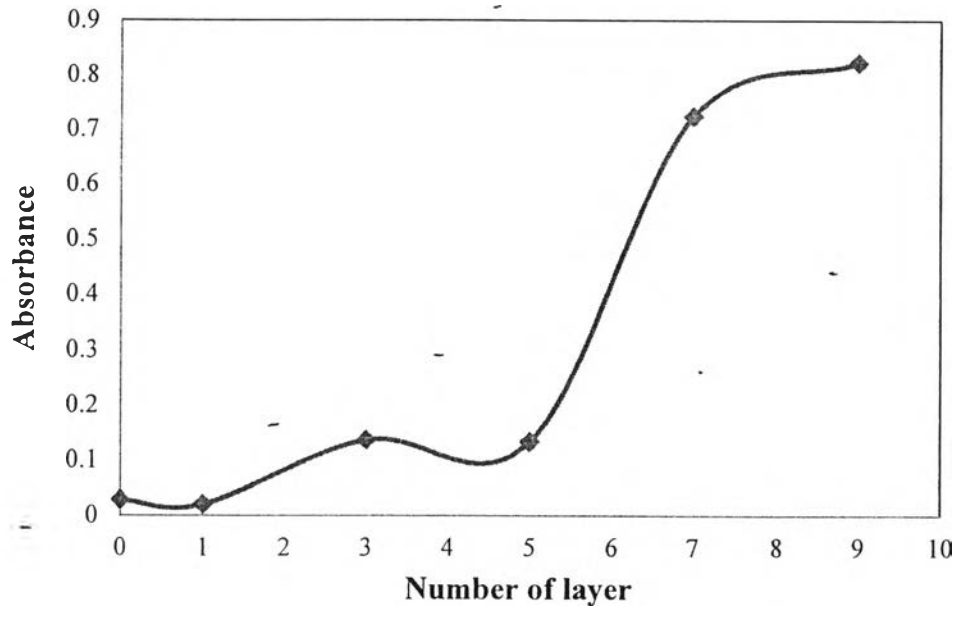


(C)

Figure A1 Nitrogen adsorption/desorption isotherm of polyHIPE in different S/DVB ratio of (A) 20:80 (b) 80:20.

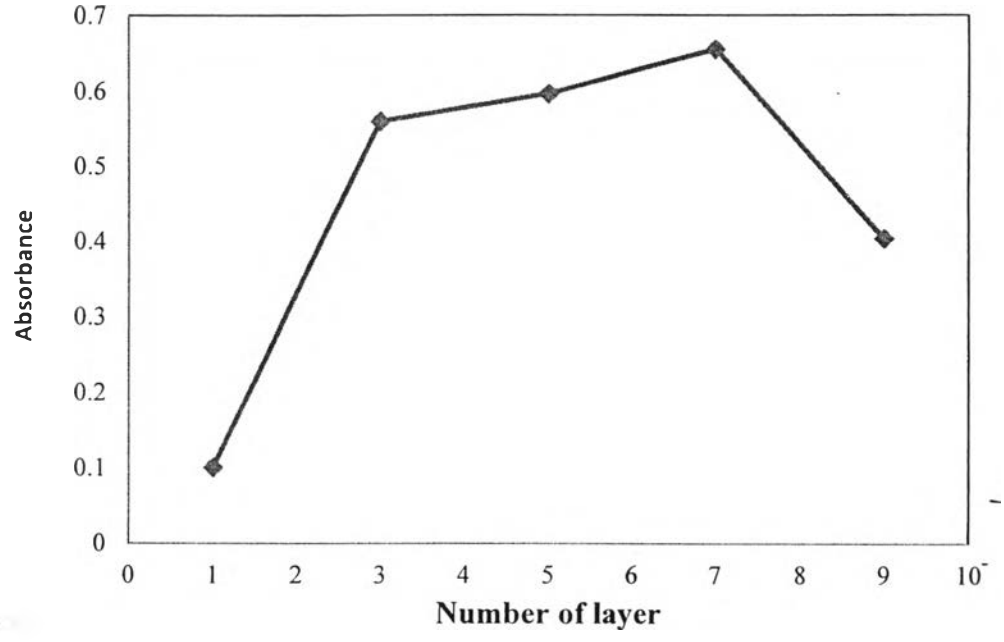


(A)

