REFERENCES

Alchin, D. (2008) Ion exchange resins. XIII-Water-D-Ion Exchange Resins, 1-7.

Carmona, M., García, M. M. T., Alcázar, Á. Á., Carnicer, Á. Á., and Rodriguez, J. F. (2012) Combining ion exchange and water adsorption processes for high grade glycerol from biodiesel. Journal of Chemical Science and Technology, 1(1),14-20.

Carmona, M., Valverde, J. L., Pérez, A., Warchol, J., and Rodriguez, J. F. (2009) Purification of glycerol/water solutions from biodiesel synthesis by ion exchange: sodium removal Part I. Journal of Chemical Technology and Biotechnology, 84(5), 738-744.

Carmona, M., Valverde, J. L., Pérez, A., Warchol, J., and Rodriguez, J. F. (2009) Purification of glycerol/water solutions from biodiesel synthesis by ion exchange: sodium removal Part II. Journal of Chemical Technology and Biotechnology, 84(8), 1130-1135.

EET Corporation. "Glycerol Purification" EET Corporation. 2011. 28 November 2013 <http://www.eetcorp.com/heepm/glycerine.htm>

Glueckauf, E. (1959) Electro-deionisation through a packed bed. British Chemical Engineering. 646-651.

Haselow, J. (2010) U.S. Patent WO/2010/033817.

Indusekh, V.K. and Krishnaswamy N. (1965) Diffusion effect during electrodialysis with ion-exchange membrane. Journal of Applied Polymer Science, 9(7), 2631-2632.

Jurenka, B. "Electrodialysis (ED) and electrodialysis reversal (EDR)" U.S.Department of the Interior Bureau of Reclamation. 20 Sep 2010. 19 Nov 2013 <http://www.usbr.gov/pmts/water/publications/primer.html>

Kabsch-Korbutowicz, M., Kozak, A., and Krupinska, B. (2008) Ion-exchange-ultrafiltration integrated process as a useful method in removing natural organic matter from water. Environment Protection Engineering, 34(2), 79.

Mah, S. K., Leo, C. P., Wu, T. Y., and Chai, S. P. (2012) A feasibility investigation on ultrafiltration of palm oil and oleic acid removal from glycerin solutions: Flux decline, fouling pattern, rejection and membrane characterizations. Journal of Membrane Science, 389, 245-256.

Mohammad, A. W., and Amin, I. N. H. M. (2013) Fouling of ultrafiltration membrane during adsorption of long chain fatty acid in glycerine solutions. Sains Malaysiana, 42(6), 827-836.

Noble R.D. and Stern S.A. (1995) Membrane separations technology: principles and applications, 221-224, New York: Elsevier Science.

Schaffner, F., Pontalier, P. Y., Sanchez, V., and Lutin, F. (2003) Bipolar electrodialysis for glycerin production from diester wastes. Filtration & Separation, 40(10). 35-39.

Schaffner, F., Pontalier, P. Y., Sanchez, V., and Lutin, F. (2004) Comparison of diester waste treatment by conventional and bipolar electrodialysis, Desalination, 170(2), 113-121.

Strathmann, H. (2004). Assessment of electrodialysis water desalination process costs. Proceedings of the International Conference on Desalination Costing, Limassol, Cyprus.

Tanaka, Y., Uchino, H., and Murakami, M. (2012) Continuous ion-exchange membrane electrodialysis of mother liquid discharged from a salt-manufacturing plant and transport of Cl^- ions and SO_4^{2-} ions. Membrane Water Treatment, 3(1), 63-76.

Tye, F.L. (1959) U.K. Patent 815,154.

