

Synthesis and Characterization of Biodiesel from Vegetable Oil

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Abstract - Efforts are being made throughout the World to reduce the consumption of liquid petroleum fuels wherever is possible. Biodiesel is recently gaining prominence as a substitute for petroleum based diesel mainly due to environmental considerations and depletion of vital resources like petroleum and coal. According to world scenario, the demand for petroleum diesel is increasing day by day hence there is a need to find out an appropriate solution. By this paper we try to make one of the substitute of natural fuels.

Keywords: TRANSITION, RENEWABLE, NONRENEWABLE ENERGY, BIODIESEL Etc.

I. INTRODUCTION

Economic reasons have been one of the major obstacles in the use of biodiesel. Diesel fuel (DF) derived from vegetable oils is more expensive than petroleum based DF1. The feedstock for biodiesel is already more expensive than conventional DF. For example, in the United States, a gallon of soybean oil costs approximately two to three times as much as a gallon of conventional DF. However, in the case of conversion of vegetable oils or fats to their esters, the resulting glycerol co-product, which has a potential market of its own, may offset some of the costs. In most European countries, however, transportation fuels are so heavily taxed that tax incentives can be applied to encourage the use of biodiesel in the form of lower or no taxes on the biofuel and higher taxes on the petroleum-based fuel2. This subsidy artificially cheapens the biodiesel to make it competitive. In many developing countries, the overriding concern is to become independent of the imported commodity petroleum.

II. MATERIALS AND METHODS

There are four ways by which oils and fats can be converted into Biodiesel, ie. Transesterification, Blending, Microemulsions and Pyrolysis3. Among these processes, transesterification is the most commonly used method. The transesterification process is achieved by reaction of a triglyceride molecule with an excess of alcohol in the presence of a catalyst to produce glycerin and fatty esters. Transesterification includes the following processes:

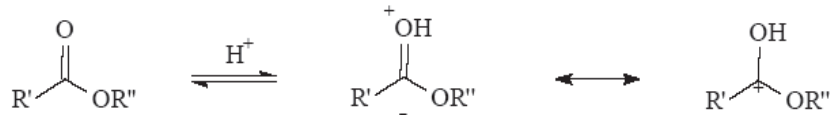
- Base-catalyzed transesterification of the oil with methanol.
- Direct acid-catalyzed esterification of the oil with methanol.
- Conversion of the oil to fatty acids, and then to alkyl esters with acid catalysis.

Alkali-catalyzed transesterification is much faster than acid-catalyzed transesterification and is used in the commercial production of biodiesel. Even at ambient temperature, the alkali-catalyzed reaction proceeds rapidly usually reaching 95% conversion in 1~2 h. On the other hand, the acid-catalyzed reaction commonly requires temperatures above 100°C, and reaction times of 3-48 h have been reported, except when reactions were conducted under high temperature and pressure4. However, for alkali-catalyzed transesterification, the starting materials (oil or fats) must be dry and free of FFA. The FFA content of the refined oil should be as low as possible (below 0.5%). The presence of minor amount of FFA and moisture in the reaction mixture produces soap, which lowers the yield of esters and renders the separation of ester and glycerol as well as the water washing difficult. Moreover, FFA consumes the catalyst and reduced catalyst efficiency. Therefore base-catalyzed transesterification require highly refined oils in order to get efficient transesterification and not suitable for oils and fats with high FFA content5. Acids used for transesterification include sulphuric acid, phosphoric acid, hydrochloric acid, and organic sulfonic acids. Although transesterification by acid catalysis is much slower than that by alkali catalysis, acid-catalyzed transesterification is more suitable for oils and fats that have relatively high FFA contents and more water6. It has been reported that acid-catalyzed transesterification can be used when the starting materials are low-grade fats or have a high FFA content.

