# Biodiesel-a Renewable Substitute for Fossil Fuels

**S. Quoreshi**
*German Technical Cooperation (GTZ), Gulshan, Dhaka, Bangladesh*
*Email: squoreshi@gmail.com*
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**Abstract**

This manuscript is written in the wake of increasing awareness in Bangladesh on biodiesel as a renewable substitute for petroleum diesel. An effort has been made to briefly describe the chemical process known as 'Transesterification' to produce fuel-grade methyl ester popularly referred to as biodiesel. The standard specifications of the inputs, required temperature, air-pressure, and potential feedstock that are available in Bangladesh have been addressed. Empirical research is required to conduct in Bangladesh to explore the full potential of the available feedstock of inedible oils from two species of naturalized plants to reach any definitive conclusion and any attempt of commercial production of biodiesel.

## Introduction

There is no denying of the necessity these days to substitute fossil fuels by renewable energy and biofuels sourced from biomass. The obvious reasons are so many in number including high price, import dependence, and ecological factors. National Biodiesel Board, USA regularly sensitizes the US policy makers about the financial and environmental benefits of biodiesel over traditional fossil fuels. The European Commission has undertaken a project called "Promotion of Biofuels for Sustainable Development in South and Southeast Asia", or ProBios for short, and Bangladesh has been a partner country in the project. The proceedings of the two international working conferences of the project, with representation from Bangladesh, India, Sri Lanka, Nepal, Thailand, Spain, and the Netherlands, have suggested in favor of expediting biodiesel production in these countries without delay.

This manuscript briefly elucidates the technical procedure of producing biodiesel, i.e., Methyl Ester in the context of Bangladesh. Two species of indigenous and naturalized plants that grow in wild throughout the country have been identified as the major sources of feedstock to produce biodiesel in the country. They are, Ricinus Communis or Castor Oil plant which is known as Bherenda, and Jatropha Curcas Linn., which is known as Jamalgota in Bangladesh. The local names are used in this article when referring to these plants. These two varieties were recommended and accepted by the inter-ministerial committee of Bangladesh government in 2006 as the two most suitable species for production of biodiesel from their seeds.

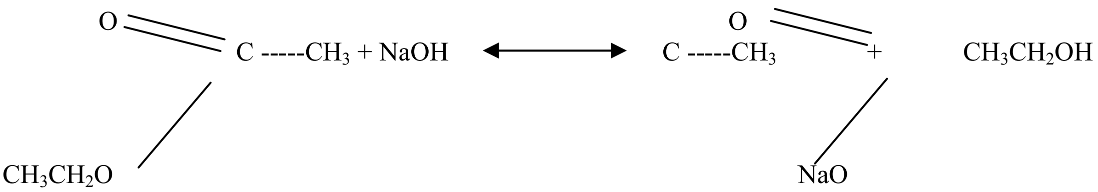
## Transesterification

The chemical process popularly known as 'Transesterification' is a simple chemical reaction that neutralizes the 'free fatty acids' present in any or all fatty substances available from vegetable and animal sources. A chemical exchange takes place between the 'Alkoxy' group of an ester compound by an alcohol. Usually methanol and ethanol type of alcohol are used for the purpose, but methanol would be more appropriate in Bangladesh. The reaction occurs by the presence of a catalyst, usually Sodium Hydroxide (NaOH), or caustic soda and Potassium Hydroxide (KOH) to form fatty esters, e.g., methyl or ethyl esters commonly known as biodiesel. It takes about 10% of methyl alcohol by weight of the fatty substance to start the transesterification process.

The transesterification process using methanol can be expressed by the simplified equation shown below:

| Oil or Fat | + | Methanol | = | Methyl Ester | + | Glycerol |
|---|---|---|---|---|---|---|
| 100 grams | | 10.75 grams | | 100.45 grams | | 10.3 grams |

The same chemical process is shown below:




Ester + Alcohol Different Ester + Different Alcohol

**Chemical Profile**

The chemical profile and the percentage of the free fatty acids present in the oil derived from Bherenda and Jamalgota, the two major species of inedible oil-seed bearing trees in Bangladesh will be discussed in the following section.

The chemical analysis of Bherenda or Castor oil from Ricinus Communis reveals that 90% of the oil content [1] is Ricinoleic Acid, the chemical formula of which is $C_{18}H_{34}O_3$, or HOO-C-$CH_2$-$CH_2$-$CH_2$-$CH_2$-$CH_2$-$CH_2$-$CH_2$-CH=CH-$CH_2$-CHOH-$CH_2$-$CH_2$-$CH_2$-$CH_2$-$CH_2$-$CH_3$. The rest is mostly comprised of Stearic, Oleic, Linoleic, and Linolenic acids. Ricinoleic Acid is a highly viscous yellow liquid, melting point at 5.5 degree Celsius and boiling point at 245 degree Celsius. The chemical composition of the oil derived from Jamalgota is more complex. Chemical properties of Jamalgota oil [2] is presented in Table 2.

