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APPENDICES

Appendix A Calculation of Gas Permeation Rate

The permeance or pressure normalized flux of component 'i' is expressed as a thickness normalized permeation rate, $\left(\frac{P}{\delta}\right)_i$. Permeance is expressed in gas permeation unit, GPU, where GPU = $1*10^{-6}$ $cm^3(STP)/cm^2.sec.cmHg$.

$$\left(\frac{P}{\delta}\right)_i = \frac{Q_i \times 14.7 \times 10^6}{(A) \times (\Delta P) \times 76}$$

Where

$\left(\frac{P}{\delta}\right)_i$	=	permeance of gas 'i' (GPU)
P	=	permeability of gas 'i' ($cm^3(STP).cm/cm^2.sec.cmHg$)
δ	=	thickness of membrane (cm)
Q_i	=	volumetric flow rate of gas 'i' (cm^3/sec)
A	=	area of membrane (cm^2)
ΔP	=	pressure different across membrane (psi)

Appendix B Data Experiments

The Experimental Flow Rate of Nitrogen (N_2), Methane (CH_4), Propane (C_3H_8), Propylene (C_3H_6), and Carbon Dioxide (CO_2) of Mixed Matrix Membranes in Performance and Plasticization Study at Room Temperature and at Pressure difference of 50 psi for N_2, 100 psi for CH_4; C_3H_8; and C_3H_6, and in Range of Pressure difference of 25-200 psi for CO_2

Table B1 CA membrane at 1st cycle

Gas	P (psi)	vol. (ml)	time (sec)	Flow rate (ml/sec)	Permeance (GPU)	Average of Permeance (GPU)	STDEV of Permeance
N_2	50	1	96.41	0.0104	0.908	0.900	0.01
		1	97.53	0.0103	0.898		
		1	97.98	0.0102	0.894		
		1	96.82	0.0103	0.904		
		1	98.00	0.0102	0.894		
CH_4	100	1	60.73	0.0165	0.721	0.723	0.01
		1	60.03	0.0167	0.729		
		1	60.41	0.0166	0.725		
		1	60.35	0.0166	0.725		
		1	61.22	0.0163	0.715		
C_3H_8	100	0.25	105.06	0.0024	0.104	0.105	0.00
		0.25	104.79	0.0024	0.104		
		0.25	104.25	0.0024	0.105		
		0.25	105.11	0.0024	0.104		
		0.25	103.40	0.0024	0.106		
C_3H_6	100	0.25	48.39	0.0052	0.226	0.227	0.00
		0.25	48.13	0.0052	0.227		
		0.25	48.58	0.0051	0.225		
		0.25	48.14	0.0052	0.227		
		0.25	48.01	0.0052	0.228		
CO_2	25	10	195.91	0.0510	8.939	8.949	0.05
		10	196.95	0.0508	8.892		
		10	194.12	0.0515	9.022		
		10	194.98	0.0513	8.982		
		10	196.51	0.0509	8.912		
	50	10	89.16	0.1122	9.821	9.847	0.05
		10	88.31	0.1132	9.915		
		10	89.35	0.1119	9.800		
		10	89.26	0.1120	9.810		
		10	88.54	0.1129	9.890		
	75	10	57.68	0.1734	10.121	10.292	0.18
		10	55.26	0.1810	10.564		
		10	56.37	0.1774	10.356		
		10	57.41	0.1742	10.168		
		10	56.95	0.1756	10.250		

Gas	P (psi)	vol. (ml)	time (sec)	Flow rate (ml/sec)	Permeance (GPU)	Average of Permeance (GPU)	STDEV of Permeance
CO_2	100	10	43.37	0.2306	10.095	10.205	0.09
		10	42.97	0.2327	10.189		
		10	42.59	0.2348	10.280		
		10	42.46	0.2355	10.311		
		10	43.13	0.2319	10.151		
	125	10	30.23	0.3308	11.586	11.542	0.08
		10	30.59	0.3269	11.450		
		10	30.13	0.3319	11.625		
		10	30.21	0.3310	11.594		
		10	30.57	0.3271	11.457		
	150	10	23.32	0.4288	12.516	12.456	0.11
		10	23.59	0.4239	12.373		
		10	23.68	0.4223	12.326		
		10	23.15	0.4320	12.608		
		10	23.43	0.4268	12.457		
	175	10	17.59	0.5685	14.223	14.160	0.05
		10	17.68	0.5656	14.150		
		10	17.75	0.5634	14.095		
		10	17.61	0.5679	14.207		
		10	17.71	0.5647	14.127		
	200	10	13.05	0.7663	16.775	16.723	0.03
		10	13.10	0.7634	16.711		
		10	13.09	0.7639	16.723		
		10	13.12	0.7622	16.685		
		10	13.09	0.7639	16.723		

Table B2 CA membrane at 2nd cycle

Gas	P (psi)	vol. (ml)	time (sec)	Flow rate (ml/sec)	Permeance (GPU)	Average of Permeance (GPU)	STDEV of Permeance
N_2	50	1	83.45	0.0120	1.049	1.064	0.01
		1	82.66	0.0121	1.059		
		1	80.90	0.0124	1.082		
		1	83.20	0.0120	1.052		
		1	81.46	0.0123	1.075		
CH_4	100	1	42.32	0.0236	1.035	1.032	0.01
		1	42.01	0.0238	1.042		
		1	42.54	0.0235	1.029		
		1	42.83	0.0233	1.022		
		1	42.50	0.0235	1.030		
C_3H_8	100	0.25	75.92	0.0033	0.144	0.144	0.00
		0.25	76.75	0.0033	0.143		
		0.25	76.35	0.0033	0.143		
		0.25	75.29	0.0033	0.145		
		0.25	76.68	0.0033	0.143		
C_3H_6	100	0.25	39.17	0.0064	0.279	0.279	0.00
		0.25	39.27	0.0064	0.279		
		0.25	39.35	0.0064	0.278		
		0.25	39.10	0.0064	0.280		
		0.25	39.36	0.0064	0.278		

Gas	P (psi)	vol. (ml)	time (sec)	Flow rate (ml/sec)	Permeance (GPU)	Average of Permeance (GPU)	STDEV of Permeance
CO_2	25	10	170.98	0.0585	10.243	10.267	0.07
		10	169.21	0.0591	10.350		
		10	169.60	0.0590	10.326		
		10	171.28	0.0584	10.225		
		10	171.85	0.0582	10.191		
	50	10	82.35	0.1214	10.633	10.546	0.09
		10	83.46	0.1198	10.492		
		10	83.96	0.1191	10.429		
		10	83.17	0.1202	10.528		
		10	82.25	0.1216	10.646		
	75	10	52.19	0.1916	11.185	11.127	0.05
		10	52.26	0.1914	11.170		
		10	52.69	0.1898	11.079		
		10	52.59	0.1902	11.100		
		10	52.58	0.1902	11.102		
	100	10	37.62	0.2658	11.638	11.656	0.08
		10	37.23	0.2686	11.760		
		10	37.37	0.2676	11.716		
		10	37.85	0.2642	11.567		
		10	37.74	0.2650	11.601		
	125	10	26.89	0.3719	13.025	12.987	0.07
		10	26.81	0.3730	13.064		
		10	26.94	0.3712	13.001		
		10	27.05	0.3697	12.948		
		10	27.16	0.3682	12.896		
	150	10	18.65	0.5362	15.650	15.747	0.29
		10	18.98	0.5269	15.378		
		10	18.46	0.5417	15.811		
		10	18.58	0.5382	15.709		
		10	18.03	0.5546	16.188		
	175	10	15.94	0.6274	15.695	16.377	0.39
		10	15.25	0.6557	16.405		
		10	15.14	0.6605	16.524		
		10	15.09	0.6627	16.579		
		10	15.00	0.6667	16.679		
	200	10	12.72	0.7862	17.210	17.424	0.15
		10	12.45	0.8032	17.583		
		10	12.57	0.7955	17.415		
		10	12.60	0.7937	17.374		
		10	12.48	0.8013	17.541		

Table B3 CA membrane at 3rd cycle

Gas	P (psi)	vol. (ml)	time (sec)	Flow rate (ml/sec)	Permeance (GPU)	Average of Permeance (GPU)	STDEV of Permeance
N_2	50	1	64.32	0.0155	1.361	1.360	0.01
		1	64.71	0.0155	1.353		
		1	64.29	0.0156	1.362		
		1	63.95	0.0156	1.369		
		1	64.62	0.0155	1.355		
CH_4	100	1	30.34	0.0330	1.443	1.436	0.01
		1	30.41	0.0329	1.440		
		1	30.67	0.0326	1.428		
		1	30.58	0.0327	1.432		
		1	30.42	0.0329	1.439		
C_3H_8	100	0.25	69.78	0.0036	0.157	0.158	0.00
		0.25	68.66	0.0036	0.159		
		0.25	69.34	0.0036	0.158		
		0.25	69.56	0.0036	0.157		
		0.25	68.98	0.0036	0.159		
C_3H_6	100	0.25	37.50	0.0067	0.292	0.296	0.00
		0.25	36.22	0.0069	0.302		
		0.25	36.79	0.0068	0.298		
		0.25	37.14	0.0067	0.295		
		0.25	37.48	0.0067	0.292		
CO_2	25	10	152.11	0.0657	11.513	11.584	0.08
		10	150.26	0.0666	11.655		
		10	151.37	0.0661	11.569		
		10	152.13	0.0657	11.512		
		10	150.08	0.0666	11.669		
	50	10	75.16	0.1330	11.650	11.524	0.11
		10	75.31	0.1328	11.627		
		10	76.51	0.1307	11.445		
		10	76.20	0.1312	11.491		
		10	76.76	0.1303	11.407		
	75	10	45.11	0.2217	12.941	12.891	0.06
		10	45.02	0.2221	12.967		
		10	45.32	0.2207	12.881		
		10	45.41	0.2202	12.855		
		10	45.56	0.2195	12.813		
	100	10	31.45	0.3180	13.921	13.982	0.05
		10	31.21	0.3204	14.028		
		10	31.41	0.3184	13.939		
		10	31.20	0.3205	14.033		
		10	31.30	0.3195	13.988		
	125	10	22.65	0.4415	15.464	15.511	0.20
		10	22.98	0.4352	15.242		
		10	22.65	0.4415	15.464		
		10	22.45	0.4454	15.601		
		10	22.19	0.4507	15.784		
	150	10	16.94	0.5903	17.230	17.571	0.26
		10	16.27	0.6146	17.940		
		10	16.52	0.6053	17.668		
		10	16.61	0.6020	17.572		
		10	16.73	0.5977	17.446		

Gas	P (psi)	vol. (ml)	time (sec)	Flow rate (ml/sec)	Permeance (GPU)	Average of Permeance (GPU)	STDEV of Permeance
CO_2	175	10	12.75	0.7843	19.622	19.807	0.21
		10	12.52	0.7987	19.982		
		10	12.64	0.7911	19.793		
		10	12.47	0.8019	20.063		
		10	12.78	0.7825	19.576		
	200	10	9.79	1.0215	22.360	22.274	0.12
		10	9.82	1.0183	22.292		
		10	9.77	1.0235	22.406		
		10	9.89	1.0111	22.134		
		10	9.87	1.0132	22.179		

Table B4 CA membrane at 4rd cycle

Gas	P (psi)	vol. (ml)	time (sec)	Flow rate (ml/sec)	Permeance (GPU)	Average of Permeance (GPU)	STDEV of Permeance
N_2	50	1	46.90	0.0213	1.867	1.876	0.01
		1	46.74	0.0214	1.873		
		1	46.49	0.0215	1.883		
		1	46.34	0.0216	1.890		
		1	46.89	0.0213	1.867		
CH_4	100	1	19.25	0.0519	2.274	2.262	0.02
		1	19.11	0.0523	2.291		
		1	19.62	0.0510	2.231		
		1	19.40	0.0515	2.257		
		1	19.39	0.0516	2.258		
C_3H_8	100	0.25	50.81	0.0049	0.215	0.214	0.00
		0.25	51.25	0.0049	0.214		
		0.25	51.33	0.0049	0.213		
		0.25	50.97	0.0049	0.215		
		0.25	51.01	0.0049	0.215		
C_3H_6	100	0.25	33.93	0.0074	0.323	0.323	0.00
		0.25	33.79	0.0074	0.324		
		0.25	33.81	0.0074	0.324		
		0.25	33.96	0.0074	0.322		
		0.25	34.00	0.0074	0.322		
CO_2	25	10	118.31	0.0845	14.802	14.920	0.09
		10	116.88	0.0856	14.983		
		10	117.43	0.0852	14.913		
		10	117.70	0.0850	14.879		
		10	116.58	0.0858	15.022		
	50	10	56.41	0.1773	15.523	15.457	0.06
		10	56.47	0.1771	15.506		
		10	56.90	0.1757	15.389		
		10	56.87	0.1758	15.397		
		10	56.61	0.1766	15.468		
	75	10	35.87	0.2788	16.274	16.323	0.06
		10	35.71	0.2800	16.347		
		10	35.59	0.2810	16.402		
		10	35.74	0.2798	16.333		
		10	35.90	0.2786	16.261		

