

IONIC LIQUID CATALYSIS TO PRODUCE COTTONSEED OIL BY TRANSESTERIFICATION AND PERFORMANCE TEST IN DIESEL ENGINE

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ABSTRACT

This work is based on the performance of biodiesel blends with diesel in providing for a suitable alternative fuel. There are various methods in which the biodiesel blends are made. Every approach uses the preparation of biofuel initially from a parent oil blend. Here cottonseed oil is taken to make biodiesel. For the conversion ionic liquids have been used as catalysts. The process of transesterification has shorter reaction times with ionic liquid usage. Then subsequently test is made on a diesel engine particularly suited for alternative fuels to find out the biodiesel performance. All the tests to find the suitability of the transesterified biofuel for use in a diesel engine have been done and results presented. The performance graphs show B30 to be the optimum based biofuel blend for which maximum efficiency has been found.

Keywords: Hybrid wind turbine, Vertical axis wind turbine, Low wind speed.

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1. INTRODUCTION

Reserves shortage and price fluctuation along with emitted pollutants like tetra hydrocarbons are causing a ever growing substitution of fossil fuels with fuels derived from vegetable oil such as biodiesel. Biodiesel production mainly is the process of producing the biofuel, biodiesel through the chemical reactions transesterification and esterification.

This involves vegetable or animal fats and oils being reacted with shortchain alcohols like methanol. Greater conversions into biodiesel can be reached using methanol because of short chain structure. Although the transesterification reaction can be catalyzed by either acids or

bases the most common means of production is base catalyzed transesterification because of high yields possible. This path has lower reaction times and catalyst cost than those posed by acid catalysts and this is a major advantage. The reason for using catalyst is to speed up the conversion process to suit the parent oil as well as to increase the yield.

Animal fats and plant oils are made up of triglycerides which are esters formed by the reactions of three free fatty acids and the trihydric alcohol and glycerol. In the transesterification process, the added alcohol is deprotonated with a base to make it a stronger nucleophile which later decomposes. The reactions have no other inputs than the triglyceride and the alcohol and this is sufficient to cause the reaction. Under normal conditions, this reaction will proceed either Exceedingly slowly or not at all, so heat as well as catalysts are used to speed the reaction and also to increase the yield. The acid or base catalysts are not consumed by the transesterification reaction. Common catalyst for transesterification include sodium hydroxide or even ionic liquids. The biosource used in this project for producing biodiesel is cottonseed oil. Cottonseed oil is extracted from the seeds of cotton plants of various species. Its fatty acid profile consists of 70% unsaturated fatty acids and 26% saturated fatty acids.

2. METHOD OF EXTRACTION OF COTTONSEED OIL

The process of extraction of cottonseed oil is by using SCF ie Supercritical fluid. The fluid used usually is carbon dioxide. Dehulled cottonseed is passed through cracking and flaking rolls to yield flakes. The flaked cottonseed is charged into an alloy steel autoclave and extracted. The process may be mechanical as in crushing or pressing or chemical as in solvent extraction. The production steps are as follows.

- Seed cleaning
- Cracking
- Flaking
- Cooking
- Expelling
- Refining

Seed Cleaning

This process involves getting rid of organic impurity like stems, leaves, hull, rope etc, inorganic impurity like dust, silt, pebbles and metals, oiliness impurity like grain of insects, grain of faultiness, heterogeneity seeds etc. Magnetic Separator, Vibrating Sieve, De-stoner, Decorticator are used in the process.

Cracking

Toothed cracking rollers are used to convert the cotton seeds kernel into right uniform pieces which can keep a moderate block size for squeezing out the oil.

Flaking

This process converts the cracked cotton seeds kernel pieces into uniform smaller flakes. The non oil spilled pinching is done slowly. The pieces are passed through sieve mesh to separate the powder.

Cooking

This process is used to add steam into the crushed and flaked seed pieces. It is then dried to get rid of more water content. A vertical stack cooker with five layers is adopted in this process. The temperature reached is 95 to 100 degrees Celsius.