**Production of Fuel Grade Biodiesel**

The different stages of the production process of fuel-grade methyl ester, or biodiesel is discussed in the following section. The first step is to expel the oil from the air-dried seeds of Verenda and Jamalgota. The average oil content [3] is 30 to 38 % and 32 to 40 % of the weight of air-dried seeds respectively. Sophisticated mechanical crushing and expelling process may yield an average of 36 grams of crude oil from 100 grams of air-dried seeds of both the species. Traditional crude method of semi-mechanized expelling is less efficient and may yield as little as 28 grams of oil per 100 grams of seeds [4].

There is another indigenous way still practiced in some rural areas in Bangladesh to extract oil from Jamalgota seeds. In this process, as observed by the author in rural settings of Barisal district, seeds are first crushed in mortars, and then the crude powder is boiled in water. After cooling the water, the crude Jamalgota oil is poured from the top. This method yields even less oil, about 20 to 25%.

The next step is to clean up the crude oil derived after expelling either Verenda or Jamalgota seeds by filtering them to get rid of various solid substances and soluble substances. The unprocessed oil ready for transesterification process to get fuel-grade biodiesel should have the following ideal specifications [5].

- Foreign matter: Not more than 2.0%
- Total ash: Not more than 6.0%
- Acid insoluble ash: Not more than 0.3%
- Ethanol soluble extractive: Not less than 25.0%
- Water soluble extractive: Not less than 7.0%
- Loss on drying: Not more than 11.0%

**Table 1 Chemical analysis of Jamalgota (Jatropha Curcas Linn.) oil [2]**

| | Type I | Type II | Type III |
|---|---|---|---|
| FFA | 0.03 % | 0.18 % | 3.69 % |
| Color (5 1/4" Lovibond) | 17 yellow; 1, red | 14 yellow; 1,4 red | |
| Viscosity @ 100°F | 38.8 CST | 37 CST | |
| Saponification number | 195.5 | 193.6 | 192 |
| Iodine number | 94.9 | 105.2 | 96 |
| Free Fatty Acid Profile in % | | | |
| Myristic | 0.06 | 0.13 | |
| Pentadecanoic | Trace | 0.02 | |
| Palmitic | 14.6 | 3.45 | 15.6 |
| Palmitoleic | 0.85 | 0.72 | 0.9 |
| Margaric | 0.09 | 0.09 | |
| Margaroleic | 0.05 | 0.05 | |
| Stearic | 7.15 | 7.46 | 6.7 |
| Oleic | 46.27 | 34.3 | 42.6 |
| Linoleic | 30.80 | 43.12 | 33.9 |
| Linolenic | 0.20 | 0.20 | 0.2 |
| Arachidic | 0.21 | 0.21 | 0.2 |
| Gadoleic | 0.08 | 0.09 | |
| Behenic | 0.07 | 0.04 | |
| Lignoceric | 0.06 | 0.05 | |
| Nurvonic | 0.05 | 0.05 | |

Then this cleaned up crude oil becomes ready for the transesterification process. To get fuel-grade biodiesel, the transesterification process must be conducted under controlled environment, i.e., under specific temperature, air-pressure, flow-control in addition with exact amount of methanol as the active reagent and sodium or potassium hydroxide as the catalyst. The analytical parameters of a demonstrative production of fuel-grade biodiesel from Jamalgota oil is given below:

- Amount of test sample applied: 0.1 μl
- Air pressure: 2-3 psi
- Detector temperature: 250 °C
- Injector temperature: 230 °C
- Column: Stainless steel column coated with diethylene glycol succinate (DEGS) on Chromosorb W (HP) (180 cm , 0.3 cm)
- Oven: 170 °C
- Detector: FID
- Flow rate: 2 ml/min

The next step is to purify the methyl ester, or biodiesel by letting it settle down in a settling tank for a while to allow the formation of layering of soap substance, glycerol produced, unchanged fatty acids, water, methanol, and biodiesel itself. After 2 to 3 hours, the whole thing is transferred into a separate washing tank to remove the soap substance by water flow. Then methanol is almost completely recovered by a simple chemical process for reuse. In the same process, glycerol is also separated. The key quality control issues involve complete (or nearly complete) removal of alcohol, catalyst, water, soap, glycerin and un-reacted or partially reacted triglycerides. Failing to purify the methyl ester properly causes bio-diesel to fall short in one or more fuel standards. In an efficient operation of transesterification process, it is possible to get 980 grams of fuel-grade methyl ester or biodiesel from 1000 grams of oil of fat. The rest 20 grams are a mixture of water, glycerol, and unchanged free fatty acids. The whole transesterification process is diagrammatically shown in Fig. 1:

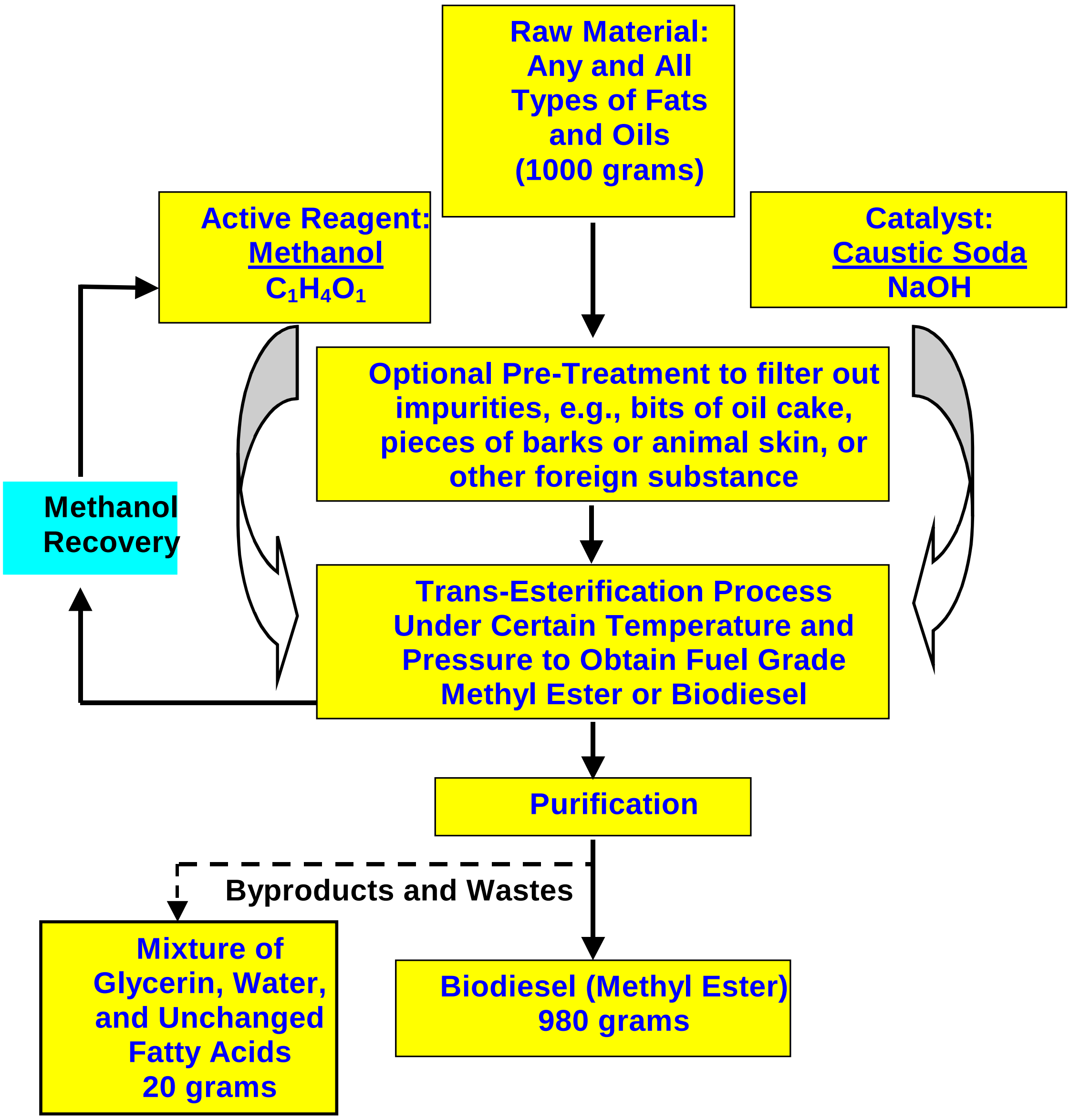



**Fig. 1** Production Flow of Biodiesel

### Properties of Biodiesel

Physical and Chemical properties of Fuel-Grade Biodiesel are given below [6]:

| | |
|---|---|
| Ignition point: | 130 $^{o}$C |
| Specific gravity: | 0.85 ~ 0.90 |
| Volatility by % volume: | < 2 % |
| Stability: | Very High |
| Solubility in water: | Insoluble |
| Atomic weight: | 292 (approx.) |
| Appearance and odor: | Pale yellow liquid with mild fruity odor |
| Chemical formula: | C1H3O2 ~ C10H11O5 |

### Conclusion

Producing biodiesel from suitable feedstock by transesterification process is simple and is getting increasingly attractive in the eyes of the world as a cost-effective substitute of fossil fuels. Bangladesh, despite her limited land resources, has a very good possibility to successfully venture produce large volume of biodiesel from managed plantations of Bherenda and Jamalgota plants. The government of Bangladesh decided to take up a pilot project to assess the feasibility of producing biodiesel from Jamalgota. Private sector enthusiasts are also taking initiative for small and medium block-plantations of inedible oil-seed bearing trees to develop feedstock inventory. It will not be wrong to expect to see domestic production of biodiesel in the next few years. Research activities on plantation, harvesting, oil extraction, and transesterification, and blending undertaken by academic and research institutions at this beginning stage will go a long way in contributing to the cause of renewable fuel and energy in Bangladesh.

### Acknowledgment

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