Gas	P (psi)	vol. (ml)	time (sec)	Flow rate (ml/sec)	Permeance (GPU)	Average of Permeance (GPU)	STDEV of Permeance
CO_2	100	10	23.94	0.4177	18.288	18.356	0.07
		10	23.71	0.4218	18.465		
		10	23.83	0.4196	18.372		
		10	23.88	0.4188	18.334		
		10	23.90	0.4184	18.319		
	125	10	17.91	0.5583	19.556	19.565	0.06
		10	17.95	0.5571	19.513		
		10	17.83	0.5609	19.644		
		10	17.86	0.5599	19.611		
		10	17.96	0.5568	19.502		
	150	10	12.31	0.8123	23.711	23.566	0.12
		10	12.43	0.8045	23.482		
		10	12.35	0.8097	23.634		
		10	12.47	0.8019	23.406		
		10	12.37	0.8084	23.596		
	175	10	9.56	1.0460	26.169	26.403	0.24
		10	9.34	1.0707	26.786		
		10	9.46	1.0571	26.446		
		10	9.49	1.0537	26.363		
		10	9.53	1.0493	26.252		
	200	10	6.75	1.4815	32.431	32.345	0.12
		10	6.74	1.4837	32.479		
		10	6.80	1.4706	32.192		
		10	6.79	1.4728	32.240		
		10	6.76	1.4793	32.383		

Table B5 Selectivity at 100 psi and Slope of CO_2 permeance for CA membrane

	Selectivity		slope of CO_2 permeance's graph
Cycle Order	C_3H_6/C_3H_8	CO_2/CH_4	
1st	2.166	14.113	0.040
2nd	1.941	11.299	0.0450
3nd	1.871	9.735	0.0628
4nd	1.507	8.114	0.0951

Table B6 10%NaA/CA MMM

Gas	P (psi)	vol. (ml)	time (sec)	Flow rate (ml/sec)	Permeance (GPU)	Average of Permeance (GPU)	STDEV of Permeance
N_2	50	0.25	125.69	0.0020	0.174	0.174	0.00
		0.25	125.62	0.0020	0.174		
		0.25	125.93	0.0020	0.174		
		0.25	125.87	0.0020	0.174		
		0.25	125.63	0.0020	0.174		
CH_4	100	0.25	41.72	0.0060	0.262	0.263	0.00
		0.25	41.38	0.0060	0.265		
		0.25	41.51	0.0060	0.264		
		0.25	41.48	0.0060	0.264		
		0.25	41.69	0.0060	0.263		

Gas	P (psi)	vol. (ml)	time (sec)	Flow rate (ml/sec)	Permeance (GPU)	Average of Permeance (GPU)	STDEV of Permeance
C_3H_8	100	0.25	110.97	0.0023	0.099	0.099	0.00
		0.25	111.38	0.0022	0.098		
		0.25	111.17	0.0022	0.098		
		0.25	111.81	0.0022	0.098		
		0.25	110.09	0.0023	0.099		
C_3H_6	100	0.25	54.50	0.0046	0.201	0.199	0.00
		0.25	55.32	0.0045	0.198		
		0.25	55.57	0.0045	0.197		
		0.25	55.11	0.0045	0.199		
		0.25	54.99	0.0045	0.199		
CO_2	25	1	40.64	0.0246	4.309	4.324	0.02
		1	40.66	0.0246	4.307		
		1	40.25	0.0248	4.351		
		1	40.51	0.0247	4.323		
		1	40.47	0.0247	4.327		
	50	1	19.16	0.0522	4.570	4.561	0.02
		1	19.12	0.0523	4.580		
		1	19.30	0.0518	4.537		
		1	19.26	0.0519	4.546		
		1	19.15	0.0522	4.572		
	75	1	12.61	0.0793	4.629	4.633	0.04
		1	12.77	0.0783	4.571		
		1	12.55	0.0797	4.651		
		1	12.52	0.0799	4.663		
		1	12.55	0.0797	4.651		
	100	1	9.22	0.1085	4.749	4.695	0.05
		1	9.46	0.1057	4.628		
		1	9.32	0.1073	4.698		
		1	9.36	0.1068	4.678		
		1	9.27	0.1079	4.723		
	125	10	70.03	0.1428	5.001	4.997	0.01
		10	69.93	0.1430	5.009		
		10	69.99	0.1429	5.004		
		10	70.43	0.1420	4.973		
		10	70.06	0.1427	4.999		
	150	10	53.94	0.1854	5.411	5.424	0.01
		10	53.62	0.1865	5.443		
		10	53.74	0.1861	5.431		
		10	53.81	0.1858	5.424		
		10	53.93	0.1854	5.412		
	175	10	45.13	0.2216	5.544	5.557	0.01
		10	45.14	0.2215	5.542		
		10	44.93	0.2226	5.568		
		10	45.02	0.2221	5.557		
		10	44.88	0.2228	5.574		
	200	10	38.87	0.2573	5.632	5.640	0.03
		10	38.58	0.2592	5.674		
		10	39.12	0.2556	5.596		
		10	38.68	0.2585	5.659		
		10	38.83	0.2575	5.638		

Table B7 20%NaA/CA MMM

Gas	P (psi)	vol. (ml)	time (sec)	Flow rate (ml/sec)	Permeance (GPU)	Average of Permeance (GPU)	STDEV of Permeance
N_2	50	0.25	151.97	0.0016	0.144	0.145	0.00
		0.25	150.69	0.0017	0.145		
		0.25	151.88	0.0016	0.144		
		0.25	151.93	0.0016	0.144		
		0.25	150.46	0.0017	0.145		
CH_4	100	0.25	71.66	0.0035	0.153	0.153	0.00
		0.25	72.09	0.0035	0.152		
		0.25	71.78	0.0035	0.152		
		0.25	72.04	0.0035	0.152		
		0.25	71.15	0.0035	0.154		
C_3H_8	100	0.25	157.91	0.0016	0.069	0.070	0.00
		0.25	156.68	0.0016	0.070		
		0.25	155.24	0.0016	0.071		
		0.25	156.56	0.0016	0.070		
		0.25	155.62	0.0016	0.070		
C_3H_6	100	0.25	96.72	0.0026	0.113	0.113	0.00
		0.25	96.03	0.0026	0.114		
		0.25	97.02	0.0026	0.113		
		0.25	96.34	0.0026	0.114		
		0.25	97.00	0.0026	0.113		
CO_2	25	1	49.72	0.0201	3.522	3.536	0.03
		1	50.14	0.0199	3.493		
		1	49.05	0.0204	3.570		
		1	49.16	0.0203	3.562		
		1	49.56	0.0202	3.534		
	50	1	24.31	0.0411	3.602	3.613	0.01
		1	24.15	0.0414	3.626		
		1	24.25	0.0412	3.611		
		1	24.27	0.0412	3.608		
		1	24.19	0.0413	3.620		
	75	1	16.10	0.0621	3.626	3.615	0.02
		1	16.23	0.0616	3.597		
		1	16.16	0.0619	3.612		
		1	16.21	0.0617	3.601		
		1	16.04	0.0623	3.639		
	100	1	11.88	0.0842	3.685	3.700	0.01
		1	11.79	0.0848	3.713		
		1	11.84	0.0845	3.698		
		1	11.85	0.0844	3.695		
		1	11.81	0.0847	3.707		
	125	10	94.08	0.1063	3.723	3.692	0.02
		10	95.47	0.1047	3.669		
		10	95.14	0.1051	3.681		
		10	94.60	0.1057	3.702		
		10	95.02	0.1052	3.686		
	150	10	78.18	0.1279	3.733	3.721	0.01
		10	78.35	0.1276	3.725		
		10	78.68	0.1271	3.710		
		10	78.51	0.1274	3.718		
		10	78.49	0.1274	3.719		

Gas	P (psi)	vol. (ml)	time (sec)	Flow rate (ml/sec)	Permeance (GPU)	Average of Permeance (GPU)	STDEV of Permeance
CO_2	175	10	66.03	0.1514	3.789	3.793	0.01
		10	65.92	0.1517	3.795		
		10	65.90	0.1517	3.796		
		10	66.07	0.1514	3.787		
		10	65.87	0.1518	3.798		
	200	10	55.89	0.1789	3.917	3.948	0.03
		10	55.02	0.1818	3.979		
		10	55.26	0.1810	3.961		
		10	55.12	0.1814	3.971		
		10	55.98	0.1786	3.910		

Table B8 30%NaA/CA MMM

Gas	P (psi)	vol. (ml)	time (sec)	Flow rate (ml/sec)	Permeance (GPU)	Average of Permeance (GPU)	STDEV of Permeance
N_2	50	0.25	122.00	0.0020	0.179	0.180	0.00
		0.25	121.63	0.0021	0.180		
		0.25	120.83	0.0021	0.181		
		0.25	121.30	0.0021	0.180		
		0.25	122.37	0.0020	0.179		
CH_4	100	0.25	41.28	0.0061	0.265	0.264	0.00
		0.25	41.86	0.0060	0.261		
		0.25	41.92	0.0060	0.261		
		0.25	41.19	0.0061	0.266		
		0.25	41.14	0.0061	0.266		
C_3H_8	100	0.25	100.14	0.0025	0.109	0.109	0.00
		0.25	100.07	0.0025	0.109		
		0.25	101.57	0.0025	0.108		
		0.25	101.26	0.0025	0.108		
		0.25	100.32	0.0025	0.109		
C_3H_6	100	0.25	64.25	0.0039	0.170	0.171	0.00
		0.25	63.37	0.0039	0.173		
		0.25	64.27	0.0039	0.170		
		0.25	63.80	0.0039	0.172		
		0.25	64.15	0.0039	0.171		
CO_2	25	1	36.01	0.0278	4.86	4.83	0.04
		1	36.09	0.0277	4.85		
		1	36.65	0.0273	4.78		
		1	36.59	0.0273	4.79		
		1	36.02	0.0278	4.86		
	50	1	17.10	0.0585	5.12	5.11	0.01
		1	17.12	0.0584	5.11		
		1	17.20	0.0581	5.09		
		1	17.19	0.0582	5.09		
		1	17.15	0.0583	5.11		
	75	1	10.81	0.0925	5.40	5.37	0.02
		1	10.90	0.0917	5.36		
		1	10.93	0.0915	5.34		
		1	10.90	0.0917	5.36		
		1	10.85	0.0922	5.38		

Gas	P (psi)	vol. (ml)	time (sec)	Flow rate (ml/sec)	Permeance (GPU)	Average of Permeance (GPU)	STDEV of Permeance
CO_2	100	1	7.32	0.1366	5.98	6.00	0.05
		1	7.39	0.1353	5.92		
		1	7.20	0.1389	6.08		
		1	7.31	0.1368	5.99		
		1	7.27	0.1376	6.02		
	125	10	52.12	0.1919	6.72	6.69	0.05
		10	52.41	0.1908	6.68		
		10	52.97	0.1888	6.61		
		10	52.06	0.1921	6.73		
		10	52.21	0.1915	6.71		
	150	10	41.25	0.2424	7.08	7.10	0.02
		10	41.00	0.2439	7.12		
		10	41.14	0.2431	7.09		
		10	40.99	0.2440	7.12		
		10	41.09	0.2434	7.10		
	175	10	33.91	0.2949	7.38	7.42	0.05
		10	33.99	0.2942	7.36		
		10	33.08	0.3023	7.56		
		10	33.73	0.2965	7.42		
		10	33.89	0.2951	7.38		
	200	10	26.92	0.3715	8.13	8.14	0.02
		10	26.93	0.3713	8.13		
		10	26.88	0.3720	8.14		
		10	26.79	0.3733	8.17		
		10	26.95	0.3711	8.12		