APPENDICES

Appendix A Experimental Data and Salt Ions Balance in Each Stream

Table A1 Experimental data at 70% water concentration

Cycle	Conductivity (micro siemens)										Current(A)		
	Feed	Product			Concentrate			Electrode					
		1	2	3	1	2	3	1	2	3	1	2	3
1	5.22	4.18	4.42	4.52	10.82	9	8.31	8.7	6.86	6.7	3	2.2	1.9
2	4.18	3.28	3.45	3.6	9.09	6.87	6.97	7.46	6.31	5.99	1.7	1.6	1.5
3	3.49	3.04	3.08	2.98	5.91	5.8	5.86	5.7	4.73	4.76	1.4	1.4	1.4
4	2.96	2.4	2.45	2.46	5.14	5.25	5.08	4.73	4.35	4.41	1.4	1.4	1.4
5	2.43	2.1	2	2.19	4.56	4.46	4.35	4.48	4.88	3.82	1.2	1.2	1.2

Table A 2 Experimental data at 60% water concentration

Cycle	Conductivity (micro siemens)										Current(A)		
	Feed	Product			Concentrate			Electrode					
		1	2	3	1	2	3	1	2	3	1	2	3
1	6.35	5.65	5.77	5.71	9.37	8.8	8.54	8.21	7.53	7.89	2.2	2.2	2
2	5.61	5.37	5.27	5.32	8.54	8.94	8.46	7.14	7.56	7.44	2.1	2.3	2.1
3	5.22	4.89	4.94	4.93	7.65	7.68	7.44	6.84	6.83	6.51	2.1	2.1	1.9
4	4.79	4.51	4.53	4.49	7.3	7	7.04	6.08	5.87	5.9	2	2	1.8
5	4.36	4.04	4.1	4	6.13	6.25	6.44	5.42	5.38	5.97	1.7	1.8	1.8

Table A3 Experimental data at 50% water concentration

Cycle	Conductivity (micro siemens)										Current(A)		
	Feed	Product			Concentrate			Electrode					
		1	2	3	1	2	3	1	2	3	1	2	3
1	5.34	5.2	5.24	5.21	7.06	7.15	7.03	6.82	6.61	6.39	1.6	1.5	1.5
2	5.22	5.06	5.04	5.1	6.77	7	6.84	6.56	6.82	6.34	1.6	1.6	1.6
3	4.96	4.82	4.86	4.86	6.46	6.9	6.79	5.83	5.62	5.82	1.6	1.6	1.6
4	4.83	4.58	4.6	4.63	6.11	6.13	6.24	5.84	5.66	5.61	1.6	1.6	1.6
5	4.5	4.34	4.35	4.25	5.97	5.91	5.97	5.31	5.42	5.59	1.5	1.6	1.6

Table A4 Experimental data at 40% water concentration

Cycle	Conductivity (micro siemens)									Current(A)		
	Feed	Product			Concentrate			Electrode				
		1	2	3	1	2	3	1	2	3	1	2	3
1	4.66	4.49	4.51	4.48	6.01	5.96	5.97	5.38	5.44	5.24	1.3	1.2	1.2
2	4.46	4.35	4.36	4.32	5.76	5.86	5.96	5.21	5.21	5.27	1.2	1.2	1.2
3	4.3	4.15	4.21	4.1	5.58	5.69	5.45	5.21	5.14	5.08	1.3	1.3	1.3
4	4.12	4	3.97	3.97	5.52	5.44	5.46	4.93	5	4.91	1.3	1.3	1.3
5	3.97	3.86	3.83	3.84	5.18	5.42	5.28	4.93	4.82	4.91	1.2	1.2	1.2

Table A5 Experimental data at 30% water concentration

Cycle	Conductivity (micro siemens)									Current(A)		
	Feed	Product			Concentrate			Electrode				
		1	2	3	1	2	3	1	2	3	1	2	3
1	2.35	2.13	2.13	2.11	2.35	2.44	2.35	2.24	2.23	2.27	0.8	0.9	0.9
2	2.13	2.07	2.07	2.07	2.28	2.26	2.27	2.43	2.43	2.39	0.9	0.9	0.9
3	2.07	2.04	2.14	2.01	2.3	2.19	2.33	2.33	2.37	2.42	1	1	1
4	2.1	2.01	2.04	1.97	2.19	2.34	2.34	2.46	2.26	2.52	1	1	1
5	2.03	1.94	1.97	1.98	2.12	2.23	2.23	2.09	2.04	2.03	1	1	1