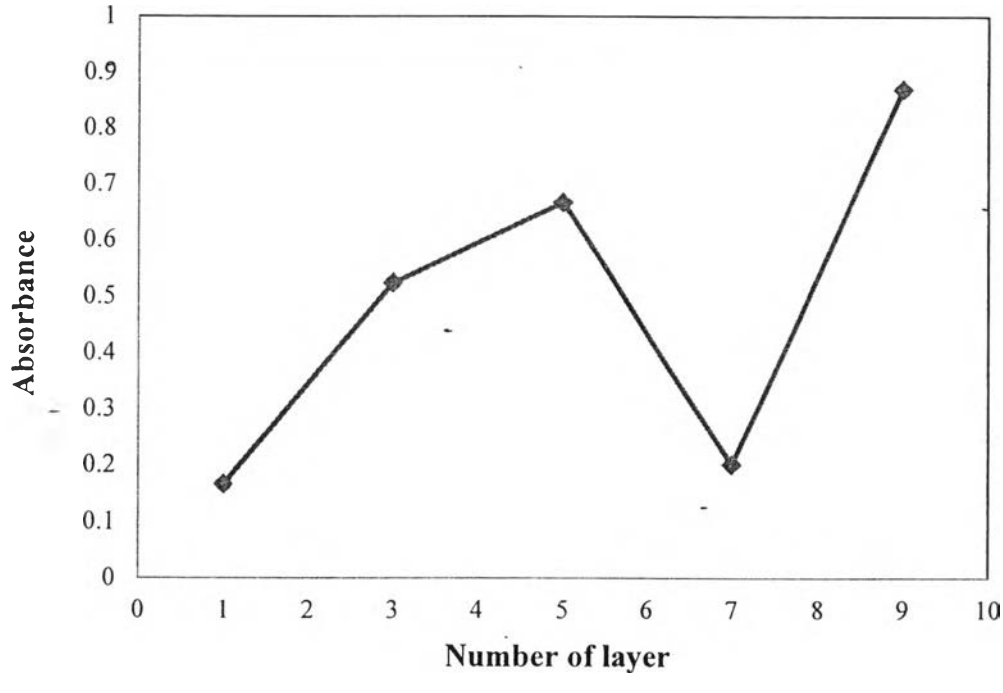


(B)

Figure A2 Absorbance vs number of layer for PDAD/PSS deposited 1.0 M NaCl. (A) S:DVB 20:80, and (B) S:DVB 80:20.



(A)



(B)

Figure A3 Absorbance vs number of layer for PEI/PSS deposited from 1.0 M NaCl. (A) S:DVB 20:80, and (B) S:DVB 80:20.

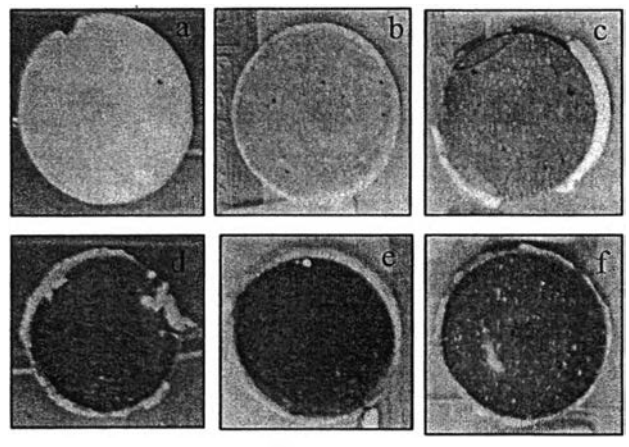


Figure A4 Photograph of polyHIPE coated surface of PDADMAC-PSS on S:DVB 20:80 a) no coating, b) 1 layer, c) 3 layers, d) 5 layers, e) 7 layers and f) 9 layers.