Table B9 40%NaA/CA MMM

Gas	P (psi)	vol. (ml)	time (sec)	Flow rate (ml/sec)	Permeance (GPU)	Average of Permeance (GPU)	STDEV of Permeance
N_2	50	0.25	169.03	0.0015	0.130	0.130	0.00
		0.25	168.06	0.0015	0.130		
		0.25	168.93	0.0015	0.130		
		0.25	167.66	0.0015	0.131		
		0.25	169.53	0.0015	0.129		
CH_4	100	0.25	40.72	0.0061	0.269	0.269	0.00
		0.25	40.36	0.0062	0.271		
		0.25	40.81	0.0061	0.268		
		0.25	40.78	0.0061	0.268		
		0.25	40.75	0.0061	0.269		
C_3H_8	100	0.25	134.14	0.0019	0.082	0.081	0.00
		0.25	135.11	0.0019	0.081		
		0.25	134.98	0.0019	0.081		
		0.25	134.71	0.0019	0.081		
		0.25	135.72	0.0018	0.081		
C_3H_6	100	0.25	89.50	0.0028	0.122	0.123	0.00
		0.25	87.69	0.0029	0.125		
		0.25	88.25	0.0028	0.124		
		0.25	88.68	0.0028	0.123		
		0.25	89.37	0.0028	0.122		

Gas	P (psi)	vol. (ml)	time (sec)	Flow rate (ml/sec)	Permeance (GPU)	Average of Permeance (GPU)	STDEV of Permeance
CO_2	25	1	44.11	0.0227	3.97	3.95	0.03
		1	44.20	0.0226	3.96		
		1	44.99	0.0222	3.89		
		1	44.07	0.0227	3.97		
		1	44.19	0.0226	3.96		
	50	1	20.53	0.0487	4.27	4.24	0.02
		1	20.68	0.0484	4.23		
		1	20.78	0.0481	4.21		
		1	20.56	0.0486	4.26		
		1	20.64	0.0484	4.24		
	75	1	12.35	0.0810	4.73	4.75	0.02
		1	12.29	0.0814	4.75		
		1	12.23	0.0818	4.77		
		1	12.30	0.0813	4.75		
		1	12.24	0.0817	4.77		
	100	1	8.23	0.1215	5.32	5.32	0.04
		1	8.27	0.1209	5.29		
		1	8.23	0.1215	5.32		
		1	8.14	0.1229	5.38		
		1	8.31	0.1203	5.27		
	125	10	60.57	0.1651	5.78	5.77	0.02
		10	61.02	0.1639	5.74		
		10	60.37	0.1656	5.80		
		10	60.56	0.1651	5.78		
		10	60.80	0.1645	5.76		
	150	10	47.10	0.2123	6.20	6.20	0.02
		10	47.28	0.2115	6.17		
		10	46.96	0.2129	6.22		
		10	46.97	0.2129	6.21		
		10	47.17	0.2120	6.19		
	175	10	38.08	0.2626	6.57	6.58	0.01
		10	37.98	0.2633	6.59		
		10	37.94	0.2636	6.59		
		10	38.06	0.2627	6.57		
		10	38.14	0.2622	6.56		
	200	10	31.95	0.3130	6.85	6.85	0.02
		10	31.78	0.3147	6.89		
		10	31.97	0.3128	6.85		
		10	32.08	0.3117	6.82		
		10	32.01	0.3124	6.84		

Table B10 Selectivity at 100 psi and Slope of CO_2 permeance for NaA/CA membrane

Membrane	Selectivity		slope of CO_2 permeance's graph
	C_3H_6/C_3H_8	CO_2/CH_4	
CA membrane	2.166	14.113	0.040
10%NaA-CA MMMs	2.016	17.825	0.0080
20%NaA-CA MMMs	1.619	24.250	0.0019
30%NaA-CA MMMs	1.574	22.734	0.0175
40%NaA-CA MMMs	1.521	19.760	0.0194

Table B11 10%CaA/CA MMM

Gas	P (psi)	vol. (ml)	time (sec)	Flow rate (ml/sec)	Permeance (GPU)	Average of Permeance (GPU)	STDEV of Permeance
N_2	50	0.25	108.66	0.0023	0.201	0.200	0.00
		0.25	109.88	0.0023	0.199		
		0.25	111.60	0.0022	0.196		
		0.25	107.46	0.0023	0.204		
		0.25	109.24	0.0023	0.200		
CH_4	100	0.25	103.38	0.0024	0.106	0.106	0.00
		0.25	102.69	0.0024	0.107		
		0.25	102.02	0.0025	0.107		
		0.25	105.43	0.0024	0.104		
		0.25	104.86	0.0024	0.104		
C_3H_8	100	0.25	485.06	0.0005	0.023	0.023	0.00
		0.25	491.99	0.0005	0.022		
		0.25	464.24	0.0005	0.024		
		0.25	489.83	0.0005	0.022		
		0.25	486.17	0.0005	0.023		
C_3H_6	100	0.25	136.40	0.0018	0.080	0.081	0.00
		0.25	131.27	0.0019	0.083		
		0.25	137.49	0.0018	0.080		
		0.25	131.90	0.0019	0.083		
		0.25	136.81	0.0018	0.080		
CO_2	25	1	101.00	0.0099	1.734	1.715	0.03
		1	100.87	0.0099	1.736		
		1	104.46	0.0096	1.676		
		1	101.49	0.0099	1.726		
		1	102.81	0.0097	1.703		
	50	1	50.19	0.0199	1.745	1.746	0.01
		1	49.71	0.0201	1.761		
		1	50.58	0.0198	1.731		
		1	50.30	0.0199	1.741		
		1	50.05	0.0200	1.750		
	75	1	29.44	0.0340	1.983	1.981	0.00
		1	29.53	0.0339	1.977		
		1	29.41	0.0340	1.985		
		1	29.51	0.0339	1.978		
		1	29.46	0.0339	1.982		
	100	1	18.55	0.0539	2.360	2.351	0.01
		1	18.61	0.0537	2.353		
		1	18.77	0.0533	2.333		
		1	18.52	0.0540	2.364		
		1	18.67	0.0536	2.345		
	125	1	14.16	0.0706	2.474	2.477	0.01
		1	14.18	0.0705	2.470		
		1	14.13	0.0708	2.479		
		1	14.22	0.0703	2.463		
		1	14.02	0.0713	2.498		
	150	1	10.43	0.0959	2.798	2.835	0.03
		1	10.27	0.0974	2.842		
		1	10.18	0.0982	2.867		
		1	10.42	0.0960	2.801		
		1	10.19	0.0981	2.864		

Gas	P (psi)	vol. (ml)	time (sec)	Flow rate (ml/sec)	Permeance (GPU)	Average of Permeance (GPU)	STDEV of Permeance
CO_2	175	1	8.27	0.1209	3.025	3.035	0.02
		1	8.29	0.1206	3.018		
		1	8.25	0.1212	3.032		
		1	8.20	0.1220	3.051		
		1	8.20	0.1220	3.051		
	200	1	6.95	0.1439	3.150	3.142	0.04
		1	6.83	0.1464	3.205		
		1	7.04	0.1420	3.109		
		1	7.02	0.1425	3.118		
		1	7.00	0.1429	3.127		

Table B12 20%CaA/CA MMM

Gas	P (psi)	vol. (ml)	time (sec)	Flow rate (ml/sec)	Permeance (GPU)	Average of Permeance (GPU)	STDEV of Permeance
N_2	50	0.25	138.65	0.0018	0.158	0.158	0.00
		0.25	138.91	0.0018	0.158		
		0.25	137.10	0.0018	0.160		
		0.25	137.97	0.0018	0.159		
		0.25	139.02	0.0018	0.157		
CH_4	100	0.25	51.43	0.0049	0.213	0.212	0.00
		0.25	51.78	0.0048	0.211		
		0.25	51.81	0.0048	0.211		
		0.25	51.58	0.0048	0.212		
		0.25	51.89	0.0048	0.211		
C_3H_8	100	0.25	273.82	0.0009	0.040	0.040	0.00
		0.25	275.75	0.0009	0.040		
		0.25	273.67	0.0009	0.040		
		0.25	274.58	0.0009	0.040		
		0.25	273.39	0.0009	0.040		
C_3H_6	100	0.25	109.84	0.0023	0.100	0.101	0.00
		0.25	108.50	0.0023	0.101		
		0.25	106.47	0.0023	0.103		
		0.25	109.25	0.0023	0.100		
		0.25	108.24	0.0023	0.101		
CO_2	25	1	65.11	0.0154	2.690	2.677	0.01
		1	65.74	0.0152	2.664		
		1	65.21	0.0153	2.686		
		1	65.51	0.0153	2.673		
		1	65.47	0.0153	2.675		
	50	1	31.16	0.0321	2.810	2.834	0.02
		1	30.86	0.0324	2.837		
		1	30.72	0.0326	2.850		
		1	30.74	0.0325	2.849		
		1	30.99	0.0323	2.826		
	75	1	17.18	0.0582	3.398	3.426	0.02
		1	17.03	0.0587	3.428		
		1	17.00	0.0588	3.434		
		1	17.02	0.0588	3.430		
		1	16.96	0.0590	3.442		

Gas	P (psi)	vol. (ml)	time (sec)	Flow rate (ml/sec)	Permeance (GPU)	Average of Permeance (GPU)	STDEV of Permeance
CO_2	100	1	10.09	0.0991	4.339	4.345	0.02
		1	10.09	0.0991	4.339		
		1	10.01	0.0999	4.374		
		1	10.13	0.0987	4.322		
		1	10.06	0.0994	4.352		
	125	10	75.01	0.1333	4.669	4.734	0.06
		10	74.09	0.1350	4.727		
		10	74.70	0.1339	4.689		
		10	72.54	0.1379	4.828		
		10	73.62	0.1358	4.758		
	150	10	55.60	0.1799	5.250	5.226	0.01
		10	55.85	0.1791	5.226		
		10	56.00	0.1786	5.212		
		10	55.94	0.1788	5.218		
		10	55.89	0.1789	5.222		
	175	10	45.88	0.2180	5.453	5.471	0.03
		10	45.35	0.2205	5.517		
		10	45.63	0.2192	5.483		
		10	45.85	0.2181	5.456		
		10	45.93	0.2177	5.447		
	200	10	38.50	0.2597	5.686	5.710	0.02
		10	38.42	0.2603	5.698		
		10	38.35	0.2608	5.708		
		10	38.12	0.2623	5.743		
		10	38.29	0.2612	5.717		

Table B13 30%CaA/CA MMM

Gas	P (psi)	vol. (ml)	time (sec)	Flow rate (ml/sec)	Permeance (GPU)	Average of Permeance (GPU)	STDEV of Permeance
N_2	50	0.25	121.60	0.0021	0.180	0.182	0.00
		0.25	120.80	0.0021	0.181		
		0.25	119.27	0.0021	0.184		
		0.25	120.29	0.0021	0.182		
		0.25	119.21	0.0021	0.184		
CH_4	100	0.25	95.31	0.0026	0.115	0.115	0.00
		0.25	94.89	0.0026	0.115		
		0.25	94.57	0.0026	0.116		
		0.25	95.81	0.0026	0.114		
		0.25	95.22	0.0026	0.115		
C_3H_8	100	0.25	317.19	0.0008	0.035	0.034	0.00
		0.25	319.36	0.0008	0.034		
		0.25	319.30	0.0008	0.034		
		0.25	317.39	0.0008	0.034		
		0.25	317.34	0.0008	0.034		
C_3H_6	100	0.25	235.59	0.0011	0.046	0.047	0.00
		0.25	234.30	0.0011	0.047		
		0.25	232.99	0.0011	0.047		
		0.25	234.52	0.0011	0.047		
		0.25	232.68	0.0011	0.047		