Table A6 Experimental data of turbidity

Sample	Before (NTU)			After (NTU)		
	1	2	3	1	2	3
0% Water	20.9	20.9	20.9	N/A	N/A	N/A
30%Water	29.8	29.8	29.9	10.1	10.0	9.9
40%Water	31.8	31.8	31.8	11.0	11.0	11.0
50%Water	35.0	35.0	35.0	11.2	11.2	11.2
60%Water	49.2	49.2	49.2	11.0	11.0	11.1
70%Water	44.8	45.0	45.1	10.3	10.5	10.5

Mix UF's treated glycerol of 40% = 15.0, 15.0 and 15.0

Mix UF's treated glycerol of 60% = 13.8, 14.0 and 13.8

Appendix B Simulation Data of Distillation Treatment

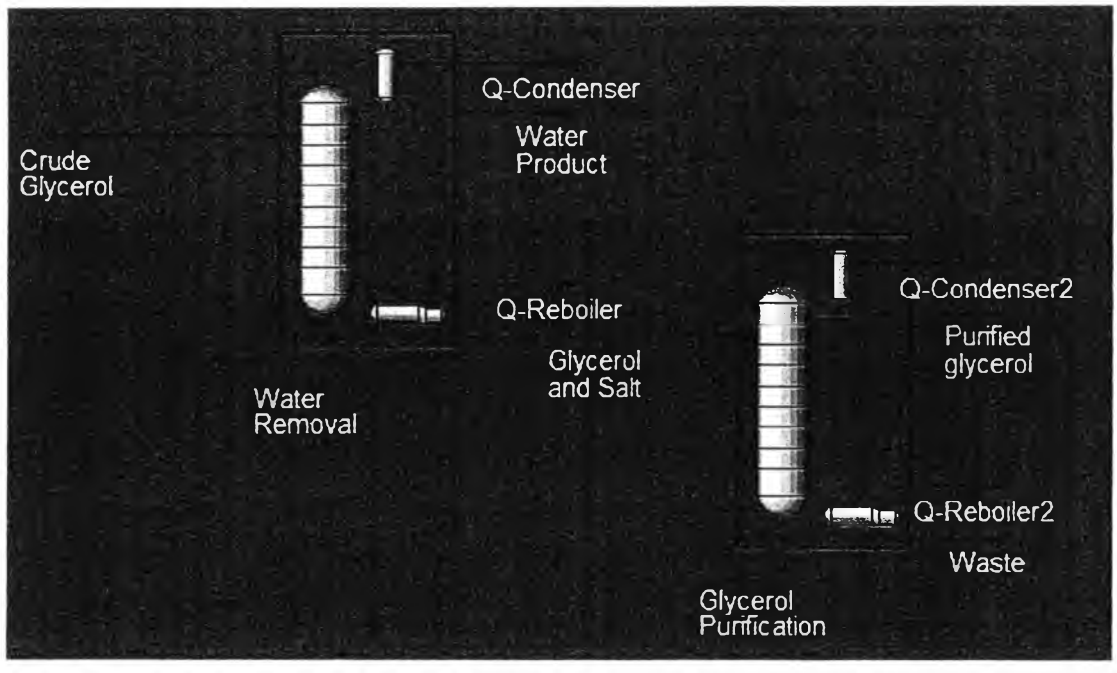

Figure B1 Process flow diagram of glycerol purification by distillation.