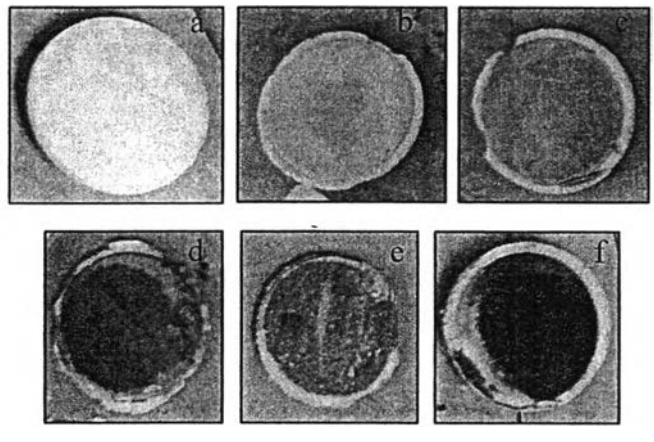


Figure A5 Photograph of polyHIPE coated surface of PDADMAC-PSS on S:DVB 80:20 a) no coating, b) 1 layer, c) 3 layers, d) 5 layers, e) 7 layers and f) 9 layers.

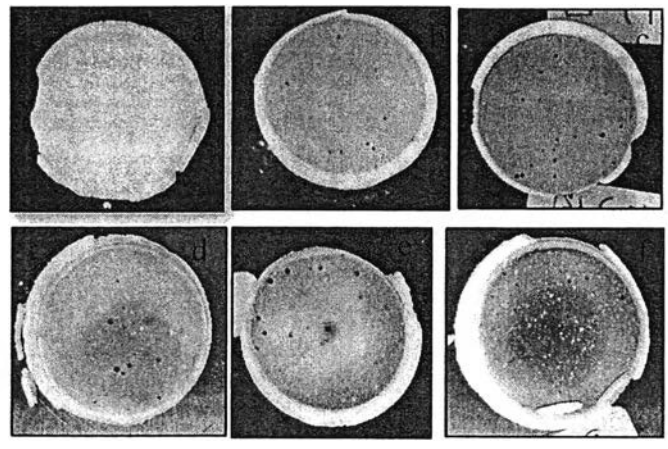


Figure A6 Photograph of polyHIPE coated surface of PEI-PSS on S:DVB 20:80 a) no coating, b) 1 layer, c) 3 layers, d) 5 layers, e) 7 layers and f) 9 layers.

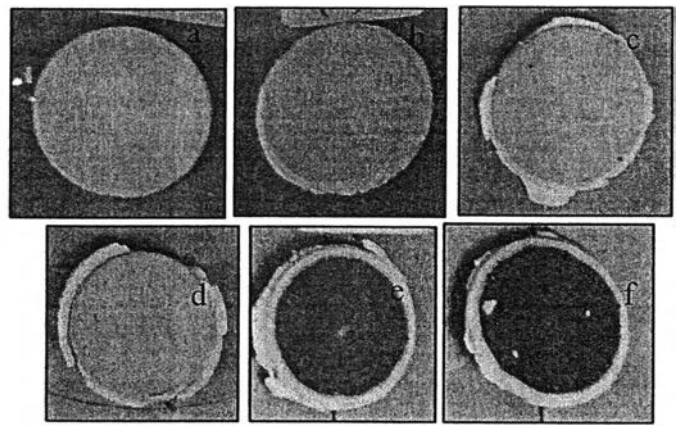


Figure A7 Photograph of polyHIPE coated surface of PEI-PSS on S:DVB 80:20 a) no coating, b) 1 layer, c) 3 layers, d) 5 layers, e) 7 layers and f) 9 layers.

Table A1 **N2** adsorption-desorption isotherm of polyHIPE filled with different S/DVB ratio