Gas	P (psi)	vol. (ml)	time (sec)	Flow rate (ml/sec)	Permeance (GPU)	Average of Permeance (GPU)	STDEV of Permeance
CO_2	25	1	120.15	0.0083	1.46	1.46	0.00
		1	120.02	0.0083	1.46		
		1	119.96	0.0083	1.46		
		1	119.68	0.0084	1.46		
		1	120.34	0.0083	1.46		
	50	1	57.84	0.0173	1.51	1.52	0.01
		1	57.77	0.0173	1.52		
		1	57.21	0.0175	1.53		
		1	57.40	0.0174	1.53		
		1	57.49	0.0174	1.52		
	75	1	29.23	0.0342	2.00	1.97	0.02
		1	29.86	0.0335	1.95		
		1	29.77	0.0336	1.96		
		1	29.28	0.0342	1.99		
		1	29.67	0.0337	1.97		
	100	1	19.84	0.0504	2.21	2.22	0.01
		1	19.52	0.0512	2.24		
		1	19.64	0.0509	2.23		
		1	19.74	0.0507	2.22		
		1	19.67	0.0508	2.23		
	125	1	13.94	0.0717	2.51	2.52	0.01
		1	13.96	0.0716	2.51		
		1	13.80	0.0725	2.54		
		1	13.96	0.0716	2.51		
		1	13.86	0.0722	2.53		
	150	1	10.32	0.0969	2.83	2.82	0.01
		1	10.40	0.0962	2.81		
		1	10.39	0.0962	2.81		
		1	10.30	0.0971	2.83		
		1	10.31	0.0970	2.83		
	175	1	6.73	0.1486	3.72	3.76	0.04
		1	6.56	0.1524	3.81		
		1	6.70	0.1493	3.73		
		1	6.70	0.1493	3.73		
		1	6.58	0.1520	3.80		
	200	1	5.26	0.1901	4.16	4.16	0.01
		1	5.27	0.1898	4.15		
		1	5.26	0.1901	4.16		
		1	5.26	0.1901	4.16		
		1	5.28	0.1894	4.15		

Table B14 40%CaA/CA MMM

Gas	P (psia)	vol. (ml)	time (sec)	Flow rate (ml/sec)	Permeance (GPU)	Average of Permeance (GPU)	STDEV of Permeance
N_2	50	0.25	103.97	0.0024	0.211	0.212	0.00
		0.25	102.93	0.0024	0.213		
		0.25	102.84	0.0024	0.213		
		0.25	103.42	0.0024	0.212		
		0.25	103.04	0.0024	0.212		

Table B14 40%CaA/CA MMM

Gas	P (psi)	vol. (ml)	time (sec)	Flow rate (ml/sec)	Permeance (GPU)	Average of Permeance (GPU)	STDEV of Permeance
CH_4	100	0.25	70.42	0.0036	0.155	0.156	0.00
		0.25	70.21	0.0036	0.156		
		0.25	70.87	0.0035	0.154		
		0.25	70.17	0.0036	0.156		
		0.25	70.05	0.0036	0.156		
C_3H_8	100	0.25	68.81	0.0036	0.159	0.158	0.00
		0.25	69.62	0.0036	0.157		
		0.25	69.33	0.0036	0.158		
		0.25	69.24	0.0036	0.158		
		0.25	69.03	0.0036	0.159		
C_3H_6	100	0.25	71.78	0.0035	0.152	0.153	0.00
		0.25	72.74	0.0034	0.150		
		0.25	71.93	0.0035	0.152		
		0.25	71.07	0.0035	0.154		
		0.25	71.28	0.0035	0.154		
CO_2	25	1	95.12	0.0105	1.84	1.84	0.01
		1	95.55	0.0105	1.83		
		1	96.02	0.0104	1.82		
		1	94.43	0.0106	1.85		
		1	95.27	0.0105	1.84		
	50	1	45.36	0.0220	1.93	1.92	0.01
		1	45.90	0.0218	1.91		
		1	46.02	0.0217	1.90		
		1	45.40	0.0220	1.93		
		1	45.52	0.0220	1.92		
	75	1	22.58	0.0443	2.59	2.61	0.02
		1	22.17	0.0451	2.63		
		1	22.20	0.0450	2.63		
		1	22.29	0.0449	2.62		
		1	22.55	0.0443	2.59		
	100	1	15.43	0.0648	2.84	2.85	0.01
		1	15.25	0.0656	2.87		
		1	15.40	0.0649	2.84		
		1	15.40	0.0649	2.84		
		1	15.37	0.0651	2.85		
	125	1	12.07	0.0829	2.90	2.89	0.01
		1	12.19	0.0820	2.87		
		1	12.12	0.0825	2.89		
		1	12.10	0.0826	2.89		
		1	12.08	0.0828	2.90		
	150	1	7.90	0.1266	3.69	3.69	0.01
		1	7.96	0.1256	3.67		
		1	7.93	0.1261	3.68		
		1	7.91	0.1264	3.69		
		1	7.90	0.1266	3.69		
	175	1	5.87	0.1704	4.26	4.28	0.02
		1	5.87	0.1704	4.26		
		1	5.86	0.1706	4.27		
		1	5.82	0.1718	4.30		
		1	5.83	0.1715	4.29		

Gas	P (psia)	vol. (ml)	time (sec)	Flow rate (ml/sec)	Permeance (GPU)	Average of Permeance (GPU)	STDEV of Permeance
CO_2	200	1	4.11	0.2433	5.33	5.32	0.02
		1	4.11	0.2433	5.33		
		1	4.15	0.2410	5.27		
		1	4.10	0.2439	5.34		
		1	4.12	0.2427	5.31		

Table B15 Selectivity at 100 psi and Slope of CO_2 permeance for CaA/CA membrane

Membrane	Selectivity		slope of CO_2 permeance's graph
	C_3H_6/C_3H_8	CO_2/CH_4	
CA membrane	2.166	14.113	0.0399
10%CaA-CA MMMs	3.587	22.264	0.0091
20%CaA-CA MMMs	2.529	20.523	0.0157
30%CaA-CA MMMs	1.359	19.340	0.0188
40%CaA-CA MMMs	0.964	18.307	0.0191

Table B16 10%NaX/CA MMM

Gas	P (psi)	vol. (ml)	time (sec)	Flow rate (ml/sec)	Permeance (GPU)	Average of Permeance (GPU)	STDEV of Permeance
N_2	50	0.25	450.80	0.0006	0.049	0.049	0.00
		0.25	441.40	0.0006	0.050		
		0.25	446.55	0.0006	0.049		
		0.25	450.62	0.0006	0.049		
		0.25	445.80	0.0006	0.049		
CH_4	100	0.25	148.90	0.0017	0.074	0.075	0.00
		0.25	141.46	0.0018	0.077		
		0.25	142.02	0.0018	0.077		
		0.25	145.15	0.0017	0.075		
		0.25	149.18	0.0017	0.073		
C_3H_8	100	0.25	92.12	0.0027	0.119	0.118	0.00
		0.25	94.15	0.0027	0.116		
		0.25	93.24	0.0027	0.117		
		0.25	92.06	0.0027	0.119		
		0.25	91.68	0.0027	0.119		
C_3H_6	100	0.25	127.55	0.0020	0.086	0.086	0.00
		0.25	125.27	0.0020	0.087		
		0.25	128.30	0.0019	0.085		
		0.25	128.21	0.0019	0.085		
		0.25	127.43	0.0020	0.086		
CO_2	25	1	143.15	0.0070	1.223	1.229	0.01
		1	141.09	0.0071	1.241		
		1	142.30	0.0070	1.231		
		1	144.62	0.0069	1.211		
		1	141.43	0.0071	1.238		
	50	1	68.92	0.0145	1.271	1.284	0.01
		1	68.65	0.0146	1.276		
		1	67.34	0.0149	1.300		
		1	68.62	0.0146	1.276		
		1	67.46	0.0148	1.298		

Gas	P (psi)	vol. (ml)	time (sec)	Flow rate (ml/sec)	Permeance (GPU)	Average of Permeance (GPU)	STDEV of Permeance
CO_2	75	1	44.60	0.0224	1.309	1.315	0.01
		1	44.09	0.0227	1.324		
		1	44.93	0.0223	1.299		
		1	44.02	0.0227	1.326		
		1	44.27	0.0226	1.319		
	100	1	31.48	0.0318	1.391	1.387	0.01
		1	31.49	0.0318	1.390		
		1	31.37	0.0319	1.396		
		1	31.90	0.0313	1.372		
		1	31.65	0.0316	1.383		
	125	1	24.71	0.0405	1.417	1.423	0.00
		1	24.63	0.0406	1.422		
		1	24.58	0.0407	1.425		
		1	24.68	0.0405	1.419		
		1	24.51	0.0408	1.429		
	150	1	19.00	0.0526	1.536	1.527	0.01
		1	19.06	0.0525	1.531		
		1	19.05	0.0525	1.532		
		1	19.36	0.0517	1.508		
		1	19.11	0.0523	1.527		
	175	1	15.91	0.0629	1.572	1.568	0.01
		1	16.05	0.0623	1.559		
		1	15.87	0.0630	1.576		
		1	15.93	0.0628	1.570		
		1	16.02	0.0624	1.562		
	200	1	13.42	0.0745	1.631	1.631	0.01
		1	13.46	0.0743	1.626		
		1	13.46	0.0743	1.626		
		1	13.47	0.0742	1.625		
		1	13.32	0.0751	1.643		

Table B17 20%NaX/CA MMM

Gas	P (psi)	vol. (ml)	time (sec)	Flow rate (ml/sec)	Permeance (GPU)	Average of Permeance (GPU)	STDEV of Permeance
N_2	50	0.25	177.25	0.0014	0.124	0.123	0.00
		0.25	176.27	0.0014	0.124		
		0.25	180.65	0.0014	0.121		
		0.25	176.05	0.0014	0.124		
		0.25	177.71	0.0014	0.123		
CH_4	100	0.25	210.87	0.0012	0.052	0.052	0.00
		0.25	207.46	0.0012	0.053		
		0.25	211.58	0.0012	0.052		
		0.25	206.83	0.0012	0.053		
		0.25	210.62	0.0012	0.052		
C_3H_8	100	0.25	96.48	0.0026	0.113	0.116	0.00
		0.25	92.77	0.0027	0.118		
		0.25	94.21	0.0027	0.116		
		0.25	93.96	0.0027	0.116		
		0.25	93.99	0.0027	0.116		

Gas	P (psi)	vol. (ml)	time (sec)	Flow rate (ml/sec)	Permeance (GPU)	Average of Permeance (GPU)	STDEV of Permeance
C_3H_6	100	0.25	180.72	0.0014	0.061	0.059	0.00
		0.25	186.62	0.0013	0.059		
		0.25	185.34	0.0013	0.059		
		0.25	182.06	0.0014	0.060		
		0.25	186.49	0.0013	0.059		
CO_2	25	1	153.20	0.0065	1.143	1.145	0.01
		1	152.17	0.0066	1.151		
		1	153.67	0.0065	1.140		
		1	154.08	0.0065	1.137		
		1	151.36	0.0066	1.157		
	50	1	75.44	0.0133	1.161	1.156	0.01
		1	75.83	0.0132	1.155		
		1	75.90	0.0132	1.154		
		1	76.49	0.0131	1.145		
		1	75.02	0.0133	1.167		
	75	1	50.47	0.0198	1.157	1.163	0.01
		1	50.16	0.0199	1.164		
		1	50.55	0.0198	1.155		
		1	50.08	0.0200	1.166		
		1	49.77	0.0201	1.173		
	100	1	36.35	0.0275	1.204	1.202	0.01
		1	36.68	0.0273	1.194		
		1	36.15	0.0277	1.211		
		1	36.62	0.0273	1.196		
		1	36.37	0.0275	1.204		
	125	1	24.22	0.0413	1.446	1.458	0.01
		1	24.01	0.0416	1.459		
		1	23.86	0.0419	1.468		
		1	23.99	0.0417	1.460		
		1	24.05	0.0416	1.456		
	150	1	19.38	0.0516	1.506	1.495	0.02
		1	19.71	0.0507	1.481		
		1	19.77	0.0506	1.476		
		1	19.36	0.0517	1.508		
		1	19.39	0.0516	1.505		
	175	1	16.53	0.0605	1.513	1.505	0.01
		1	16.67	0.0600	1.501		
		1	16.68	0.0600	1.500		
		1	16.72	0.0598	1.496		
		1	16.52	0.0605	1.514		
	200	1	14.59	0.0685	1.500	1.516	0.01
		1	14.39	0.0695	1.521		
		1	14.48	0.0691	1.512		
		1	14.36	0.0696	1.524		
		1	14.36	0.0696	1.524		

