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APPENDICES

APPENDIX A

Material Properties

Table A1 Physical Properties of the chemicals used in the experiments.

Chemical	Density (g/ml)	b.p. (C)	MW	Molecular formular
PX	0.8660	138	106.16	C ₈ H ₁₀
MX	0.8670	139	106.16	C ₈ H ₁₀
OX	0.8780	143-145	106.16	C ₈ H ₁₀
EB	0.8670	136	106.16	C ₈ H ₁₀
n-C ₉	0.7176	151	128.25	C ₉ H ₂₀
Toluene	0.8669	109.6-111.6	92.14	C ₇ H ₈
hexane	0.65	68.5-69.5	86.17	C ₆ H ₁₄
hexene	0.678	62-65	84.16	C ₆ H ₁₂
iso-octane	0.69	98-99	114.23	C ₈ H ₁₈
octane	0.7	125-127	114.23	C ₈ H ₁₈
octene	0.715	121-123	112.21	C ₈ H ₁₆
NMP	1.03	202.2	99.13	C ₅ H ₉ NO

Table A2 Physical , chemical , stability , and reactivity properties of Polyimide (Ultem 1000).

Physical state	Solid
m.p.	340°F
Vapor pressure (mmHg)	Negligible
Specific gravity	>1
Water solubility	Insoluble
% Volatiles	Negligible
Evaporation rate	Negligible
Stability	Stable
Reactivity	Not reactive

Note: Data from Material Safety Data Sheet, General Electric Co. (GE).

APPENDIX B

Membrane Separation Results from Extraction Unit

Table B1 Concentration of each component (wt%) in the retentate and permeate versus time using Polyimide membrane.

time (hr)	wt % of retentate					
	n-C ₉	EB	PX	MX	OX	I-octane
0	18.976	20.277	20.225	20.191	20.333	0.000
16	19.024	20.224	20.191	20.186	20.375	0.000
34	19.065	20.219	20.180	20.178	20.360	0.000

time (hr)	wt % of permeate				
	n-C ₉	EB	PX	MX	OX
0					
16	19.419	20.104	20.115	20.081	20.281
34	19.330	20.161	20.095	20.100	20.316

Feed composition: n-C₉:EB:PX:OX:MX = 1:1:1:1:1

Desorbent : iso-octane

Table B2 Concentration of each component (wt%) in the retentate and permeate versus time using 20 wt%Silicalite/Polyimide membrane.

time (hr)	wt % of retentate					
	n-C ₉	EB	PX	MX	OX	I-octane
0	18.915	20.361	20.135	20.499	20.091	0.000
1	18.920	20.420	20.069	20.524	20.067	0.000
17	19.158	20.191	19.980	20.478	20.193	0.000

time (hr)	wt % of permeate				
	n-C ₉	EB	PX	MX	OX
0					
1	19.529	20.211	19.892	20.335	20.034
17	19.647	20.231	19.585	20.355	20.181

Feed composition: n-C₉:EB:PX:OX:MX = 1:1:1:1:1

Desorbent : iso-octane

Table B3 Concentration of each component (wt%) in the retentate and permeate versus time using 20 wt%KY/Polyimide membrane.

time (hr)	wt % of retentate					
	n-C ₉	EB	PX	MX	OX	I-octane
0	18.897	20.415	20.066	20.539	20.081	0.000
2	18.963	20.393	20.002	20.508	20.134	0.000
17	19.066	20.368	20.019	20.499	20.048	0.000

time (hr)	wt % of permeate				
	n-C ₉	EB	PX	MX	OX
0					
2	18.963	20.393	20.002	20.508	20.134
17	18.737	20.503	19.945	20.557	20.257

Feed composition: n-C₉:EB:PX:OX:MX = 1:1:1:1:1

Desorbent : iso-octane

Table B4 Concentration of each component (wt%) in the retentate and permeate versus time using 20 wt%NaX/Polyimide membrane.

time (hr)	wt % of retentate					
	n-C ₉	EB	PX	MX	OX	I-octane
0	18.862	20.281	20.079	20.748	20.032	0.000
0.5	18.953	20.186	20.022	20.742	20.098	0.000
1.5	19.041	20.138	20.002	20.722	20.097	0.000

time (hr)	wt % of permeate				
	n-C ₉	EB	PX	MX	OX
0					
0.5	19.065	20.075	19.644	21.285	19.931
1.5	19.353	20.138	20.146	20.093	20.270

Feed composition: n-C₉:EB:PX:OX:MX = 1:1:1:1:1

Desorbent : iso-octane

APPENDIX C

Membrane Separation Results from Pervaporation Unit

Table C1 Concentration of each component (wt%) in the charger and permeate using Polyimide membrane. Feed composition (wt. ratio) octane : octene : n-C₉: EB: PX: MX: OX = 2:2:1:1:1:1:1.

Sample	Temperature (°C)	Charger						
		wt% octane	wt% octene	wt% n-C ₉	wt% EB	wt% PX	wt% MX	wt% OX
0	21	19.522	19.803	11.346	12.394	11.917	12.962	12.055
1	21	19.545	19.831	11.287	12.412	11.923	12.966	12.035
2	21	19.552	19.837	11.291	12.412	11.924	12.965	12.018
3	21	19.544	50.351	11.289	12.416	11.927	12.967	12.036
4	21	19.549	50.340	11.296	12.407	11.929	12.972	12.029
5	40	19.504	50.341	11.313	12.436	11.952	12.994	12.028
6	40	19.496	50.374	11.323	12.410	11.929	12.978	12.073
7	40	19.513	50.370	11.316	12.412	11.931	12.978	12.045
8	40	19.479	50.342	11.331	12.428	11.948	12.994	12.072