S/DVB 0:100		S/DVB 20:80		S/DVB 80:20	
P/P0	**V (cc/g)**	**P/P0**	**V (cc/g)**	**P/P0**	**V (cc/g)**
0.049170	102.7042	0.047756	32.3530	0.057771	0.8359
0.073448	112.0566	0.077125	37.6832	0.083729	0.8514
0.099067	120.5908	0.103036	41.8976	0.108467	1.0828
0.152875	134.9228	0.151164	47.7331	0.158463	1.2400
0.197862	144.1818	0.201537	52.8650	0.208252	1.2577
0.255444	154.4745	0.252398	57.5016	0.258024	1.4362
0.299343	162.0415	0.302401	61.8308	0.308377	1.3566
0.400735	178.6173	0.397361	69.6869	0.407536	1.2752
0.501148	194.9591	0.504069	78.7170	0.507080	1.3779
0.598571	213.0198	0.603011	89.2472	0.606538	1.1938
0.701419	237.0780	0.701426	103.1364	0.705885	1.3888
0.801495	273.1491	0.799098	126.4470	0.805765	1.7086
0.899152	340.3608	0.901053	188.6921	0.905115	2.1572
0.988942	429.2778	0.989815	260.8160	0.987824	8.1359
0.994050	437.2847	0.993377	268.0764	0.995485	14.3136
0.898103	379.9793	0.893464	223.3391	0.894186	2.3895
0.800944	334.8586	0.800819	186.1906	0.791403	2.1120
0.695611	271.8361	0.694873	133.4579	0.692892	1.5930
0.599790	239.7320	0.601373	113.5801	0.591445	1.8231
0.495704	215.6974	0.497758	100.4909	0.491630	1.7145
0.395980	187.1247	0.395944	87.1336	0.391714	1.5785
0.298021	171.9087	0.294303	79.8472	0.292252	1.3924
0.198355	155.1657	0.194042	72.5617	0.191328	1.4995
0.101053	133.5621	0.094773	63.3887	0.091579	0.8812

Table A2 Multipoint BET surface area of polyHIPE filled with different S/DVB ratio

S/DVB 0:100					
P/Po	**cc/g**	**P/Po**	**cc/g**	**P/Po**	**cc/g**
0.053126	89.9761	0.554209	99.8122	0.049409	107.0839
0.073146	97.0405	0.073401	107.3078	0.078992	119.6734
0.098145	103.9566	0.098525	114.6921	0.100175	127.0906
0.152355	115.8470	0.152427	127.7234	0.154451	140.6946
0.204606	124.7348	0.203911	137.7498	0.204691	151.7670
0.254091	132.7867	0.254908	146.2675	0.247764	160.7204
0.304726	140.3355	0.297524	153.4776	0.304937	170.8096

S/DVB 20:80					
P/Po	**cc/g**	**P/Po**	**cc/g**	**P/Po**	**cc/g**
0.051575	71.3933	0.054208	99.8122	0.049185	62.1566
0.073349	78.6975	0.073401	107.3078	0.072230	69.8751
0.099219	85.3908	0.098525	114.6921	0.099734	75.9927
0.015528	95.9271	0.152427	127.7234	0.147323	83.8589
0.198326	103.0635	0.203911	137.7498	0.198547	90.8468
0.248887	109.7385	0.254908	146.2675	0.248699	97.1015
0.298489	116.4373	0.297524	153.4776	0.300135	102.8013

S/DVB 80:20					
P/Po	**cc/g**	**P/Po**	**cc/g**	**P/Po**	**cc/g**
0.057185	1.3117	0.057577	0.9855	0.057185	1.2930
0.083517	1.3959	0.083551	1.0758	0.083517	1.3665
0.10848	1.4773	0.108383	1.2377	0.108489	1.4362
0.158091	1.7845	0.158300	1.3196	0.158091	1.7214
0.208519	1.7462	0.208246	1.4050	0.208519	1.6575
0.257779	2.0249	0.258082	1.5086	0.257779	1.9086
0.308027	2.1171	0.308212	1.3874	0.308027	1.9700

Table A3 Universal testing machine of polyHIPE filled with different S/DVB ratio

S/DVB 0:100						
Speed (mm/min)	**Height (cm)**	**Diameter (cm)**	**Maximum Load (N)**	**Area (mm^2)**	**Compressive stress(MPa)**	**Young's Modulus (MPa)**
1.27	2.54	2.54	221.4359332	506.7074791	0.437009404	9.305792529
1.27	2.54	2.54	112.4616615	506.7074791	0.221945928	5.035658081
1.27	2.54	2.54	130.88062	506.7074791	0.258296207	6.70442771
1.27	2.54	2.54	154.0129533	506.7074791	0.303948451	5.880355061
1.27	2.54	2.54	151.6801148	506.7074791	0.299344535	6.012641163
1.27	2.54	2.54	132.2793733	506.7074791	0.261056682	5.254740583
1.27	2.54	2.54	124.3412143	506.7074791	0.245390525	1.807235871