Table B18 30%NaX/CA MMM

Gas	P (psi)	vol. (ml)	time (sec)	Flow rate (ml/sec)	Permeance (GPU)	Average of Permeance (GPU)	STDEV of Permeance
N_2	50	0.25	260.37	0.0010	0.084	0.083	0.00
		0.25	265.18	0.0009	0.083		
		0.25	266.39	0.0009	0.082		
		0.25	268.87	0.0009	0.081		
		0.25	264.12	0.0009	0.083		
CH_4	100	0.25	120.74	0.0021	0.091	0.090	0.00
		0.25	122.43	0.0020	0.089		
		0.25	120.37	0.0021	0.091		
		0.25	124.68	0.0020	0.088		
		0.25	122.52	0.0020	0.089		
C_3H_8	100	0.25	132.60	0.0019	0.083	0.082	0.00
		0.25	135.57	0.0018	0.081		
		0.25	131.85	0.0019	0.083		
		0.25	134.15	0.0019	0.082		
		0.25	134.77	0.0019	0.081		
C_3H_6	100	0.25	162.05	0.0015	0.068	0.068	0.00
		0.25	160.31	0.0016	0.068		
		0.25	158.38	0.0016	0.069		
		0.25	164.58	0.0015	0.067		
		0.25	162.44	0.0015	0.067		
CO_2	25	1	132.78	0.0075	1.32	1.32	0.02
		1	130.56	0.0077	1.34		
		1	134.52	0.0074	1.30		
		1	130.80	0.0076	1.34		
		1	134.39	0.0074	1.30		
	50	1	62.62	0.0160	1.40	1.42	0.02
		1	61.65	0.0162	1.42		
		1	62.55	0.0160	1.40		
		1	61.55	0.0162	1.42		
		1	60.24	0.0166	1.45		
	75	1	39.69	0.0252	1.47	1.47	0.01
		1	39.80	0.0251	1.47		
		1	39.83	0.0251	1.47		
		1	39.36	0.0254	1.48		
		1	39.68	0.0252	1.47		
	100	1	23.90	0.0418	1.83	1.82	0.01
		1	24.22	0.0413	1.81		
		1	24.19	0.0413	1.81		
		1	23.94	0.0418	1.83		
		1	23.97	0.0417	1.83		
	125	1	17.75	0.0563	1.97	1.98	0.02
		1	17.66	0.0566	1.98		
		1	17.40	0.0575	2.01		
		1	17.74	0.0564	1.97		
		1	17.80	0.0562	1.97		

Gas	P (psi)	vol. (ml)	time (sec)	Flow rate (ml/sec)	Permeance (GPU)	Average of Permeance (GPU)	STDEV of Permeance
CO_2	150	1	14.38	0.0695	2.03	2.04	0.01
		1	14.16	0.0706	2.06		
		1	14.25	0.0702	2.05		
		1	14.35	0.0697	2.03		
		1	14.31	0.0699	2.04		
	175	1	12.06	0.0829	2.07	2.07	0.01
		1	12.10	0.0826	2.07		
		1	12.10	0.0826	2.07		
		1	12.03	0.0831	2.08		
		1	12.01	0.0833	2.08		
	200	1	10.37	0.0964	2.11	2.11	0.00
		1	10.37	0.0964	2.11		
		1	10.38	0.0963	2.11		
		1	10.41	0.0961	2.10		
		1	10.35	0.0966	2.12		

Table B19 40%NaX/CA MMM

Gas	P (psi)	vol. (ml)	time (sec)	Flow rate (ml/sec)	Permeance (GPU)	Average of Permeance (GPU)	STDEV of Permeance
N_2	50	0.25	225.22	0.0011	0.097	0.097	0.00
		0.25	229.66	0.0011	0.095		
		0.25	225.05	0.0011	0.097		
		0.25	224.52	0.0011	0.098		
		0.25	228.77	0.0011	0.096		
CH_4	100	0.25	68.69	0.0036	0.159	0.166	0.00
		0.25	65.84	0.0038	0.166		
		0.25	66.89	0.0037	0.164		
		0.25	64.05	0.0039	0.171		
		0.25	64.63	0.0039	0.169		
C_3H_8	100	0.25	132.44	0.0019	0.083	0.081	0.00
		0.25	138.11	0.0018	0.079		
		0.25	135.77	0.0018	0.081		
		0.25	139.58	0.0018	0.078		
		0.25	133.74	0.0019	0.082		
C_3H_6	100	0.25	72.40	0.0035	0.151	0.152	0.00
		0.25	71.46	0.0035	0.153		
		0.25	72.58	0.0034	0.151		
		0.25	71.55	0.0035	0.153		
		0.25	71.83	0.0035	0.152		
CO_2	25	1	100.12	0.0100	1.75	1.74	0.02
		1	99.91	0.0100	1.75		
		1	101.31	0.0099	1.73		
		1	102.40	0.0098	1.71		
		1	100.27	0.0100	1.75		
	50	1	40.07	0.0250	2.19	2.16	0.02
		1	40.82	0.0245	2.15		
		1	40.52	0.0247	2.16		
		1	40.44	0.0247	2.17		
		1	40.69	0.0246	2.15		

Gas	P (psi)	vol. (ml)	time (sec)	Flow rate (ml/sec)	Permeance (GPU)	Average of Permeance (GPU)	STDEV of Permeance
CO_2	75	1	20.85	0.0480	2.80	2.80	0.01
		1	20.72	0.0483	2.82		
		1	20.90	0.0478	2.79		
		1	20.93	0.0478	2.79		
		1	20.77	0.0481	2.81		
	100	1	13.54	0.0739	3.23	3.21	0.02
		1	13.66	0.0732	3.21		
		1	13.67	0.0732	3.20		
		1	13.71	0.0729	3.19		
		1	13.62	0.0734	3.21		
	125	1	9.14	0.1094	3.83	3.81	0.02
		1	9.24	0.1082	3.79		
		1	9.23	0.1083	3.79		
		1	9.18	0.1089	3.82		
		1	9.21	0.1086	3.80		
	150	1	6.96	0.1437	4.19	4.21	0.02
		1	6.91	0.1447	4.22		
		1	6.91	0.1447	4.22		
		1	6.97	0.1435	4.19		
		1	6.90	0.1449	4.23		
	175	1	5.66	0.1767	4.42	4.44	0.03
		1	5.67	0.1764	4.41		
		1	5.60	0.1786	4.47		
		1	5.66	0.1767	4.42		
		1	5.58	0.1792	4.48		
	200	1	4.84	0.2066	4.52	4.49	0.03
		1	4.86	0.2058	4.50		
		1	4.88	0.2049	4.49		
		1	4.91	0.2037	4.46		
		1	4.90	0.2041	4.47		

Table B20 Selectivity at 100 psi and Slope of CO_2 permeance for CaA/CA membrane

Membrane	Selectivity		slope of CO_2 permeance's graph
	C_3H_6/C_3H_8	CO_2/CH_4	
CA membrane	2.166	14.113	0.0399
10%NaX-CA MMMs	0.727	18.402	0.0023
20%NaX-CA MMMs	0.512	22.996	0.0027
30%NaX-CA MMMs	0.828	20.318	0.0051
40%NaX-CA MMMs	1.888	19.349	0.0169

Table B21 10%NaY/CA MMM

Gas	P (psi)	vol. (ml)	time (sec)	Flow rate (ml/sec)	Permeance (GPU)	Average of Permeance (GPU)	STDEV of Permeance
N_2	50	0.25	132.39	0.0019	0.165	0.165	0.00
		0.25	132.81	0.0019	0.165		
		0.25	132.01	0.0019	0.166		
		0.25	132.22	0.0019	0.166		
		0.25	132.76	0.0019	0.165		
CH_4	100	0.25	74.24	0.0034	0.147	0.146	0.00
		0.25	74.73	0.0033	0.146		
		0.25	75.63	0.0033	0.145		
		0.25	74.88	0.0033	0.146		
		0.25	75.47	0.0033	0.145		
C_3H_8	100	0.25	156.73	0.0016	0.070	0.070	0.00
		0.25	156.69	0.0016	0.070		
		0.25	157.14	0.0016	0.070		
		0.25	156.81	0.0016	0.070		
		0.25	156.57	0.0016	0.070		
C_3H_6	100	0.25	40.32	0.0062	0.271	0.270	0.00
		0.25	40.80	0.0061	0.268		
		0.25	40.53	0.0062	0.270		
		0.25	40.78	0.0061	0.268		
		0.25	40.34	0.0062	0.271		
CO_2	25	1	62.69	0.0160	2.794	2.837	0.04
		1	61.38	0.0163	2.853		
		1	62.62	0.0160	2.797		
		1	60.97	0.0164	2.872		
		1	61.06	0.0164	2.868		
	50	1	31.71	0.0315	2.761	2.770	0.02
		1	31.45	0.0318	2.784		
		1	31.24	0.0320	2.803		
		1	31.79	0.0315	2.754		
		1	31.88	0.0314	2.747		
	75	1	20.29	0.0493	2.877	2.850	0.04
		1	20.75	0.0482	2.813		
		1	20.84	0.0480	2.801		
		1	20.34	0.0492	2.870		
		1	20.22	0.0495	2.887		
	100	1	14.93	0.0670	2.932	2.928	0.03
		1	14.72	0.0679	2.974		
		1	14.91	0.0671	2.936		
		1	15.12	0.0661	2.896		
		1	15.10	0.0662	2.899		
	125	1	9.77	0.1024	3.585	3.566	0.02
		1	9.80	0.1020	3.574		
		1	9.90	0.1010	3.538		
		1	9.79	0.1021	3.578		
		1	9.85	0.1015	3.556		
	150	1	8.56	0.1168	3.410	3.523	0.07
		1	8.30	0.1205	3.517		
		1	8.19	0.1221	3.564		
		1	8.20	0.1220	3.559		
		1	8.19	0.1221	3.564		

Gas	P (psi)	vol. (ml)	time (sec)	Flow rate (ml/sec)	Permeance (GPU)	Average of Permeance (GPU)	STDEV of Permeance
CO_2	175	1	6.53	0.1531	3.831	3.834	0.05
		1	6.53	0.1531	3.831		
		1	6.66	0.1502	3.756		
		1	6.41	0.1560	3.903		
		1	6.50	0.1538	3.849		
	200	1	5.66	0.1767	3.868	3.968	0.08
		1	5.50	0.1818	3.980		
		1	5.37	0.1862	4.076		
		1	5.59	0.1789	3.916		
		1	5.47	0.1828	4.002		

Table B22 20%NaY/CA MMM

Gas	P (psi)	vol. (ml)	time (sec)	Flow rate (ml/sec)	Permeance (GPU)	Average of Permeance (GPU)	STDEV of Permeance
N_2	50	0.25	178.34	0.0014	0.123	0.123	0.00
		0.25	178.99	0.0014	0.122		
		0.25	179.34	0.0014	0.122		
		0.25	178.01	0.0014	0.123		
		0.25	177.68	0.0014	0.123		
CH_4	100	0.25	124.10	0.0020	0.088	0.088	0.00
		0.25	125.25	0.0020	0.087		
		0.25	124.61	0.0020	0.088		
		0.25	124.94	0.0020	0.088		
		0.25	125.05	0.0020	0.088		
C_3H_8	100	0.25	228.00	0.0011	0.048	0.048	0.00
		0.25	228.56	0.0011	0.048		
		0.25	227.75	0.0011	0.048		
		0.25	229.91	0.0011	0.048		
		0.25	228.94	0.0011	0.048		
C_3H_6	100	0.25	36.15	0.0069	0.303	0.302	0.00
		0.25	36.41	0.0069	0.301		
		0.25	36.28	0.0069	0.302		
		0.25	36.19	0.0069	0.302		
		0.25	36.28	0.0069	0.302		
CO_2	25	0.25	20.90	0.0120	2.095	2.099	0.03
		0.25	20.54	0.0122	2.132		
		0.25	21.31	0.0117	2.055		
		0.25	20.59	0.0121	2.126		
		0.25	20.97	0.0119	2.088		
	50	1	39.09	0.0256	2.240	2.251	0.01
		1	39.06	0.0256	2.242		
		1	38.72	0.0258	2.261		
		1	38.75	0.0258	2.260		
		1	38.84	0.0257	2.254		
	75	1	26.25	0.0381	2.224	2.201	0.02
		1	26.34	0.0380	2.216		
		1	26.60	0.0376	2.195		
		1	26.84	0.0373	2.175		
		1	26.57	0.0376	2.197		