Sample	Temperature (°C)	Permeate						
		wt% octane	wt% octene	wt% n-C ₉	wt% EB	wt% PX	wt% MX	wt% OX
0	21							
1	21	18.437	18.712	11.768	12.804	12.341	13.428	12.509
2	21	19.062	19.336	11.484	12.592	12.113	13.174	12.239
3	21	19.360	19.660	11.371	12.467	11.986	13.034	12.121
4	21	19.471	19.753	11.339	12.431	11.947	12.991	12.066
5	40	19.300	19.596	11.386	12.494	12.013	13.062	12.148
6	40	19.455	19.739	11.330	12.439	11.955	13.003	12.081
7	40	19.418	19.696	11.348	12.450	11.972	13.017	12.098
8	40	19.479	19.746	11.319	12.443	11.960	12.996	12.055

Table C2 Separation factors of polyimide membrane. Feed composition (wt. ratio)
octane : octene : n-C₉: EB: PX: MX: OX = 2:2:1:1:1:1:1.

Temperature (°C)	Average of separation factor with respect to n-octane at each temperature				
	EB	PX	MX	OX	octene
21	1.04	1.04	1.04	1.04	0.85
40	1.01	1.01	1.01	1.01	0.39
70	1.00	1.00	1.00	1.00	0.39

Pressure inlet: 1200 psi

Feed flowrate: 9 ml/min

Table C3 Concentration of each component (wt%) in the charger and permeate using polyimide membrane. Feed composition (wt. ratio) = octane : octene : PX = 1:1:1.

Sample	Temperature (°C)	Charger		
		wt% octane	wt% octene	wt% PX
0	21	32.737	31.993	35.269
1	21	32.741	31.919	35.340
2	40	32.755	32.012	35.233

Sample	Temperature (°C)	Permeate		
		wt% octane	wt% octene	wt% PX
1	21	27.438	21.017	51.545
2	40	32.905	32.102	34.993

Table C4 Separation factor of polyimide membrane. Feed composition (wt. ratio) = octane : octene : PX = 1:1:1

			Separation factor		
			octane	octene	PX
Temperature (°C)	21	octane	1.00	0.78	1.74
		octene	1.28	1.00	2.22
		PX	0.57	0.45	1.00
	40	octane	1.00	1.00	0.99
		octene	1.00	1.00	0.98
		PX	1.01	1.02	1.00

Pressure inlet: 1200 psi

Feed flowrate: 9 ml/min

Table C5 Concentration of each component (wt%) in the charger and permeate using 20 wt%NaY/Polyimide MMM. Feed composition (wt. ratio) = octane : octene : PX = 1:1:1.

Sample	Temperature (°C)	Charger		
		wt% octane	wt% octene	wt% PX
0	21	32.726	31.998	35.275
1	54	32.755	32.012	35.233
2	60	32.747	32.011	35.243

Sample	Temperature (°C)	Permeate		
		wt% octane	wt% octene	wt% PX
1	21	26.786	21.637	51.577
2	40	32.973	32.010	35.018

Table C6 Separation factor of 20 wt%NaY/polyimide MMM. Feed composition (wt. ratio) = octane : octene : PX = 1:1:1.

			Separation factor		
			octane	octene	PX
Temperature (°C)	54	octane	1.00	0.83	1.79
		octene	1.21	1.00	2.16
		PX	0.56	0.46	1.00
	60	octane	1.00	0.99	0.99
		octene	1.01	1.00	0.99
		PX	1.01	1.01	1.00

Pressure inlet: 1200 psi

Feed flowrate: 9 ml/min

Table C7 Concentration of each component (wt%) in the charger and permeate using 20 wt%Silicalite/Polyimide MMM. Feed composition (wt. ratio) = octane : octene : PX = 1:1:1.

Sample	Temperature (°C)	Charger		
		wt% octane	wt% octene	wt% PX
0	40	32.706	31.845	35.448
1	40	32.792	31.892	35.317
2	40	32.736	31.886	35.377

Sample	Temperature (°C)	Permeate		
		wt% octane	wt% octene	wt% PX
1	40	33.515	33.270	33.214
2	40	27.221	20.676	52.103

Table C8 Separation factor of 20 wt%Silicalite/polyimide MMM. Feed composition (wt. ratio) = octane : octene : PX = 1:1:1.

			Separation factor		
			octane	octene	PX
Temperature (°C)	40	octane	1.00	0.78	1.78
		octene	1.28	1.00	2.28
		PX	0.56	0.44	1.00

Pressure inlet: 1200 psi

Feed flowrate: 9 ml/min

Table C9 Concentration of each component (wt%) in the charger and permeate using 20 wt%AC/Polyimide MMM. Feed composition (wt. ratio) = octane : octene : PX = 1:1:1.

Sample	Temperature (°C)	Charger		
		wt% octane	wt% octene	wt% PX
0	21	32.729	31.917	35.355
1	21	32.752	31.902	35.347
2	40	32.736	31.886	35.377

Sample	Temperature (°C)	Permeate		
		wt% octane	wt% octene	wt% PX
1	21	33.307	30.488	36.204
2	40	32.770	31.874	35.357

Table C10 Separation factor of 20 wt%AC/polyimide MMM. Feed composition (wt. ratio) = octane : octene : PX = 1:1:1.

			Separation factor		
			octane	octene	PX
Temperature (°C)	21	octane	1.00	0.94	1.01
		octene	1.07	1.00	1.07
		PX	0.99	0.93	1.00
	40	octane	1.00	1.00	1.00
		octene	1.00	1.00	1.00
		PX	1.00	1.00	1.00

Pressure inlet: 1200 psi

Feed flowrate: 9 ml/min

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