Expelling

This method uses solvents for extraction of oil. The solvent is used after pre-pressing by oil expellers to get more oil.

Refining

The process involves the following.

Alkali Refining

The oil and alkali are mixed allowing free fatty acids and alkali to form a soap. The resulting soapstock is removed through centrifuging. This process removes free fatty acids, glycerol, carbohydrates, resins, metals, phosphalides and protein meal.

Bleaching

Bleaching clays are used which adsorb the impurities. This eliminates trace metals and other colour bodies.

Winterisation

In this process the oil is chilled with gentle agitation which causes higher melting fractions to precipitate. The fraction which settles out is called stearin. Care is taken that the oil does not become cloudy.

Hydrogenation

This process involves treatment of oil with hydrogen gas in the presence of catalyst resulting in the addition of hydrogen to the carbon-carbon double bond. It is a selective process that can be controlled to produce various levels of hardening.

Deodorization

Deodorization is a steam distillation process carried out under a vacuum. It removes volatile compounds from the oil. The end product has a low level of free fatty acids and has a zero peroxide value. This step also removes any residual pesticides or metabolites that might be present.

Interesterification

This process is used to rearrange or redistribute fatty acids on the glycerol backbone. It improves the functional properties of the oil. This is most often accomplished by catalytic methods. The oil is heated, agitated and mixed with the catalyst at 90°C. Enzymatic systems may also be used in this process. It does not change the degree of saturation or isomeric state of the fatty acids.

Cottonseed oil does not need to be hydrogenated as much as other polyunsaturated oils. Recent technological, social, and environmental changes are forcing the search for new alternatives for both edible and non-edible oil derived fuels. Presently, the first generation biofuels such as biodiesel and bioethanol dominate the biofuel sector. These biofuels can be used in low percentage blends with conventional fuels and can be distributed through the

existing infrastructure. Today these fuels are not competitive with fossil fuels and can be seen as an intermediate step to reduce greenhouse gas emissions and to diversify transport energy sources.

Ionic liquids were originally used as solvents for biodiesel synthesis with high biodiesel yield in short reaction time which can improve productivity in large scale. The acids were almost completely retained in the Ionic liquid phase and could be reused at least six times without any significant decrease in the selectivity and thus have a long life. A series of Ionic liquids were used as catalysts and solvents for ester synthesis from oleic acid and methanol and their performances are noted.

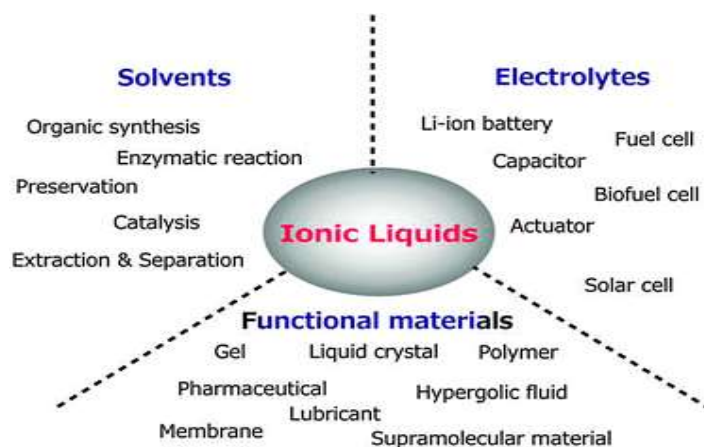


Figure 1 Ionic liquids classification

Reaction temperature plays an important role in esterification because activity of traditional Ionic liquids is very low, and therefore new ionic liquids are emerging in the market. At identical conditions, sulphuric acid functional ionic liquids performed more active than other kinds of ionic liquids because sulphuric acid groups have active sites for the reaction and does not allow for decomposition. The interest of this process lies in the possibility of recycling the biocatalyst and the easy separation of the biodiesel from the reaction mixture by filtering out the glycol formed. The ionic liquids used were hexadecyl methylimidazolium triflimide and octadecyl methylimidazolium triflimide etc.