Gas	P (psi)	vol. (ml)	time (sec)	Flow rate (ml/sec)	Permeance (GPU)	Average of Permeance (GPU)	STDEV of Permeance
CO_2	100	1	19.62	0.0510	2.231	2.243	0.01
		1	19.34	0.0517	2.264		
		1	19.43	0.0515	2.253		
		1	19.57	0.0511	2.237		
		1	19.63	0.0509	2.230		
	125	1	14.60	0.0685	2.399	2.415	0.01
		1	14.47	0.0691	2.421		
		1	14.47	0.0691	2.421		
		1	14.53	0.0688	2.411		
		1	14.44	0.0693	2.426		
	150	10	103.59	0.0965	2.818	2.836	0.02
		10	102.41	0.0976	2.850		
		10	102.27	0.0978	2.854		
		10	102.97	0.0971	2.835		
		10	103.36	0.0967	2.824		
	175	10	78.56	0.1273	3.185	3.192	0.01
		10	78.30	0.1277	3.195		
		10	78.72	0.1270	3.178		
		10	78.22	0.1278	3.198		
		10	78.03	0.1282	3.206		
	200	10	66.78	0.1497	3.278	3.279	0.00
		10	66.75	0.1498	3.280		
		10	66.77	0.1498	3.279		
		10	66.63	0.1501	3.285		
		10	66.91	0.1495	3.272		

Table B23 30%NaY/CA MMM

Gas	P (psi)	vol. (ml)	time (sec)	Flow rate (ml/sec)	Permeance (GPU)	Average of Permeance (GPU)	STDEV of Permeance
N_2	50	0.25	182.66	0.0014	0.120	0.120	0.00
		0.25	184.75	0.0014	0.118		
		0.25	184.10	0.0014	0.119		
		0.25	181.81	0.0014	0.120		
		0.25	182.28	0.0014	0.120		
CH_4	100	0.25	98.66	0.0025	0.111	0.111	0.00
		0.25	99.63	0.0025	0.110		
		0.25	98.32	0.0025	0.111		
		0.25	99.17	0.0025	0.110		
		0.25	98.56	0.0025	0.111		
C_3H_8	100	0.25	205.03	0.0012	0.053	0.053	0.00
		0.25	205.84	0.0012	0.053		
		0.25	207.95	0.0012	0.053		
		0.25	207.60	0.0012	0.053		
		0.25	205.31	0.0012	0.053		
C_3H_6	100	0.25	65.13	0.0038	0.168	0.167	0.00
		0.25	65.75	0.0038	0.166		
		0.25	65.37	0.0038	0.167		
		0.25	65.82	0.0038	0.166		
		0.25	65.22	0.0038	0.168		

Gas	P (psi)	vol. (ml)	time (sec)	Flow rate (ml/sec)	Permeance (GPU)	Average of Permeance (GPU)	STDEV of Permeance
CO_2	25	1	90.88	0.0110	1.93	1.93	0.01
		1	91.13	0.0110	1.92		
		1	89.38	0.0112	1.96		
		1	90.41	0.0111	1.94		
		1	90.77	0.0110	1.93		
	50	1	44.84	0.0223	1.95	1.95	0.01
		1	45.02	0.0222	1.94		
		1	44.79	0.0223	1.95		
		1	44.91	0.0223	1.95		
		1	45.12	0.0222	1.94		
	75	1	28.87	0.0346	2.02	2.05	0.02
		1	28.66	0.0349	2.04		
		1	28.47	0.0351	2.05		
		1	28.16	0.0355	2.07		
		1	28.40	0.0352	2.06		
	100	1	19.79	0.0505	2.21	2.22	0.02
		1	19.63	0.0509	2.23		
		1	19.97	0.0501	2.19		
		1	19.53	0.0512	2.24		
		1	19.50	0.0513	2.25		
	125	1	14.71	0.0680	2.38	2.36	0.02
		1	14.73	0.0679	2.38		
		1	14.99	0.0667	2.34		
		1	15.03	0.0665	2.33		
		1	14.80	0.0676	2.37		
	150	1	11.71	0.0854	2.49	2.52	0.02
		1	11.55	0.0866	2.53		
		1	11.46	0.0873	2.55		
		1	11.70	0.0855	2.49		
		1	11.59	0.0863	2.52		
	175	1	9.86	0.1014	2.54	2.54	0.02
		1	9.89	0.1011	2.53		
		1	9.73	0.1028	2.57		
		1	9.83	0.1017	2.55		
		1	9.86	0.1014	2.54		
	200	1	8.58	0.1166	2.55	2.55	0.01
		1	8.65	0.1156	2.53		
		1	8.61	0.1161	2.54		
		1	8.58	0.1166	2.55		
		1	8.55	0.1170	2.56		

Table B24 40%NaY/CA MMM

Gas	P (psi)	vol. (ml)	time (sec)	Flow rate (ml/sec)	Permeance (GPU)	Average of Permeance (GPU)	STDEV of Permeance
N_2	50	0.25	146.52	0.0017	0.149	0.149	0.00
		0.25	146.63	0.0017	0.149		
		0.25	147.31	0.0017	0.149		
		0.25	146.89	0.0017	0.149		
		0.25	146.78	0.0017	0.149		

Gas	P (psi)	vol. (ml)	time (sec)	Flow rate (ml/sec)	Permeance (GPU)	Average of Permeance (GPU)	STDEV of Permeance
CH_4	100	0.25	96.84	0.0026	0.113	0.112	0.00
		0.25	98.88	0.0025	0.111		
		0.25	97.74	0.0026	0.112		
		0.25	96.76	0.0026	0.113		
		0.25	97.86	0.0026	0.112		
C_3H_8	100	0.25	193.61	0.0013	0.057	0.056	0.00
		0.25	194.25	0.0013	0.056		
		0.25	194.78	0.0013	0.056		
		0.25	193.88	0.0013	0.056		
		0.25	194.12	0.0013	0.056		
C_3H_6	100	0.25	64.33	0.0039	0.170	0.170	0.00
		0.25	64.97	0.0038	0.168		
		0.25	64.49	0.0039	0.170		
		0.25	64.26	0.0039	0.170		
		0.25	64.75	0.0039	0.169		
CO_2	25	0.25	21.90	0.0114	2.00	2.00	0.00
		0.25	21.96	0.0114	1.99		
		0.25	21.90	0.0114	2.00		
		0.25	21.93	0.0114	2.00		
		0.25	21.97	0.0114	1.99		
	50	0.25	11.28	0.0222	1.94	1.95	0.01
		0.25	11.24	0.0222	1.95		
		0.25	11.23	0.0223	1.95		
		0.25	11.19	0.0223	1.96		
		0.25	11.23	0.0223	1.95		
	75	1	27.72	0.0361	2.11	2.10	0.01
		1	27.82	0.0359	2.10		
		1	27.69	0.0361	2.11		
		1	27.85	0.0359	2.10		
		1	27.85	0.0359	2.10		
	100	1	19.88	0.0503	2.20	2.19	0.01
		1	19.87	0.0503	2.20		
		1	20.03	0.0499	2.19		
		1	20.00	0.0500	2.19		
		1	20.03	0.0499	2.19		
	125	1	15.26	0.0655	2.30	2.29	0.01
		1	15.26	0.0655	2.30		
		1	15.35	0.0651	2.28		
		1	15.32	0.0653	2.29		
		1	15.29	0.0654	2.29		
	150	10	107.76	0.0928	2.71	2.71	0.00
		10	107.63	0.0929	2.71		
		10	107.88	0.0927	2.71		
		10	107.65	0.0929	2.71		
		10	107.71	0.0928	2.71		
	175	10	80.23	0.1246	3.12	3.12	0.00
		10	80.16	0.1248	3.12		
		10	80.14	0.1248	3.12		
		10	80.27	0.1246	3.12		
		10	80.10	0.1248	3.12		

Gas	P (psi)	vol. (ml)	time (sec)	Flow rate (ml/sec)	Permeance (GPU)	Average of Permeance (GPU)	STDEV of Permeance
CO_2	200	10	57.56	0.1737	3.80	3.80	0.00
		10	57.54	0.1738	3.80		
		10	57.62	0.1736	3.80		
		10	57.59	0.1736	3.80		
		10	57.55	0.1738	3.80		

Table B25 Selectivity at 100 psi and Slope of CO_2 permeance for NaY/CA MMM

Membrane	Selectivity		slope of CO_2 permeance's graph
	C_3H_6/C_3H_8	CO_2/CH_4	
CA membrane	2.166	14.113	0.0399
10%NaY-CA MMMs	3.866	20.057	0.0076
20%NaY-CA MMMs	6.305	20.262	0.0072
30%NaY-CA MMMs	3.152	25.360	0.0042
40%NaY-CA MMMs	3.007	19.559	0.0097

Table B26 10%Silicalite/CA MMM

Gas	P (psi)	vol. (ml)	time (sec)	Flow rate (ml/sec)	Permeance (GPU)	Average of Permeance (GPU)	STDEV of Permeance
N_2	50	0.25	673.91	0.0004	0.032	0.033	0.00
		0.25	669.27	0.0004	0.033		
		0.25	671.33	0.0004	0.033		
		0.25	675.81	0.0004	0.032		
		0.25	676.34	0.0004	0.032		
CH_4	100	0.25	284.44	0.0009	0.038	0.039	0.00
		0.25	286.25	0.0009	0.038		
		0.25	282.81	0.0009	0.039		
		0.25	281.06	0.0009	0.039		
		0.25	286.50	0.0009	0.038		
C_3H_8	100	0.25	823.75	0.0003	0.013	0.013	0.00
		0.25	815.38	0.0003	0.013		
		0.25	824.99	0.0003	0.013		
		0.25	827.32	0.0003	0.013		
		0.25	820.16	0.0003	0.013		
C_3H_6	100	0.25	185.53	0.0013	0.059	0.060	0.00
		0.25	179.88	0.0014	0.061		
		0.25	184.36	0.0014	0.059		
		0.25	184.22	0.0014	0.059		
		0.25	182.72	0.0014	0.060		
CO_2	25	0.25	95.78	0.0026	0.457	0.453	0.01
		0.25	98.50	0.0025	0.444		
		0.25	96.66	0.0026	0.453		
		0.25	96.79	0.0026	0.452		
		0.25	95.65	0.0026	0.458		
	50	0.25	48.63	0.0051	0.450	0.454	0.00
		0.25	48.31	0.0052	0.453		
		0.25	47.80	0.0052	0.458		
		0.25	48.22	0.0052	0.454		
		0.25	48.18	0.0052	0.454		

Gas	P (psi)	vol. (ml)	time (sec)	Flow rate (ml/sec)	Permeance (GPU)	Average of Permeance (GPU)	STDEV of Permeance
CO_2	75	0.25	32.17	0.0078	0.454	0.451	0.00
		0.25	32.43	0.0077	0.450		
		0.25	32.45	0.0077	0.450		
		0.25	32.49	0.0077	0.449		
		0.25	32.27	0.0077	0.452		
	100	0.25	21.11	0.0118	0.518	0.522	0.00
		0.25	20.87	0.0120	0.524		
		0.25	20.97	0.0119	0.522		
		0.25	20.83	0.0120	0.525		
		0.25	21.08	0.0119	0.519		
	125	1	42.39	0.0236	0.826	0.825	0.00
		1	42.44	0.0236	0.825		
		1	42.58	0.0235	0.823		
		1	42.51	0.0235	0.824		
		1	42.47	0.0235	0.825		
	150	1	29.47	0.0339	0.990	0.997	0.01
		1	29.00	0.0345	1.006		
		1	29.27	0.0342	0.997		
		1	29.38	0.0340	0.993		
		1	29.32	0.0341	0.995		
	175	1	23.64	0.0423	1.058	1.056	0.00
		1	23.72	0.0422	1.055		
		1	23.62	0.0423	1.059		
		1	23.74	0.0421	1.054		
		1	23.69	0.0422	1.056		
	200	1	17.81	0.0561	1.229	1.224	0.00
		1	17.97	0.0556	1.218		
		1	17.84	0.0561	1.227		
		1	17.93	0.0558	1.221		
		1	17.91	0.0558	1.222		

Table B27 20%Silicalite/CA MMM

Gas	P (psi)	vol. (ml)	time (sec)	Flow rate (ml/sec)	Permeance (GPU)	Average of Permeance (GPU)	STDEV of Permeance
N_2	50	0.25	430.04	0.0006	0.051	0.051	0.00
		0.25	435.81	0.0006	0.050		
		0.25	431.33	0.0006	0.051		
		0.25	432.16	0.0006	0.051		
		0.25	435.37	0.0006	0.050		
CH_4	100	0.25	198.18	0.0013	0.055	0.056	0.00
		0.25	197.34	0.0013	0.055		
		0.25	195.72	0.0013	0.056		
		0.25	196.11	0.0013	0.056		
		0.25	194.24	0.0013	0.056		
C_3H_8	100	0.25	418.10	0.0006	0.026	0.026	0.00
		0.25	422.51	0.0006	0.026		
		0.25	424.77	0.0006	0.026		
		0.25	421.87	0.0006	0.026		
		0.25	418.90	0.0006	0.026		