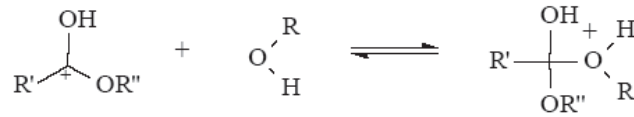
The mechanism of acid catalyzed transesterification is described below.

Transesterification can be catalyzed by sulfuric or sulfonic acids.

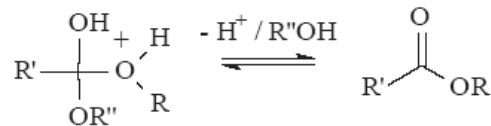
The first step involves the protonation of a carbonyl group, which results in the formation of a carbon cation.



The second step involves the nucleophilic attack of alcohol, producing a tetrahedral intermediate.



The tetrahedral intermediate rearranges, releasing an alkyl ester and proton catalyst.



III. PROCESS DETAIL

Mixing of alcohol and catalyst

The catalyst, sodium hydroxide (caustic soda), is dissolved in the alcohol using a standard agitator or mixer. The alcohol/catalyst mix is then charged into a closed reaction vessel and the oil or fat is added. The system from here on is totally closed to the atmosphere to prevent the loss of alcohol. The reaction mix is kept just above the boiling point of the alcohol (around 160 °F) to speed up the reaction and the reaction takes place. Recommended reaction time varies from 1 to 8 hours, and some systems recommend the reaction take place at room temperature. Excess alcohol is normally used to ensure total conversion of the fat or oil to its esters. Care must be taken to monitor the amount of water and free fatty acids in the incoming oil or fat. If the free fatty acid level or water level is too high it may cause problems with soap formation and the separation of the glycerin by-product downstream.

Separation

Once the reaction is complete, two major products exist: glycerin and biodiesel. Each has a substantial amount of the excess methanol that was used in the reaction. The reacted mixture is sometimes neutralized at this step if needed. The glycerin phase is much more dense than biodiesel phase and the two can be gravity separated with glycerin simply drawn off the bottom of the settling vessel. In some cases, a centrifuge is used to separate the two materials faster.

Alcohol Removal

Once the glycerin and biodiesel phases have been separated, the excess alcohol in each phase is removed with a flash evaporation process or by distillation. In others systems, the alcohol is removed and the mixture neutralized before the glycerin and esters have been separated. In either case, the alcohol is recovered using distillation equipment and is re-used. Care must be taken to ensure no water accumulates in the recovered alcohol stream.

Methyl Ester Wash

Once separated from the glycerin, the biodiesel is sometimes purified by washing gently with warm water to remove residual catalyst or soaps, dried, and sent to storage. In some processes this step is unnecessary. This is normally the end of the production process resulting in a clear amber-yellow liquid with a viscosity similar to

petrodiesel. In some systems the biodiesel is distilled in an additional step to remove small amounts of color bodies to produce a colorless biodiesel.

Product Quality

Prior to use as a commercial fuel, the finished biodiesel must be analyzed using sophisticated analytical equipment to ensure it meets any required specifications. The most important aspects of biodiesel production to ensure trouble free operation in diesel engines are complete Reaction, removal of Glycerin, removal of catalyst, removal of alcohol and absence of free fatty acids.

IV. ANALYSIS OF BIODIESEL

Viscosity

Its analysis show less variation in the viscosity of the product as the temperature rises.

Density

Density is an important biodiesel parameter, with impact of fuel quality. The biodiesel density decreases with an increasing temperature and with the level of unsaturation of the FAMES.

Calorific value

The calorific value of biodiesel is lower than diesel because bio diesel consists of long chain alkyl esters whereas diesel in contrast have pure long chain alkanes consisting of 8-30 carbon atoms. Hence bio diesel requires more ignition temperature to start the reaction, due to presence of double bonds between molecules of bio diesel.