Table B1 Simulation data of water removal unit

Distillation: Water Removal @Main

MONITOR

Specifications Summary

	Specified Value	Current Value	Wt. Error	Wt. Tol	Abs. Tol	Active	Estimate	Used
Reflux Ratio	0.2500 *	0.2500	1.586e-008	1.000e-002	1.000e-002	On	On	On
Distillate Rate	1165 kg/h *	973.3 kg/h	-0.1646	1.000e-002	1.000 kg/h	Off	On	Off
Reflux Rate	-	13.51 kgmole/h		1.000e-002	1.000 kgmole/h	Off	On	Off
4 Rate		31.68 kgmole/h		1.000e-002	1.000 kgmole/h	Off	On	Off
Comp Fraction	1.000e-004 *	1.001e-004	1.417e-004	1.000e-002	1.000e-003	On	On	On

CONDITIONS

Name		ude Glycerol @Main	erol and Salt @Main	ater Product @Main	Q-Reboiler @Main	Q-Condenser @Main
Vapour		0.0000	0.0000	0.0000		
Temperature	(C)	30.0000 *	287.5972	99.9913		
Pressure	(kPa)	101.3000 *	101.3000	101.3000		
Molar Flow	(kgmole/h)	85.7090	31.6822	54.0268		
Mass Flow	(kg/h)	3973.8723	3000.5738	973.2984		
Std Ideal Liq Vol Flow	(m3/h)	3.4000 *	2.4247	0.9753		
Molar Enthalpy	(kJ/kgmole)	-4.303e+005	-6.088e+005	-2.792e+005		
Molar Entropy	(kJ/kgmole-C)	-3.908	247.8	23.57		
Heat Flow	(kJ/h)	-3.6882e+07	-1.9287e+07	-1.5085e+07	5.2546e+06	2.7453e+06

Table B2 Simulation data of water removal unit (cont.)

SUMMARY					
Flow Basis:		Molar	The composition option is selected		
Feed Composition					
	5				
Flow Rate (kgmole/h)	85.7090				
Glycerol	0.3635				
1C16oicAcid	0.0060				
H2O	0.6305				
Flow Basis:		Molar	The composition option is selected		
Feed Flows					
	5				
Flow Rate (kgmole/h)	85.7090				
Glycerol (kgmole/h)	31.1541				
1C16oicAcid (kgmole/h)	0.5114				
H2O (kgmole/h)	54.0435				
Products					
Flow Basis:		Molar	The composition option is selected		
Product Compositions					
	6	4			
Flow Rate (kgmole/h)	54.0268	31.6822			
Glycerol	0.0000	0.9833			
1C16oicAcid	0.0000	0.0161			
H2O	1.0000	0.0005			
Flow Basis:		Molar	The composition option is selected		
SUMMARY					
	6	4			
Flow Rate (kgmole/h)	54.0268 *	31.6822 *			
Glycerol (kgmole/h)	0.0000 *	31.1541 *			
1C16oicAcid (kgmole/h)	0.0000 *	0.5114 *			
H2O (kgmole/h)	54.0268 *	0.0167 *			
Flow Basis:		Molar	The composition option is selected		
Product Recoveries					
	6	4			
Flow Rate (kgmole/h)	54.0268	31.6822			
Glycerol (%)	0.0000	100.0000			
1C16oicAcid (%)	0.0000	100.0000			
H2O (%)	99.9692	0.0308			

Table B3 Simulation data of glycerol purification unit

Distillation: Glycerol Purification @Main

MONITOR

Specifications Summary

	Specified Value	Current Value	Wt. Error	Wt. Tol	Abs. Tol	Active	Estimate	Used
Comp Fraction	0.9950 *	0.9950	-4.378e-009	1.000e-002	1.000e-003	On	On	On
Reflux Ratio	0.2500 *	0.2500	1.015e-008	1.000e-002	1.000e-002	On	On	On
Purified glycerol Rate		2884 kg/h		1.000e-002	1.000 kg/h	Off	On	Off
Waste Rate		117.0 kg/h		1.000e-002	1.000 kg/h	Off	On	Off

