Production of Biodiesel by Homogeneous Catalysis using Reactive Distillation

Kumaran Nagappan K
SASTRA Deemed University

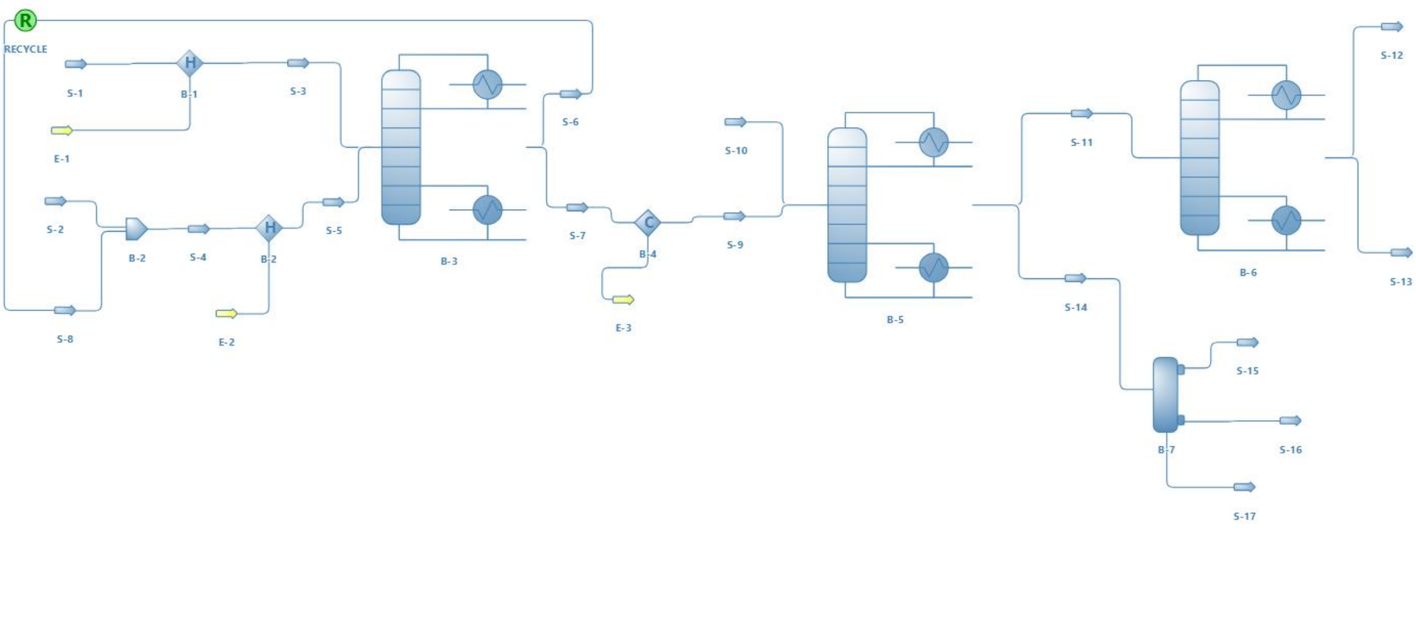
A. Background & Description:

With the reducing fossil fuel reserves, there is an urge to find a solution to meet our energy demands sustainably. One of such alternative options is biodiesel. It is derived from renewable biomass source like vegetable oil. It can be used as transportation fuel. Usage of biodiesel can reduce the emission of air pollutants, thus minimizing the environmental hazards.

Biodiesel is the fatty acid alkyl ester obtained as a result of the transesterification of triglycerides present in the vegetable oils and an alcohol in presence of homogeneous alkaline catalyst or heterogeneous solid oxide catalyst. Biodiesel is recovered from the product stream along with glycerol as a by-product. Instead of using two separate units namely reactor and distillation columns, a single column of reactive distillation can be used to intensify the process for reducing energy and capital costs.

In the present simulation, soybean oil and methanol are used as feed stocks. Triolein is used to represent all of the triglyceride present in the vegetable oil since it is the major component. Methanol and triolein in the ratio of 6:1 is fed to the reactive distillation column at 60 °C. Most of the unconverted methanol is recovered as distillate and recycled back. The bottoms consist of methyl oletate (biodiesel), glycerol and small quantities of unconverted triolein and methanol. Hexane is used to extract biodiesel from the bottoms mixture. The extract phase is enriched with biodiesel while the raffinate phase consists of immiscible mixture of glycerol and hexane with small quantities of methanol. The raffinate phase is separated using liquid-liquid separator and glycerol of about 98% is obtained. The extract phase is fractionated in a distillation column to obtain biodiesel in the bottoms. The resulting biodiesel has the desired amount of ester content (>96.5% mass).

B. Flowsheet:



Flowsheet of Production of Biodiesel by Homogeneous Distillation using Reactive Distillation

C. Results:

The results of the main streams are given in the following table.

Property	**S-1**	**S-2**	**S-6**	**S-7**	**Unit**
Temperature	25.00	25.00	64.83	223.29	oC
Pressure	1.01	1.01	1.01	1.01	bar
Mass Flow	4058.31	431.92	487.00	4490.07	kg/h
Molar Flow	4.58	13.48	14.04	18.06	kmol/h
Molar Flow	4.58	13.48	14.04	18.06	-
Mass Fraction (Mixture) / Triolein	1.000	0.000	0.000	0.021	-
Mass Fraction (Mixture) / Methanol	0.000	1.000	0.915	0.000	-
Mass Fraction (Mixture) / Methyl Oleate	0.000	0.000	0.085	0.887	-
Mass Fraction (Mixture) / Glycerol	0.000	0.000	0.000	0.092	-
Property	**S-11**	**S-13**	**S-16**	**S-17**	**Unit**
Temperature	16.71	160.89	4.68	4.68	oC
Pressure	1.01	0.20	1.01	1.01	bar
Mass Flow	4659.02	3644.08	272.81	420.00	kg/h
Molar Flow	20.30	12.09	3.17	4.59	kmol/h
Mass Fraction (Mixture) / Triolein	20.30	12.09	3.17	4.59	-
Mass Fraction (Mixture) / Methanol	0.020	0.026	0.000	0.000	-
Mass Fraction (Mixture) / Methyl Oleate	0.000	0.000	0.000	0.003	-
Mass Fraction (Mixture) / Glycerol	0.855	0.974	0.000	0.000	-
Mass Fraction (Mixture) / N-hexane	0.000	0.000	0.000	0.978	-

D. Reference:

Poddar, T., Jagannath, A., & Almansoori, A. (2017). Use of reactive distillation in biodiesel production: A simulation-based comparison of energy requirements and profitability indicators. *Applied Energy*, *185*, 985–997. https://doi.org/10.1016/j.apenergy.2015.12.054