Acid value

In enzymatic biodiesel, the presence of free fatty acids in the raw material is not a problem, because they are converted into esters along with triglycerides. The acid value of sunflower oil used as feedstock for biodiesel production is 0.06 mg KOH/g oil, a value that indicates a low content of free fatty acids.

Moisture content

Saturation moisture in biodiesel ranged from 0.1 to .17% wt in the temperature range of 4°C to 35°C, which was 15 to 25 times higher than that of biodiesel.

Perfomance of biodiesel on disel engine

FOR PURE DIESEL													
S.N	W ₁ (in k.g.)	W ₂ (in k.g.)	RPM (N)	x(ml)	t (sec)	T ₁ °C	T ₃ °C	T ₃ °C	Load in kg(W)	Radius Of Rope in Meters (R)	Torque in N- M(T)	Brake Power in KW (BP)	Fuel Consumpti on in litres per hour
1	0	0	1560	10	42	42	34	12 7	0	0.162	0	0	0.8571429
2	0	5	1550	10	35	43	34	13 9	2.5	0.162	7.9461	1.289122 29	1.0285714
3	0	10	1533	10	27	43	33	15 6	5	0.162	15.8922	2.549967 06	1.15
4	0	15	1528	10	24	44	33	17 3	7.5	0.162	23.8383	3.812475 21	1.4
5	1	20	1520	10	21	45	33	19 2	10.5	0.162	32	4.803851 84	1.7142857
6		25	1504	10	17	50	33	21 7	13.5	0.162	38.2	5.753976 55	2.1176471

FOR BIO – DIESEL (B-30)													
S.N.	W ₁ (in k.g.)	W ₂ (in k.g.)	RPM (N)	x(ml)	t(sec)	T ₁ °C	T ₂ °C	T ₃ °C	Load in kg(W)	Radi us Of Rope in Mete rs (R)	Torq ue in N- M(T)	Brak e Powe r in KW (BP)	Fuel Consu mption in litres per hour
1	0	0	1550	10	40	41	34	126	0	0.162	0	0	0.9
2	0	5	1532	10	33	42	34	136	2.5	0.162	9.012 4	1.282 46875 6	1.0909 09091
3	0	10	1528	10	29	43	34	159	5	0.162	12.04 4	2.561 61074 4	1.2413 7931
4	0.8	15	1525	10	24	45	35	169	7.5	0.162	22.56 6924	3.602 05718 6	1.5
5	1	20	1504	10	19	45	35	204	10.5	0.162	30.19 518	4.753 28497 5	1.8947 36842
6	1.5	25	1500	10	16	49	35	219	13.5	0.162	37.34 667	5.863 42719	2.15

V. RESULT AND DISCUSSION

Various physical and chemical properties of edible oils and their esters are determined experimentally. The values of different properties of edible oils are given in Table 1.1 and 1.2. As acid values of edible oils are less than 3.0, hence only transesterification has been done to prepare biodiesel from them. . These standard values were calculated according to ASTM. The American Society for Testing and Materials International (ASTM) specification for biodiesel (B100) is ASTM D 6751-03, for diesel it is ASTM D 975.

Fuels possessing a certain minimum viscosity as well as a certain maximum viscosity are required for proper engine performance. Specific gravity of biodiesels ranges between .848 and .901 g/L. It is also observed that the density of vegetable methyl ester(0.8690 gm/ml) is slightly higher than that of diesel fuel(0.84 gm/ml). As it is slightly heavier than diesel fuel hence their viscosities are also little higher than that of diesel fuel. Fuel system deposits and reduced life of fuel pumps and filters contribute to an acid number higher than 0.80.

It has been observed that biodiesel can effectively be used as diesel fuel substitute in existing diesel engine without any engine modification .Biodiesel can be used as an alternative to diesel in a compression ignition engine without any engine modifications. Biodiesel from vegetable oils can also be used directly or blended with diesel to operate compression ignition engines. It can be used directly in the engine without any previous treatment with the required engine modification.

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