CONDITIONS

Name		erol and Salt @Main	Waste @Main	ified glycerol @Main	Q-Reboiler2 @Main	-Condenser2 @Main
Vapour		0.0000	0.0000	0.0000		
Temperature	(C)	287.5972	198.2226	159.3746		
Pressure	(kPa)	101.3000	1.0000	1.0000		
Molar Flow	(kgmole/h)	31.6822	0.4563	31.2258		
Mass Flow	(kg/h)	3000.5738	117.0203	2883.5535		
Std Ideal Liq Vol Flow	(m3/h)	2.4247	0.1327	2.2920		
Molar Enthalpy	(kJ/kgmole)	-6.088e+005	-7.407e+005	-6.441e+005		
Molar Entropy	(kJ/kgmole-C)	247.8	415.0	93.32		
Heat Flow	(kJ/h)	-1.9287e+07	-3.3804e+05	-2.0114e+07	1.8428e+06	3.0071e+06

SUMMARY

Flow Basis:	Mass	The composition option is selected

Feed Composition

	4				
Flow Rate (kg/h)	3.000574e+03				
Glycerol	0.9562				
1C16oicAcid	0.0437				
H2O	0.0001				

Flow Basis:	Mass	The composition option is selected

Feed Flows

	4				
Flow Rate (kg/h)	3.000574e+03				
Glycerol (kg/h)	2.869136e+03				
1C16oicAcid (kg/h)	131.1378				
H2O (kg/h)	0.3003				

Products

Flow Basis:	Mass	The composition option is selected

Product Compositions

	Purified glycerol	Waste			
Flow Rate (kg/h)	2.883554e+03	117.0203			
Glycerol	0.9950	0.0000			
1C16oicAcid	0.0049	1.0000			
H2O	0.0001	0.0000			

Flow Basis:	Mass	The composition option is selected

Table B4 Simulation data of glycerol purification unit (cont.)

SUMMARY					
	Purified glycerol	Waste			
Flow Rate (kg/h)	2.883554e+03 *	117.0203 *			
Glycerol (kg/h)	2.869136e+03 *	0.0000 *			
1C16oicAcid (kg/h)	14.1175 *	117.0203 *			
H2O (kg/h)	0.3003 *	0.0000 *			
Flow Basis:		Mass	The composition option is selected		
Product Recoveries					
	Purified glycerol	Waste			
Flow Rate (kg/h)	2.883554e+03	117.0203			
Glycerol (%)	100.0000	0.0000			
1C16oicAcid (%)	10.7654	89.2346			
H2O (%)	100.0000	0.0000			