S/DVB 20:80						
Speed (mm/min)	**Height (cm)**	**Diameter (cm)**	**Maximum Load (N)**	**Area (mm^2)**	**Compressive stress(MPa)**	**Young's Modulus (MPa)**
1.27	2.54	2.54	221.4359332	506.7074791	0.400735755	2.665174
1.27	2.54	2.54	112.4616615	506.7074791	0.254834745	2.283498
1.27	2.54	2.54	130.88062	506.7074791	0.210410333	1.696562
1.27	2.54	2.54	154.0129533	506.7074791	0.3745721	2.48722
1.27	2.54	2.54	151.6801148	506.7074791	0.377539951	2.596242
1.27	2.54	2.54	132.2793733	506.7074791	0.249756077	3.368654

S/DVB 80:20						
Speed (mm/min)	**Height (cm)**	**Diameter (cm)**	**Maximum Load (N)**	**Area (mm^2)**	**Compressive stress(MPa)**	**Young's Modulus (MPa)**
1.27	2.54	2.54	158.4171	506.7074791	0.312640181	5.822527
1.27	2.54	2.54	168.3669	506.7074791	0.332276374	6.1679
1.27	2.54	2.54	145.2284	506.7074791	0.286611924	5.537964
1.27	2.54	2.54	121.9461	506.7074791	0.240663675	5.916287
1.27	2.54	2.54	105.9319	506.7074791	0.209059288	5.73074
1.27	2.54	2.54	152.1405	506.7074791	0.300253156	5.095574

Table A4 Retention time, Area of CO_2 and area of N_2 of polyHIPE filled with different S/DVB ratio

polyHIPE filled different DVB monomer ratio of 0:100 which unmodified and modified the surface.

sample	Area of N_2	Area of CO_2	Re. time of N_2	Re. time of CO_2
0	0	0	0	0
2	609.78	200.12	0.98	1.32
4	610.26	200.94	0.83	1.17
6	608.19	201.75	1	1.32
8	609.01	200.79	0.85	1.17
10	608.15	200.48	1	1.32
12	608.95	201.03	0.87	1.18
14	611.61	200.97	1	1.32
16	608.61	200.77	0.85	1.17
18	608.79	200.4	0.98	1.3
20	611.66	201.05	0.85	1.17
22	609.33	200.55	0.98	1.3
24	608.8	202.66	0.85	1.17
26	609.72	200.19	0.83	1.17
28	608.6	200.3	0.85	1.17
30	610.03	201.99	1	1.32

sample	Area of N_2	Area of CO_2	Re. time of N_2	Re. time of CO_2
0	0	0	0	0
2	762.15	18.73	0.98	1.3
4	602.47	198.3	0.85	1.17
6	605.95	199.42	0.98	1.3
8	605.33	199.25	0.85	1.17
10	610.07	201.14	0.98	1.3
12	610.52	201.91	0.87	1.18
14	609.15	198.96	1	1.32
16	609.3	201.28	0.87	1.2
18	609.63	199.46	0.98	1.32
20	609.41	198.46	0.85	1.18
22	611.2	202.12	0.87	1.18
24	606.33	199.1	0.98	1.3
26	609.45	196.87	0.85	1.17
28	602.58	202.04	0.87	1.2
30	609.18	201.24	0.87	1.18

polyHIPE filled different DVB monomer ratio of 20:80 which unmodified and modified the surface.

sample	Area of N_2	Area of CO_2	Re. time of N_2	Re. time of CO_2
0	0	0	0	0
2	606.75	207.04	0.97	1.28
4	607.4	206.46	0.85	1.17
6	608.99	207.03	0.98	1.3
8	607.55	205.54	0.85	1.17
10	605.14	207.19	0.98	1.3
12	607.54	207.9	0.87	1.18
14	606.42	204.41	0.97	1.28
16	605.66	204.57	0.98	1.32
18	607.12	206.44	0.98	1.3
20	605.22	205.16	0.98	1.3
22	606.83	206.21	0.98	1.32
24	608.94	206.51	0.97	1.28
26	607.04	206.15	0.85	1.17
28	607.33	207.36	0.98	1.3
30	606.08	205.25	0.98	1.3

sample	Area of N_2	Area of CO_2	Re. time of N_2	Re. time of CO_2
0	0	0	0	0
2	648.71	138.81	0.85	1.17
4	596.39	207.22	0.98	1.3
6	590.79	207.77	0.98	1.3
8	591.6	209.03	0.97	1.28
10	593.09	207.78	0.85	1.17
12	592.63	207.1	0.98	1.3
14	592.37	207.92	0.85	1.17
16	592.45	207.47	0.98	1.3
18	586.62	206.02	0.87	1.18
20	592.58	208.32	0.97	1.28
22	593.76	207.84	0.98	1.32
24	590.76	208.06	0.98	1.3
26	591.4	209.28	0.85	1.17
28	589.67	208.16	0.98	1.28
30	589.72	208.19	0.87	1.18

polyHIPE filled different DVB monomer ratio of 80:20 which unmodified and modified the surface.