Gas	P (psi)	vol. (ml)	time (sec)	Flow rate (ml/sec)	Permeance (GPU)	Average of Permeance (GPU)	STDEV of Permeance
C_3H_6	100	0.25	106.73	0.0023	0.103	0.102	0.00
		0.25	106.05	0.0024	0.103		
		0.25	108.48	0.0023	0.101		
		0.25	107.14	0.0023	0.102		
		0.25	105.67	0.0024	0.104		
CO_2	25	0.25	85.69	0.0029	0.511	0.510	0.00
		0.25	86.00	0.0029	0.509		
		0.25	85.90	0.0029	0.510		
		0.25	85.72	0.0029	0.511		
		0.25	85.83	0.0029	0.510		
	50	0.25	41.62	0.0060	0.526	0.529	0.00
		0.25	41.11	0.0061	0.532		
		0.25	41.49	0.0060	0.528		
		0.25	41.67	0.0060	0.525		
		0.25	41.14	0.0061	0.532		
	75	0.25	24.86	0.0101	0.587	0.593	0.00
		0.25	24.44	0.0102	0.597		
		0.25	24.49	0.0102	0.596		
		0.25	24.58	0.0102	0.594		
		0.25	24.70	0.0101	0.591		
	100	0.25	14.88	0.0168	0.736	0.737	0.01
		0.25	14.99	0.0167	0.730		
		0.25	14.68	0.0170	0.746		
		0.25	14.80	0.0169	0.740		
		0.25	14.92	0.0168	0.734		
	125	1	32.16	0.0311	1.089	1.079	0.01
		1	32.70	0.0306	1.071		
		1	32.50	0.0308	1.078		
		1	32.55	0.0307	1.076		
		1	32.34	0.0309	1.083		
	150	1	21.40	0.0467	1.364	1.369	0.00
		1	21.31	0.0469	1.370		
		1	21.25	0.0471	1.374		
		1	21.24	0.0471	1.374		
		1	21.39	0.0468	1.365		
	175	1	17.46	0.0573	1.433	1.435	0.01
		1	17.46	0.0573	1.433		
		1	17.30	0.0578	1.446		
		1	17.58	0.0569	1.423		
		1	17.40	0.0575	1.438		
	200	1	14.38	0.0695	1.522	1.528	0.01
		1	14.40	0.0694	1.520		
		1	14.28	0.0700	1.533		
		1	14.31	0.0699	1.530		
		1	14.26	0.0701	1.535		

Table B28 30%Silicalite/CA MMM

Gas	P (psi)	vol. (ml)	time (sec)	Flow rate (ml/sec)	Permeance (GPU)	Average of Permeance (GPU)	STDEV of Permeance
N_2	50	0.25	402.76	0.0006	0.054	0.054	0.00
		0.25	401.38	0.0006	0.055		
		0.25	404.60	0.0006	0.054		
		0.25	405.73	0.0006	0.054		
		0.25	402.35	0.0006	0.054		
CH_4	100	0.25	142.16	0.0018	0.077	0.077	0.00
		0.25	144.60	0.0017	0.076		
		0.25	141.72	0.0018	0.077		
		0.25	141.09	0.0018	0.078		
		0.25	143.47	0.0017	0.076		
C_3H_8	100	0.25	310.66	0.0008	0.035	0.035	0.00
		0.25	317.88	0.0008	0.034		
		0.25	315.91	0.0008	0.035		
		0.25	318.01	0.0008	0.034		
		0.25	309.87	0.0008	0.035		
C_3H_6	100	0.25	88.44	0.0028	0.124	0.124	0.00
		0.25	89.71	0.0028	0.122		
		0.25	87.40	0.0029	0.125		
		0.25	87.75	0.0028	0.125		
		0.25	88.86	0.0028	0.123		
CO_2	25	0.25	50.41	0.0050	0.87	0.86	0.02
		0.25	49.92	0.0050	0.88		
		0.25	51.22	0.0049	0.85		
		0.25	50.75	0.0049	0.86		
		0.25	52.54	0.0048	0.83		
	50	0.25	21.94	0.0114	1.00	1.00	0.01
		0.25	21.50	0.0116	1.02		
		0.25	21.81	0.0115	1.00		
		0.25	21.79	0.0115	1.00		
		0.25	21.89	0.0114	1.00		
	75	0.25	15.47	0.0162	0.94	0.94	0.01
		0.25	15.71	0.0159	0.93		
		0.25	15.56	0.0161	0.94		
		0.25	15.56	0.0161	0.94		
		0.25	15.61	0.0160	0.93		
	100	0.25	10.53	0.0237	1.04	1.02	0.01
		0.25	10.83	0.0231	1.01		
		0.25	10.76	0.0232	1.02		
		0.25	10.79	0.0232	1.01		
		0.25	10.91	0.0229	1.00		
	125	1	28.87	0.0346	1.21	1.22	0.01
		1	28.76	0.0348	1.22		
		1	28.63	0.0349	1.22		
		1	28.91	0.0346	1.21		
		1	28.90	0.0346	1.21		
	150	1	18.28	0.0547	1.60	1.59	0.01
		1	18.35	0.0545	1.59		
		1	18.43	0.0543	1.58		
		1	18.25	0.0548	1.60		
		1	18.35	0.0545	1.59		

Gas	P (psi)	vol. (ml)	time (sec)	Flow rate (ml/sec)	Permeance (GPU)	Average of Permeance (GPU)	STDEV of Permeance
CO_2	175	1	14.71	0.0680	1.70	1.70	0.00
		1	14.71	0.0680	1.70		
		1	14.80	0.0676	1.69		
		1	14.75	0.0678	1.70		
		1	14.74	0.0678	1.70		
	200	1	11.06	0.0904	1.98	1.99	0.01
		1	11.00	0.0909	1.99		
		1	10.96	0.0912	2.00		
		1	11.02	0.0907	1.99		
		1	11.03	0.0907	1.98		

Table B29 40%Silicalite/CA MMM

Gas	P (psi)	vol. (ml)	time (sec)	Flow rate (ml/sec)	Permeance (GPU)	Average of Permeance (GPU)	STDEV of Permeance
N_2	50	0.25	175.99	0.0014	0.124	0.124	0.00
		0.25	176.89	0.0014	0.124		
		0.25	176.09	0.0014	0.124		
		0.25	175.25	0.0014	0.125		
		0.25	177.71	0.0014	0.123		
CH_4	100	0.25	42.50	0.0059	0.258	0.258	0.00
		0.25	42.28	0.0059	0.259		
		0.25	42.37	0.0059	0.258		
		0.25	42.78	0.0058	0.256		
		0.25	42.53	0.0059	0.257		
C_3H_8	100	0.25	62.25	0.0040	0.176	0.176	0.00
		0.25	62.37	0.0040	0.175		
		0.25	62.60	0.0040	0.175		
		0.25	62.07	0.0040	0.176		
		0.25	62.23	0.0040	0.176		
C_3H_6	100	0.25	49.38	0.0051	0.222	0.223	0.00
		0.25	48.83	0.0051	0.224		
		0.25	49.13	0.0051	0.223		
		0.25	48.96	0.0051	0.224		
		0.25	48.71	0.0051	0.225		
CO_2	25	0.25	68.37	0.0037	0.64	0.64	0.01
		0.25	67.90	0.0037	0.64		
		0.25	67.34	0.0037	0.65		
		0.25	69.27	0.0036	0.63		
		0.25	67.84	0.0037	0.65		
	50	0.25	28.00	0.0089	0.78	0.77	0.01
		0.25	28.71	0.0087	0.76		
		0.25	28.74	0.0087	0.76		
		0.25	28.24	0.0089	0.78		
		0.25	28.49	0.0088	0.77		
	75	0.25	12.10	0.0207	1.21	1.21	0.01
		0.25	11.98	0.0209	1.22		
		0.25	12.03	0.0208	1.21		
		0.25	11.92	0.0210	1.22		
		0.25	12.05	0.0207	1.21		

Gas	P (psi)	vol. (ml)	time (sec)	Flow rate (ml/sec)	Permeance (GPU)	Average of Permeance (GPU)	STDEV of Permeance
CO_2	100	0.25	6.26	0.0399	1.75	1.74	0.01
		0.25	6.31	0.0396	1.73		
		0.25	6.27	0.0399	1.75		
		0.25	6.25	0.0400	1.75		
		0.25	6.30	0.0397	1.74		
	125	1	17.41	0.0574	2.01	1.99	0.01
		1	17.65	0.0567	1.98		
		1	17.69	0.0565	1.98		
		1	17.47	0.0572	2.00		
		1	17.59	0.0569	1.99		
	150	1	13.50	0.0741	2.16	2.14	0.01
		1	13.66	0.0732	2.14		
		1	13.68	0.0731	2.13		
		1	13.58	0.0736	2.15		
		1	13.63	0.0734	2.14		
	175	1	11.33	0.0883	2.21	2.20	0.00
		1	11.37	0.0880	2.20		
		1	11.37	0.0880	2.20		
		1	11.34	0.0882	2.21		
		1	11.39	0.0878	2.20		
	200	1	9.57	0.1045	2.29	2.29	0.01
		1	9.57	0.1045	2.29		
		1	9.53	0.1049	2.30		
		1	9.60	0.1042	2.28		
		1	9.54	0.1048	2.29		

Table B30 Selectivity at 100 psi and slope of CO_2 permeance for Silicalite/CA MMM

Membrane	Selectivity		slope of CO_2 permeance's graph
	C_3H_6/C_3H_8	CO_2/CH_4	
CA membrane	2.166	14.113	0.0399
10%Silicalite-CA MMMs	4.486	13.552	0.0049
20%Silicalite-CA MMMs	3.944	13.217	0.0068
30%Silicalite-CA MMMs	3.556	13.249	0.0064
40%Silicalite-CA MMMs	1.271	6.768	0.0103

Table B31 30%PEG/10%NaX/CA MMM

Gas	P (psi)	vol. (ml)	time (sec)	Flow rate (ml/sec)	Permeance (GPU)	Average of Permeance (GPU)	STDEV of Permeance
N_2	50	0.25	168.27	0.0015	0.130	0.131	0.00
		0.25	167.10	0.0015	0.131		
		0.25	167.73	0.0015	0.131		
		0.25	166.80	0.0015	0.131		
		0.25	165.76	0.0015	0.132		
CH_4	100	0.25	92.11	0.0027	0.119	0.120	0.00
		0.25	90.46	0.0028	0.121		
		0.25	91.74	0.0027	0.119		
		0.25	92.08	0.0027	0.119		
		0.25	90.03	0.0028	0.122		

Gas	P (psi)	vol. (ml)	time (sec)	Flow rate (ml/sec)	Permeance (GPU)	Average of Permeance (GPU)	STDEV of Permeance
C_3H_8	100	0.25	196.01	0.0013	0.056	0.056	0.00
		0.25	199.32	0.0013	0.055		
		0.25	195.74	0.0013	0.056		
		0.25	195.41	0.0013	0.056		
		0.25	199.25	0.0013	0.055		
C_3H_6	100	0.25	184.14	0.0014	0.059	0.059	0.00
		0.25	182.94	0.0014	0.060		
		0.25	186.49	0.0013	0.059		
		0.25	180.27	0.0014	0.061		
		0.25	186.31	0.0013	0.059		
CO_2	25	10	281.31	0.0355	6.225	6.244	0.03
		10	280.30	0.0357	6.248		
		10	278.19	0.0359	6.295		
		10	281.63	0.0355	6.218		
		10	280.91	0.0356	6.234		
	50	10	140.17	0.0713	6.247	6.229	0.07
		10	139.50	0.0717	6.277		
		10	142.83	0.0700	6.131		
		10	138.89	0.0720	6.304		
		10	141.52	0.0707	6.187		
	75	10	91.14	0.1097	6.405	6.336	0.10
		10	94.48	0.1058	6.179		
		10	91.36	0.1095	6.390		
		10	92.64	0.1079	6.301		
		10	91.11	0.1098	6.407		
	100	10	70.95	0.1409	6.171	6.134	0.04
		10	71.61	0.1396	6.114		
		10	71.42	0.1400	6.130		
		10	72.08	0.1387	6.074		
		10	70.83	0.1412	6.181		
	125	10	55.40	0.1805	6.322	6.285	0.03
		10	55.94	0.1788	6.261		
		10	55.69	0.1796	6.289		
		10	55.99	0.1786	6.256		
		10	55.64	0.1797	6.295		
	150	10	44.14	0.2266	6.613	6.611	0.01
		10	44.08	0.2269	6.622		
		10	44.21	0.2262	6.602		
		10	44.27	0.2259	6.593		
		10	44.05	0.2270	6.626		
	175	10	36.74	0.2722	6.809	6.823	0.02
		10	36.61	0.2731	6.834		
		10	36.68	0.2726	6.821		
		10	36.52	0.2738	6.851		
		10	36.80	0.2717	6.798		
	200	10	30.99	0.3227	7.064	7.038	0.02
		10	31.15	0.3210	7.028		
		10	31.12	0.3213	7.034		
		10	31.09	0.3216	7.041		
		10	31.18	0.3207	7.021		