Appendix C Simulation Data of EDI Treatment

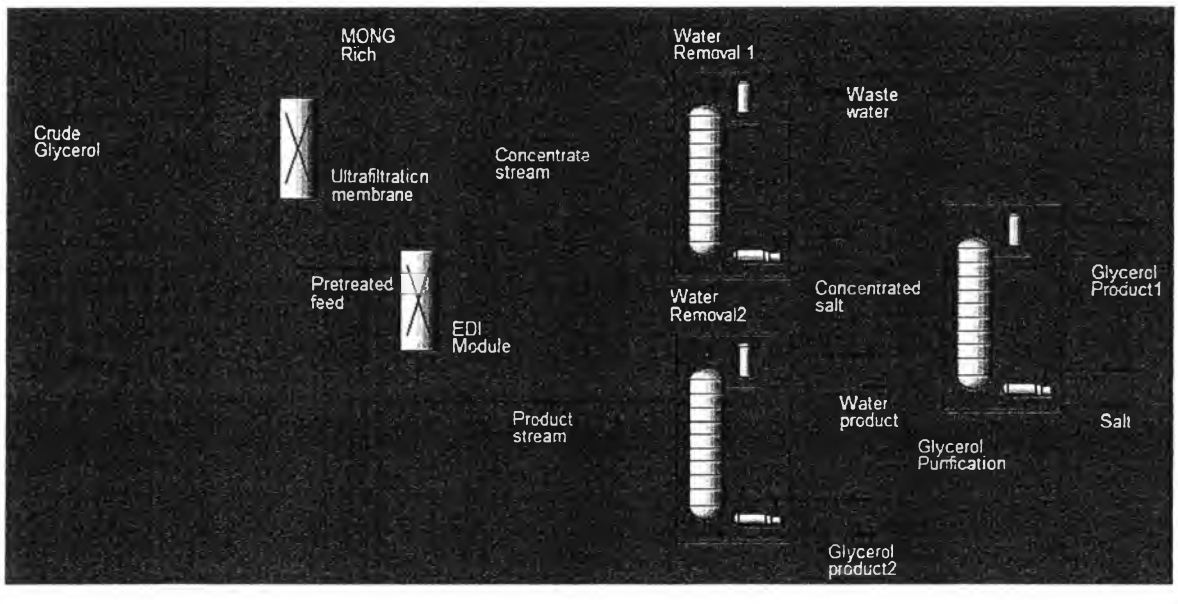

Figure C1 Process flow diagram of glycerol purification by EDI.

Table C1 Simulation data of water removal unit 1

Distillation: Water Removal 1 @Main

MONITOR

Specifications Summary

	Specified Value	Current Value	Wt. Error	Wt. Tol	Abs. Tol.	Active	Estimate	Used
Comp Fraction	1.000e-003 *	9.999e-004	-3.203e-005	2.000 *	1.000e-002 *	On	On	On
Reflux Ratio	0.2500 *	0.2500	1.139e-011	1.000e-002	1.000e-002	On	On	On
Concentrated salt Rate	365.0 kg/h *	364.4 kg/h	-1.636e-003	1.000 *	10.00 kg/h *	Off	On	Off

CONDITIONS

Name		ntrate stream @Main	centrated salt @Main	Waste water @Main	O-100-2 @Main	O-101-2 @Main
Vapour		0.0000	0.0000	1.0000		
Temperature	(C)	30.0000	282.7682	99.9913		
Pressure	(kPa)	101.3000	101.3000	101.3000		
Molar Flow	(kgmole/h)	8.7465	3.4164	5.3301		
Mass Flow	(kg/h)	460.4248	364.4029	96.0219		
Std Ideal Liq Vol Flow	(m3/h)	0.4126	0.3164	0.0962		
Molar Enthalpy	(kJ/kgmole)	-4.426e+005	-6.138e+005	-2.386e+005		
Molar Entropy	(kJ/kgmole-C)	-0.3720	272.1	132.5		
Heat Flow	(kJ/h)	-3.8708e+06	-2.0971e+06	-1.2716e+06	5.5637e+05	5.4168e+04

SUMMARY

Flow Basis:	Mass	The composition option is selected

Feed Composition

	Concentrate stream				
Flow Rate (kg/h)	460.4248				
Glycerol	0.6169				
1C16oicAcid	0.1737				
H2O	0.2093				

Flow Basis:	Mass	The composition option is selected

Feed Flows

	Concentrate stream				
Flow Rate (kg/h)	460.4248				
Glycerol (kg/h)	284.0444				
1C16oicAcid (kg/h)	79.9940				
H2O (kg/h)	96.3863				

Flow Basis:	Mass	The composition option is selected

Product Compositions

	Glycerol and Water	Concentrated salt			
Flow Rate (kg/h)	96.0219	364.4029			
Glycerol	0.0000	0.7795			
1C16oicAcid	0.0000	0.2195			
H2O	1.0000	0.0010			

Flow Basis:	Mass	The composition option is selected

Table C2 Simulation data of water removal unit 1 (cont.)

