Ethyl Lactate Synthesis using Reactive Distillation

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Unit system used – °C, bar, kg/hr, kmol/hr

Background

The most commonly used solvents in the chemical industry e.g. DMF, DMSO etc. have various negative effects on the environment since they are not bio-degradable. Hence, there is a need to produce "green-solvents". Ethyl Lactate is one of them. Other uses of Ethyl Lactate are: pharmaceutical preparations, food additive, fragrances etc. The purpose of this flowsheet is to produce Ethyl Lactate.

Description of flowsheet

A 9-stage Reactive Distillation column is used to carry out the reaction. Feeds of Lactic acid and Ethanol are given at the 2nd and the 6th stages respectively. The bottom product of the RD column is then distilled to obtain pure Ethyl Lactate. The recovered Ethanol is then recycled back in to the feed stream.

Main reaction:

Ethanol + Lactic Acid → Ethyl Lactate + Water
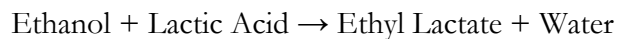
The forward reaction factor is given by

$$\mathbf{k_l} = 13300 * \exp\left(-\frac{30400 \; J/mol}{RT}\right)$$

To use these values, we convert them to the available format. We use the equation 119.

$y = \exp(a/t + b + c*t + d*t^2 + e*\ln(t))$

where a, b, c, d, e are constants and t is temperature.

Hence, we have a = -30400/8.314 = -3656 J/mol

 b = ln(13300) = 9.495

c, d, e = 0

Similarly, for the backward reaction factor we have:

$$k_{-1} = 0.799 * \exp\left(-\frac{7022.67 \; J/mol}{RT}\right)$$

a = -844.68

b = -0.22439

c, d, e = 0

Results

The final product stream S-05 approximately has a mole fraction of 0.9 Ethyl Lactate with other components consisting mostly of water.

Master Property Table								
Object	S-07	S-06	S-05	S-04	S-03	S-02	S-01	
Temperature	25	89.9764	163.765	89.9764	158.463	110	43.6762	C
Pressure	1.01325	1.01325	1.01325	1.01325	1.01325	1.01325	1.01325	bar
Mass Flow	640.837	208.28	293.084	208.28	501.357	645.421	849.762	kg/h
Molar Flow	14.8126	7.05116	2.68927	7.05116	9.74021	25.5901	21.8741	kmol/h
Molar Fraction (Mixture) / Ethyl Lactate	0	0.01	0.889734	0.01	0.252895	0	0.00322818	
Molar Fraction (Mixture) / Lactic Acid	0	4.62773E-06	0.0223814	4.62773E-06	0.00618287	0.1	1.47832E-06	
Molar Fraction (Mixture) / Ethanol	0.9	0.375037	0.01	0.375037	0.27425	0	0.731084	
Molar Fraction (Mixture) / Water	0.1	0.614992	0.0777985	0.614992	0.466672	0.9	0.265686	

Master Property Table			
Object	E-02	E-01	
Energy Flow	34.3019	160.496	kW

References

[1] Daengpradab, Boonpradab & Rattanaphanee, Panarat. (2015). Efficiency Comparison of Different Design Schemes of Reactive Distillation Process for Ethyl Lactate Production from Fermentation-Derived Magnesium Lactate. Computer Aided Chemical Engineering. 37. 1079-1084. 10.1016/B978-0-444-63577-8.50025-5.