Table B32 30%PEG/20%NaX/CA MMM

Gas	P (psi)	vol. (ml)	time (sec)	Flow rate (ml/sec)	Permeance (GPU)	Average of Permeance (GPU)	STDEV of Permeance
N_2	50	0.25	109.94	0.0023	0.199	0.200	0.00
		0.25	108.31	0.0023	0.202		
		0.25	108.99	0.0023	0.201		
		0.25	110.10	0.0023	0.199		
		0.25	109.08	0.0023	0.201		
CH_4	100	0.25	60.87	0.0041	0.180	0.181	0.00
		0.25	60.31	0.0041	0.181		
		0.25	60.27	0.0041	0.182		
		0.25	60.74	0.0041	0.180		
		0.25	60.55	0.0041	0.181		
C_3H_8	100	0.25	147.32	0.0017	0.074	0.074	0.00
		0.25	149.21	0.0017	0.073		
		0.25	149.30	0.0017	0.073		
		0.25	148.22	0.0017	0.074		
		0.25	148.59	0.0017	0.074		
C_3H_6	100	0.25	139.35	0.0018	0.079	0.079	0.00
		0.25	139.93	0.0018	0.078		
		0.25	138.81	0.0018	0.079		
		0.25	139.45	0.0018	0.078		
		0.25	139.18	0.0018	0.079		
CO_2	25	10	295.55	0.0338	5.925	5.914	0.01
		10	296.56	0.0337	5.905		
		10	296.98	0.0337	5.897		
		10	296.26	0.0338	5.911		
		10	295.29	0.0339	5.931		
	50	10	139.20	0.0718	6.290	6.276	0.02
		10	139.74	0.0716	6.266		
		10	139.10	0.0719	6.295		
		10	139.66	0.0716	6.270		
		10	139.89	0.0715	6.259		
	75	10	92.42	0.1082	6.316	6.311	0.02
		10	92.76	0.1078	6.293		
		10	92.85	0.1077	6.287		
		10	92.17	0.1085	6.333		
		10	92.28	0.1084	6.326		
	100	10	67.90	0.1473	6.448	6.471	0.02
		10	67.32	0.1485	6.504		
		10	67.83	0.1474	6.455		
		10	67.46	0.1482	6.490		
		10	67.79	0.1475	6.458		
	125	10	52.15	0.1918	6.716	6.726	0.02
		10	51.97	0.1924	6.740		
		10	52.22	0.1915	6.707		
		10	52.18	0.1916	6.712		
		10	51.87	0.1928	6.753		
	150	10	41.77	0.2394	6.988	6.974	0.02
		10	41.89	0.2387	6.968		
		10	42.03	0.2379	6.944		
		10	41.81	0.2392	6.981		
		10	41.75	0.2395	6.991		

Gas	P (psi)	vol. (ml)	time (sec)	Flow rate (ml/sec)	Permeance (GPU)	Average of Permeance (GPU)	STDEV of Permeance
CO_2	175	10	34.13	0.2930	7.330	7.308	0.02
		10	34.30	0.2915	7.294		
		10	34.32	0.2914	7.290		
		10	34.22	0.2922	7.311		
		10	34.19	0.2925	7.317		
	200	10	29.91	0.3343	7.319	7.325	0.02
		10	29.85	0.3350	7.334		
		10	29.79	0.3357	7.348		
		10	29.91	0.3343	7.319		
		10	29.97	0.3337	7.304		

Table B33 30%PEG/30%NaX/CA MMM

Gas	P (psi)	vol. (ml)	time (sec)	Flow rate (ml/sec)	Permeance (GPU)	Average of Permeance (GPU)	STDEV of Permeance
N_2	50	0.25	120.59	0.0021	0.182	0.183	0.00
		0.25	118.22	0.0021	0.185		
		0.25	117.44	0.0021	0.186		
		0.25	121.53	0.0021	0.180		
		0.25	120.71	0.0021	0.181		
CH_4	100	0.25	46.12	0.0054	0.237	0.238	0.00
		0.25	45.63	0.0055	0.240		
		0.25	46.28	0.0054	0.237		
		0.25	45.54	0.0055	0.240		
		0.25	46.28	0.0054	0.237		
C_3H_8	100	0.25	28.87	0.0087	0.379	0.380	0.00
		0.25	28.85	0.0087	0.379		
		0.25	28.91	0.0086	0.379		
		0.25	28.63	0.0087	0.382		
		0.25	28.81	0.0087	0.380		
C_3H_6	100	0.25	24.29	0.0103	0.451	0.452	0.00
		0.25	24.13	0.0104	0.454		
		0.25	24.27	0.0103	0.451		
		0.25	24.17	0.0103	0.453		
		0.25	24.31	0.0103	0.450		
CO_2	25	1	40.01	0.0250	4.38	4.39	0.01
		1	39.97	0.0250	4.38		
		1	39.87	0.0251	4.39		
		1	39.90	0.0251	4.39		
		1	39.83	0.0251	4.40		
	50	1	19.89	0.0503	4.40	4.42	0.03
		1	19.68	0.0508	4.45		
		1	19.72	0.0507	4.44		
		1	19.92	0.0502	4.40		
		1	19.95	0.0501	4.39		
	75	1	13.02	0.0768	4.48	4.45	0.03
		1	13.16	0.0760	4.44		
		1	13.15	0.0760	4.44		
		1	13.27	0.0754	4.40		
		1	13.04	0.0767	4.48		

Gas	P (psi)	vol. (ml)	time (sec)	Flow rate (ml/sec)	Permeance (GPU)	Average of Permeance (GPU)	STDEV of Permeance
CO_2	100	1	8.67	0.1153	5.05	5.11	0.04
		1	8.54	0.1171	5.13		
		1	8.49	0.1178	5.16		
		1	8.58	0.1166	5.10		
		1	8.52	0.1174	5.14		
	125	10	60.13	0.1663	5.82	5.83	0.03
		10	59.75	0.1674	5.86		
		10	60.26	0.1659	5.81		
		10	59.66	0.1676	5.87		
		10	60.47	0.1654	5.79		
	150	10	48.91	0.2045	5.97	6.01	0.03
		10	48.13	0.2078	6.06		
		10	48.59	0.2058	6.01		
		10	48.52	0.2061	6.02		
		10	48.61	0.2057	6.00		
	175	10	39.41	0.2537	6.35	6.36	0.02
		10	39.12	0.2556	6.40		
		10	39.45	0.2535	6.34		
		10	39.37	0.2540	6.35		
		10	39.22	0.2550	6.38		
	200	10	33.60	0.2976	6.52	6.51	0.01
		10	33.72	0.2966	6.49		
		10	33.58	0.2978	6.52		
		10	33.56	0.2980	6.52		
		10	33.61	0.2975	6.51		

Table B34 30%PEG/40%NaX/CA MMM

Gas	P (psi)	vol. (ml)	time (sec)	Flow rate (ml/sec)	Permeance (GPU)	Average of Permeance (GPU)	STDEV of Permeance
N_2	50	0.25	106.12	0.0024	0.206	0.204	0.00
		0.25	107.03	0.0023	0.205		
		0.25	108.65	0.0023	0.201		
		0.25	107.63	0.0023	0.203		
		0.25	106.92	0.0023	0.205		
CH_4	100	0.25	42.90	0.0058	0.255	0.257	0.00
		0.25	42.80	0.0058	0.256		
		0.25	43.10	0.0058	0.254		
		0.25	42.19	0.0059	0.259		
		0.25	42.07	0.0059	0.260		
C_3H_8	100	0.25	29.54	0.0085	0.371	0.370	0.00
		0.25	29.57	0.0085	0.370		
		0.25	29.63	0.0084	0.369		
		0.25	29.48	0.0085	0.371		
		0.25	29.71	0.0084	0.368		

Gas	P (psi)	vol. (ml)	time (sec)	Flow rate (ml/sec)	Permeance (GPU)	Average of Permeance (GPU)	STDEV of Permeance
C_3H_6	100	0.25	25.57	0.0098	0.428	0.429	0.00
		0.25	25.71	0.0097	0.426		
		0.25	25.63	0.0098	0.427		
		0.25	25.19	0.0099	0.435		
		0.25	25.44	0.0098	0.430		
CO_2	25	1	51.81	0.0193	3.38	3.38	0.01
		1	51.87	0.0193	3.38		
		1	51.69	0.0193	3.39		
		1	51.75	0.0193	3.38		
		1	51.59	0.0194	3.39		
	50	1	20.87	0.0479	4.20	4.21	0.03
		1	20.52	0.0487	4.27		
		1	20.87	0.0479	4.20		
		1	20.74	0.0482	4.22		
		1	20.91	0.0478	4.19		
	75	1	12.96	0.0771	4.50	4.52	0.04
		1	12.75	0.0785	4.58		
		1	12.96	0.0771	4.50		
		1	12.88	0.0776	4.53		
		1	12.99	0.0770	4.49		
	100	1	9.04	0.1106	4.84	4.86	0.04
		1	8.89	0.1125	4.93		
		1	9.04	0.1106	4.84		
		1	8.98	0.1113	4.87		
		1	9.06	0.1104	4.83		
	125	1	6.92	0.1445	5.06	5.05	0.03
		1	7.00	0.1428	5.00		
		1	6.92	0.1445	5.06		
		1	6.88	0.1454	5.09		
		1	6.93	0.1443	5.05		
	150	1	5.48	0.1826	5.33	5.35	0.04
		1	5.38	0.1857	5.42		
		1	5.48	0.1826	5.33		
		1	5.44	0.1838	5.36		
		1	5.49	0.1823	5.32		
	175	1	4.47	0.2236	5.59	5.62	0.04
		1	4.40	0.2273	5.69		
		1	4.47	0.2236	5.59		
		1	4.45	0.2249	5.63		
		1	4.48	0.2231	5.58		
	200	1	3.66	0.2730	5.98	6.00	0.05
		1	3.60	0.2777	6.08		
		1	3.66	0.2730	5.98		
		1	3.64	0.2747	6.01		
		1	3.67	0.2725	5.97		

Table B35 Selectivity at 100 psi and Slope of CO_2 permeance for 30%PEG/NaX/CA MMM

Membrane	Selectivity		slope of CO_2 permeance's graph
	C_3H_6/C_3H_8	CO_2/CH_4	
CA membrane	2.166	14.113	0.0399
30%PEG-10%NaX-CA MMMs	1.071	51.153	0.0045
30%PEG-20%NaX-CA MMMs	1.066	35.795	0.0082
30%PEG-30%NaX-CA MMMs	1.189	21.481	0.0133
30%PEG-40%NaX-CA MMMs	1.160	18.935	0.0143

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Presentations:

1. Tanupabrungsun, T., Rirksomboon, T., and Kulprathipanja, S. (2006) Mixed Matrix Membranes for Gas Separation. Poster presented at AIChE Annual 2006 Meeting, November 12-17, Hilton Hotel, San Francisco, CA, USA, Paper 315b.
2. Tanupabrungsun, T., Kamonchaivanich, P., and Pongstabodee, S. (2004) "Destabilisation of waste coolant emulsions and separation by coagulation and flocculation" Regional Symposium on Chemical Engineering 2004 in conjunction with the 14th National Chemical Engineering and applied Chemical Conference, 1-3 December 2004, The grand Hotel, Bangkok Thailand, ES094.