Product Flows					
	Glycerol and Water	Concentrated salt			
Flow Rate (kg/h)	96.0219 *	364.4029 *			
SUMMARY					
	Glycerol and Water	Concentrated salt			
Glycerol (kg/h)	0.0000 *	284.0444 *			
1C16oicAcid (kg/h)	0.0000 *	79.9940 *			
H2O (kg/h)	96.0219 *	0.3644 *			
Flow Basis:		Mass	The composition option is selected		
Product Recoveries					
	Glycerol and Water	Concentrated salt			
Flow Rate (kg/h)	96.0219	364.4029			
Glycerol (%)	0.0000	100.0000			
1C16oicAcid (%)	0.0000	100.0000			
H2O (%)	99.6220	0.3780			

Table C3 Simulation data of glycerol purification unit

Distillation: Glycerol Purification @Main								
MONITOR								
Specifications Summary								
	Specified Value	Current Value	Wt. Error	Wt. Tol.	Abs. Tol	Active	Estimate	Used
Reflux Ratio	0.2500 *	0.2792	0.1167	1.000e-002	1.000e-002	Off	On	Off
Comp Fraction - 2	0.9950 *	0.9950	9.065e-005	5.000 *	1.000e-003	On	On	On
Draw Rate	285.0 kg/h *	285.0 kg/h	2.918e-006	1.000e-002	10.00 kg/h *	On	On	On
CONDITIONS								
Name		centrated salt @Main	Salt @Main	erol Product1 @Main	O-106-2 @Main	O-102-2 @Main		
Vapour		0.0000	0.0000	0.0000				
Temperature	(C)	282.7682	196.6425	139.4294				
Pressure	(kPa)	101.3000	1.0000	1.0000				
Molar Flow	(kgmole/h)	3.4164	0.3129	3.1035				
Mass Flow	(kg/h)	364.4029	79.4020	285.0008				
Std Ideal Liq Vol Flow	(m3/h)	0.3164	0.0899	0.2265				
Molar Enthalpy	(kJ/kgmole)	-6.138e+005	-7.400e+005	-6.471e+005				
Molar Entropy	(kJ/kgmole-C)	272.1	408.2	72.15				
Heat Flow	(kJ/h)	-2.0971e+06	-2.3157e+05	-2.0082e+06	1.8279e+05	3.2550e+05		
SUMMARY								
Flow Basis:		Molar	The composition option is selected					

Table C4 Simulation data of glycerol purification unit (cont.)

Feed Composition					
	Concentrated salt				
Flow Rate (kgmole/h)	3.4164				
Glycerol	0.9028				
1C16oicAcid	0.0913				
H2O	0.0059				
Flow Basis:		Molar	The composition option is selected		
Feed Flows					
	Concentrated salt				
Flow Rate (kgmole/h)	3.4164				
Glycerol (kgmole/h)	3.0843				
1C16oicAcid (kgmole/h)	0.3120				
H2O (kgmole/h)	0.0202				
Products					
Flow Basis:		Molar	The composition option is selected		
Product Compositions					
	Glycerol Product1	Salt			
Flow Rate (kgmole/h)	3.1035	0.3129			
Glycerol	0.9922	0.0163			
1C16oicAcid	0.0013	0.9837			
H2O	0.0065	0.0000			
Flow Basis:		Molar	The composition option is selected		
Product Flows					
	Glycerol Product1	Salt			
Flow Rate (kgmole/h)	3.1035 *	0.3129 *			
SUMMARY					
	Glycerol Product1	Salt			
Glycerol (kgmole/h)	3.0792 *	0.0051 *			
1C16oicAcid (kgmole/h)	0.0041 *	0.3078 *			
H2O (kgmole/h)	0.0202 *	0.0000 *			
Flow Basis:		Molar	The composition option is selected		
Product Recoveries					
	Glycerol Product1	Salt			
Flow Rate (kgmole/h)	3.1035	0.3129			
Glycerol (%)	99.8350	0.1650			
1C16oicAcid (%)	1.3258	98.6742			
H2O (%)	100.0000	0.0000			

