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Process incentives by the intensification of a conventional biodiesel plant

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Abstract

With the exponential growth of global energy demand and the rising prices of conventional fuels, the necessity of developing proper alternative fuels is at an all-time high. Biodiesel is considered to be a suitable alternative that has the potential to reduce the amount of future fossil fuel requirement substantially. Process intensification is the method of combining several unit processes or operations to a single unit. The scope of the paper includes comparison of the conventional and intensified biodiesel plants through simulation in Aspen Plus V. 8.6 and subsequent result analysis. The conversion and hot utility requirement of the conventional and intensified biodiesel plants are compared and the reasons for the same are discussed. The reactive distillation process is found to have a higher conversion and lower hot utility requirement.

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1. Introduction

With the fast depleting resources and ever increasing prices of fossil fuels, the need for alternate liquid fuels are at an all-time high. The fossil fuel usage is held culpable for the massive pollution rates. Since biodiesel has a lower

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carbon footprint than petroleum diesels [1] and also because of the diverse feedstock compatibility, it holds a potential as a possible replacement for conventional fuels. Process intensification is a new branch of chemical engineering that involves reduction of size of a chemical plant by combining several unit processes or operation to a single unit. A reactor combined with a unit operation is called a multifunctional reactor. Reactive distillation is an example for a multifunctional reactor. Reactive distillation can substantially reduce the size of the process by making it more compact along with several other process incentives [2]. Here in this paper, process incentives of using a reactive distillation column over a conventional biodiesel plant with separate reactors and distillation columns is analyzed by Aspen Plus simulation.

Nomenclature

FAME Fatty Acids Methyl Ester
RDS Rate Determining Step

1.1. Biodiesel production

Various types of feedstock are compatible for biodiesel manufacture. This includes waste cooking oils, animal fats, and non-edible oils such as *jatropha curcus* oil. The major component of the oils are the triglycerides. These undergo transesterification with methanol or ethanol to give Fatty Acid Methyl Esters (FAME) and Glycerol, as given in Fig. 1 (a). Here R_N represents the fatty acid chain. Acidic and basic catalysts can be used for transesterification but basic catalysts like NaOH or KOH are used most often in industries because of higher yield at a shorter time [3]. This reaction is reversible hence excess methanol is provided to shift the kinetics in the forward direction. In this paper biodiesel manufacture by the transesterification of *jatropha curcus* oil using methanol in presence of NaOH as catalyst is simulated.

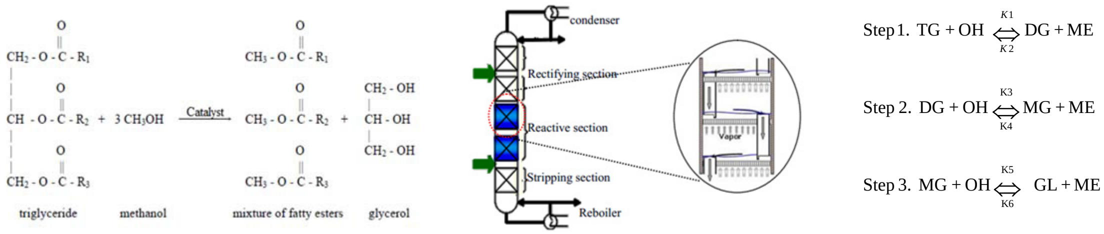

Fig. 1. (a) Transesterification reaction; (b) Sections of a reactive distillation column (c) Mechanism of transesterification reaction

1.2. Reactive Distillation

Reactive Distillation is considered as the front runner of process intensification [4]. In a reactive distillation column, chemical reactions and separation takes place simultaneously. The reactive distillation column contains multiple sections, as given in Fig.1 (b). The reaction takes place in the reactive section. The products move away from the reactive section because of the volatility difference. The products enter the distillation sections at the top and bottom of the reactive section to enhance its purity. Since the products are continuously removed from the column, forward reaction is favoured even without the provision of excess methanol. This is responsible for the higher yields of reactive distillation columns [5]. Applications of reactive distillation has been intensively researched nowadays; especially after the successful commercialization of Methyl Tertiary Butyl Ester (MTBE) and Methyl Acetate [6].

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