sample	Area of N_2	Area of CO_2	Re. time of N_2	Re. time of CO_2
0	0	0	0	0
2	593.57	209.22	0.92	1.22
4	591.25	208.62	1.02	1.33
6	591.3	208.62	1.03	1.35
8	591.39	206.87	0.92	1.23
10	593.41	208.15	1.03	1.35
12	593.45	209.2	0.92	1.23
14	588.88	203.42	1.03	1.35
16	592.99	207.25	0.92	1.20
18	591.58	205.84	0.92	1.23
20	593.65	209.58	1.03	1.33
22	591.83	207.07	1.03	1.30
24	593.05	210.79	0.92	1.33
26	592.34	208.59	1.03	1.32
28	592.52	208.42	0.95	1.20
30	590.23	206.69	0.92	1.23

sample	Area of N_2	Area of CO_2	Re. time of N_2	Re. time of CO_2
0	0	0	0	0
2	672.35	195.78	0.97	1.28
4	579.13	204.14	0.83	1.15
6	583.54	203.93	0.98	1.3
8	583.19	208.86	1.03	1.32
10	587.14	207.32	0.95	1.20
12	587.84	205.95	0.92	1.23
14	585.76	205.24	0.92	1.23
16	585.77	206.99	0.93	1.23
18	588.99	209.17	1.02	1.33
20	588.62	207.41	1.03	1.35
22	589.82	206.46	1.03	1.30
24	589.31	208.58	0.92	1.33
26	588.14	209.37	0.92	1.23
28	588.47	208.57	0.93	1.23
30	589.65	209.93	1.02	1.33

Appendix B Fourier Transform Infrared Spectroscopy (FTIR).