Table C5 Simulation data of water removal unit 2

Distillation: Water Removal2 @Main

MONITOR

Specifications Summary

	Specified Value	Current Value	Wt. Error	Wt. Tol.	Abs. Tol.	Active	Estimate	Used
Reflux Ratio	0.2500 *	0.2500	1.581e-008	1.000e-002	1.000e-002	On	On	On
Distillate Rate	2560 kg/h *	2559 kg/h	-4.247e-004	1.000 *	10.00 kg/h *	Off	On	Off
Comp Fraction - 2	0.9950 *	0.9950	1.131e-004	5.000 *	1.000e-002 *	On	On	On

CONDITIONS

Name		oduct stream @Main	erol product2 @Main	Vater product @Main	O-106 @Main	O-102 @Main
Vapour		0.0000	0.0000	0.0000		
Temperature	(C)	30.0000	281.9005	99.9913		
Pressure	(kPa)	101.3000	101.3000	101.3000		
Molar Flow	(kgmole/h)	75.9110	27.8978	48.0133		
Mass Flow	(kg/h)	3423.8764	2558.9127	864.9637		
Std Ideal Liq Vol Flow	(m3/h)	2.8969	2.0302	0.8667		
Molar Enthalpy	(kJ/kgmole)	-4.279e+005	-6.078e+005	-2.792e+005		
Molar Entropy	(kJ/kgmole-C)	-4.726	236.4	23.57		
Heat Flow	(kJ/h)	-3.2479e+07	-1.6958e+07	-1.3406e+07	- 4.5547e+06	2.4397e+06

SUMMARY

Flow Basis:	Molar	The composition option is selected

Feed Composition

	Product stream				
Flow Rate (kgmole/h)	75.9110				
Glycerol	0.3657				
1C16oicAcid	0.0000				
H2O	0.6343				
Flow Basis:		Molar	The composition option is selected		

Feed Flows

	Product stream				
Flow Rate (kgmole/h)	75.9110				
Glycerol (kgmole/h)	27.7583				
1C16oicAcid (kgmole/h)	0.0000				
H2O (kgmole/h)	48.1527				

Products

Flow Basis:	Molar	The composition option is selected

Product Compositions

	5	Glycerol product			
Flow Rate (kgmole/h)	48.0133	27.8978			
Glycerol	0.0000	0.9950			
1C16oicAcid	0.0000	0.0000			
H2O	1.0000	0.0050			
Flow Basis:		Molar	The composition option is selected		

Product Flows

	5	Glycerol product			
Flow Rate (kgmole/h)	48.0133 *	27.8978 *			

Table C6 Simulation data of water removal unit 2

SUMMARY					
	5	Glycerol product			
Glycerol (kgmole/h)	0.0000 *	27.7583 *			
1C16oicAcid (kgmole/h)	0.0000 *	0.0000 *			
H2O (kgmole/h)	48.0133 *	0.1395 *			
Flow Basis:		Molar	The composition option is selected		
Product Recoveries					
–	5	Glycerol product			
Flow Rate (kgmole/h)	48.0133	27.8978			
Glycerol (%)	0.0000	100.0000			
1C16oicAcid (%)	0.0000	0.0000			
H2O (%)	99.7103	0.2897			

CURRICULUM VITAE

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Proceedings:

1. Ngamsitthisak, D., Kitiyanan, B., and Robert M., Z. (2014, April 7) Desalination of Crude Glycerol Obtained from Biodiesel Production by Electrodeionization. Proceedings of The 5th Research Symposium on Petroleum, Petrochemicals, and Materials Technology and the 20th PPC Symposium on Petroleum, Petrochemicals and Polymers, Bangkok, Thailand.

Presentations:

1. Ngamsitthisak, D., Kitiyanan, B., and Robert M., Z. (2014, April 22) Desalination of Crude Glycerol Obtained from Biodiesel Production by Electrodeionization. Poster presented at The 5th Research Symposium on Petroleum, Petrochemicals, and Materials Technology and the 20th PPC Symposium on Petroleum, Petrochemicals and Polymers, Bangkok, Thailand.