Process simulation of glycerol production from corn oil via transesterification

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Abstract. Glycerol is widely use in the production of cosmetics, solvents for drugs, and lubricants. Glycerol can be obtained as by-product of biodiesel production from vegetable oils through the transesterification process. One of the vegetable oils with abundant raw material availability in Indonesia is corn oil. Each vegetable oil generally consists of triglycerides and free fatty acids (FFA) with different composition. The triglycerides in corn oil is round 95.59% (mostly trilinoleate and triolein), the rest are FFA (2.51%), phospholipid and phytosterol. The simulation process was designed using Aspen Hysys version 8.8. The corn oil composition was simulated as 54.30% trilinoleate, 41.35% triolein, and 3.85% oleic acid (FFA). The mole ratio of corn oil: methanol was set to 1: 20. The transesterification process was simulated using conversion reactor with conversion 98% at temperature 60°C and atmospheric. The process was followed with methanol recovery and glycerol separation from biodiesel. From the process around 99.04% of excessed methanol was recovered. Glycerol and biodiesel were separated using membrane. The simulation indicates that 100 kg/h corn oil can have converted into 101.1 kg/h green diesel and 10.41 kg/h glycerol with purity 99.85%.

1. Introduction
The chemical industry sector will continue to grow rapidly to compensate for the increasing needs from time to time. One of the chemical industry products whose use is widely used in various fields is glycerol. Glycerol has been used as a raw material for making ink, the pharmaceutical industry, cosmetics and perfumes and to prevent dryness in tobacco. Glycerol also can be converted to hydrogen via steam reforming [1]. Glycerol can be produced through various processes such as fat splitting, fat saponification with NaOH, and transesterification [2]. Transesterification is a process for producing biodiesel with glycerol as by-products. The raw material used in transesterification is vegetable oil [3]. One of commodity with abundant availability that can be used to produce vegetable oil is corn.

Corn is the second most important food commodity after rice. Corn is very beneficial for human life and animal husbandry. Corn kernels contain carbohydrates, fats, proteins, minerals, water, and vitamins. The function of nutrients contained therein can be useful for energizing, forming tissues, regulating functions, and biochemical reactions in the body. all parts of corn can be utilized. young corn stalks and leaves are very beneficial for animal feed and organic fertilizer [4].

Corn oil is used for food and non-food purposes. Use as food products, namely as cooking oil or vegetable oil, ingredients for making margarine, and salad oil. Cooking oil has the potential as a cooking oil because it has a high smoke point of 232°C [4]. The high smoke point shows that oil is stable during heating so it is not easy to smoke. This stability makes corn oil very suitable for use as cooking oil.
non-food purposes corn oil is used in the biodiesel industry as an alternative energy source. In addition, the content of fatty acids in oil can be utilized in various industries such as tire, cosmetics, plastic, paint, pharmaceutical, detergent, and soap industries [3]. Process simulation of transesterification process using Jatropha Curcas seed oil result with high purity biodiesel (> 99.65%) and by-product glycerol with purity grade 95.3% [5]. Other study simulates the transesterification process using waste cooking oil result with biodiesel and by-product glycerol [6]. In order to know the product specification for transesterification process using corn oil the process need to be simulated.

2. Method
The process simulation was designed using Aspen Hysys. The assumptions used as the basis for designing the process are the corn oil reaction process into biodiesel, glycerol and its by-products generally occur through transesterification reaction. The conversion from corn oil to its products is assumed to be 100%. There is no heat loss on all propylene production process equipment. The amount of compressive loss that occurs in the heat exchanger used is 1.5 psi. The amount of pressure loss due to fluid flow in the pipe is assumed to be zero. The corn oil was represented with trilinoleate (hypothetical) and triolein as triglycerides and oleic acid as FFA. The glycerol production from corn oil process step illustrated in figure 1.

2.1. General description of transesterification process
One of the technologies used to converted vegetable oil into glycerol is the transesterification process (Figure 1). Transesterification reaction is reaction of triglycerides in vegetable or animal oils with alcohols and alkaline / acid catalysts, to produce short chain fatty acid esters and glycerol as a by-product. Generally, the transesterification process has an average operating condition with a relatively low temperature and pressure of 60-70°C and 1 bar.

In transesterification process, catalyst is very necessary. The most common catalysts used in this process is NaOH. Some studies also use metal oxide as catalyst to produce biodiesel and glycerol via transesterification process [7].

2.2. General description of glycerol purification process
The purification stages consist of methanol recovery (stage 1 and 2) and glycerol separation from methyl ester and excess methanol. The first stage of methanol recovery is using flash distillation. Before entering the flash column, the product is cooled to around 60°C, so that most of the methanol vaporized and recycle to the feed tank. The are many technologies can be used to purify glycerol. Membrane is one of the options to remove glycerol from methyl ester [8]. After glycerol separation the process followed by the methanol recovery stage 2. In this stage the separation is conduct using distillation [9]. From this stage as distillate is rich with methanol and the bottom product is crude biodiesel. The

![Figure 1. Block flow diagram of glycerol production.](image-url)
methanol stream then recycled to the feed tank. Other method than can be used to separate glycerol is High Voltage Electrolysis [10].

3. Results and discussion
The simulation flowsheet can be seen in figure 2. The simulation consists of 4 main stages, transesterification process, methanol recovery stage 1, glycerol separation, methanol recovery stage 2.

3.1. Transesterification process
The process started with corn oil and methanol feeding to the reactor. The corn oil composition was simulated as 54.30% trilinoleate, 41.35% triolein, and 3.85% oleic acid (FFA). The triglyceride transesterification reaction to methyl ester in corn oil was carried out with a mole ratio of corn oil (100 kg/h) and methanol is 1: 20 using conversion reactor. The reactor CRV-100 operating condition was set to 65°C and 1 bar with corn oil conversion 98%. The reactor output was mostly consisting of the excess methanol, glycerol, and methyl ester. The product then flowed into methanol recovery and glycerol purification stages.

3.2. Glycerol purification process
After the transesterification products come out from the reactor then heated to 80°C so that most of the methanol evaporate. After that the mixture was separated using flash distillation. From this around 72.24% of methanol can be recovered. Then the process continued with glycerol separation using membrane [8]. Before entered the membrane, the flow was pumped and cooled into 5.5 bar and 25°C. The membrane output is glycerol (10.41 kg/h) with purity around 99.85% and mixture of methyl ester and methanol. The permeate then continued to methanol recovery stages 2 using multi-staged distillation. From this processed around 26.8% of methanol can be recovered, so that the total of 99.04% of excess methanol can be recovered.

4. Conclusion
The simulation results showed that from 100 kg/h corn oil can converted into 101.1 kg/h green diesel and 10.41 kg/h glycerol with purity 99.85%. From the process around 99.04% of excessed methanol can be recovered.

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