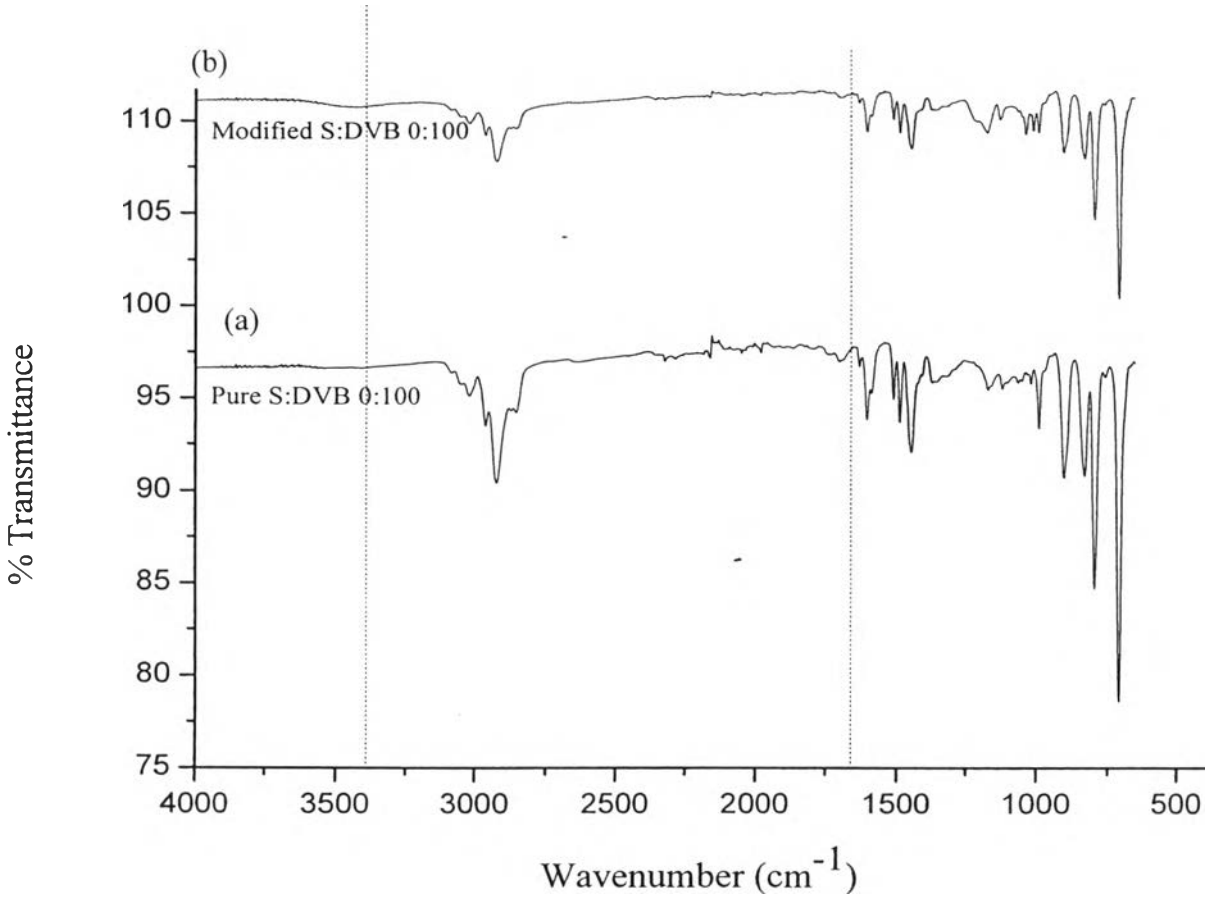


Figure B1 FTIR spectra of polyHIPE filled with different S/DVB monomer ratio of 0/100 before and after modified surface. (a) pure S:DVB 0/100 (b) modified S:DVB 0/100 and the presence of N-H stretching and bending vibrations at 3400 cm^{-1} and 1670 cm^{-1} were observed.

Appendix C Calculation CO_2 adsorption

$$Q_{ads} = \frac{FC_0t_q}{M}$$

$$t_q = \int_0^t (1 - \frac{C}{C_0})dt$$

Q_{abs} = Dynamic adsorption capacity, mol CO_2/mol amine.

C_0 = Concentration of CO_2 entering the reactor, vol%

C = Concentration of CO_2 downstream the reactor, vol%

T_q = Stoichiometric time corresponding to CO_2 stoichiometric adsorption capacity (Min), calculate form Matlab program.

M = Weight of adsorbent, g

F = Total flow rate, mol/min

$$F = \frac{P \times V}{R \times T}$$

P = 1 atm = 101325 Pa

V =Volumne (flow rate = 15 ml/min) ,$15x10^{-6}$ m^3

T = temperature 273+.25 = 298°

R = 8.31451 $Pa \times m^3 \times \frac{1}{K} \times mol$

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Proceeding

1. Chongthub, S.; Pakeyangkoon P.; Dubas T.S.; Malakul, P. and Nithitanakul, M. (2014, April 22) Highly porous material from poly(S/DVB)polyHIPE modified by layer-by-layer surface modification for CO_2 gas adsorption. Proceedings of the 5th Research Symposium on Petrochemical and Materials Technology and the 20th PPC Symposium on Petroleum, Petrochemicals, and Polymers. Bangkok, Thailand.

Presentation

1. Chongthub, S.; Pakeyangkoon P.; Dubas T.S.; Malakul, P. and Nithitanakul, M. (2014, April 22) Development Polymer from Highly Porous Material Poly(S/DVB)polyHIPE Modified by Layer-By-Layer for CO_2 Adsorption Paper present at the 5th Research Symposium on Petrochemical and Materials Technology and the 20th PPC Symposium on Petroleum, Petrochemicals, and Polymers. Bangkok, Thailand.
2. Chongthub, S.; Pakeyangkoon P.; Dubas T.S.; Malakul, P. and Nithitanakul, M. (2014, February 27-28) Polymer Advancement with Poly(High Internal Phase Emulsion) Poly(S/DVB) Modified Via Layer-by-Layer for CO_2 Adsorption. In oral and technical presentration, recognition and appreciation of research contribution to ICCEE 2014 : International conference on Chemical and Engineering, Barcelona, Spain.