3. EXPERIMENTAL SETUP

The experimental design procedure was used to optimize the following process variables : reaction time, catalyst content and cottonseed oil to methanol molar ratio. The effects of these variables on biodiesel conversion were investigated.

3.1. Preparation of Biofuel

In this project work , 200ml of cottonseed oil was taken in a beaker . Methanol of 50ml was taken and 0.5 grams of sodium hydroxide pellets were dissolved in it. The cotton seed oil and methanol with sodium hydroxide catalyst were mixed and placed on a magnetic hot plate. A magnetic stirrer is introduced into the beaker.

A condenser with flowing cooling water is kept on top of the beaker and held firmly in a stand. Electric supply is given to the hot plate. The stirrer automatically stirs the mixture. Heat is supplied for about an hour and the temperature of the mixture reached 70 degrees. The mixture is then cooled in air until the temperature comes down to room temperature. The contents are taken in a separating funnel and left for one day for the separation of biofuel and glycerol. Biofuel is then collected separately after the glycerol is drained. The oil is in the

upper portion of the separating funnel and glycerol collects in the bottom. The yield percentage is noted.

The values obtained were as follows

Input = Cottonseed oil + Methanol + Sodium hydroxide=232.34g

Evaporation loss=5.5g

Yield of Biofuel=193.66g

Glycerol=33.1g

The yielding percentage of bio-oil from the bio-source =83.35%

The experiment was repeated to get a substantial yield of biofuel.

Density of cotton seed oil =965 kg/m³



Figure 2

3.2. Engine Details

IC Engine set up under test is Kirloskar TV1 having power 5.20 kW @ 1500 rpm which is 1 Cylinder, Four stroke, Constant Speed, Water Cooled, Diesel Engine, with Cylinder Bore 87.50(mm), Stroke Length 110.00(mm), Connecting Rod length 234.00(mm), Compression Ratio 17.50, Swept volume 661.45 (cc)

3.3. Combustion Parameters

Specific Gas Const (kJ/kgK) : 1.00, Air Density (kg/m³) : 1.17, Adiabatic Index : 1.41, Polytrophic Index : 1.26, Number Of Cycles : 10, Cylinder Pressure Reference : 7, Smoothing 2, TDC Reference : 0

3.4. Performance Parameters

Orifice Diameter (mm) : 20.00, Orifice Coeff. Of Discharge: 0.60, Dynamometer Arm Length (mm) : 185, Fuel Pipe dia (mm) : 12.40, Ambient Temp. (Deg C) : 27, Pulses Per revolution : 360, Fuel Type : Diesel, Fuel Density (Kg/m³) : 830, Calorific Value Of Fuel (kJ/kg) : 42000

4. RESULTS AND DISCUSSIONS

Table 1

Speed (rpm)	Load (kg)	IP (kW)	BP (kW)	FP (kW)
1533.00	0.35	6.67	0.10	6.57
1526.00	2.69	7.79	0.78	7.01
1507.00	5.90	8.87	1.69	7.18
1488.00	8.80	7.69	2.49	5.20
1476.00	11.56	6.76	3.24	3.51

Table 2

Speed (rpm)	Load (kg)	IMEP (bar)	BMEP (bar)	FMEP (bar)
1533.00	0.35	7.89	0.12	7.77
1526.00	2.69	9.26	0.93	8.33
1507.00	5.90	10.68	2.04	8.64
1488.00	8.80	9.37	3.03	6.34
1476.00	11.56	8.31	3.99	4.32

Table 3

Torque (Nm)	BP (kW)	FP (kW)	IP (kW)	BMEP (bar)	IMEP (bar)	BTHE (%)	ITHE (%)	Mech Eff. (%)
0.63	0.10	6.57	6.67	0.12	7.89	1.93	127.54	1.51
4.88	0.78	7.01	7.79	0.93	9.26	11.20	111.74	10.02
10.72	1.69	7.18	8.87	2.04	10.68	18.19	95.42	19.07
15.97	2.49	5.20	7.69	3.03	9.37	21.42	66.17	32.37
20.98	3.24	3.51	6.76	3.99	8.31	24.27	50.56	47.99

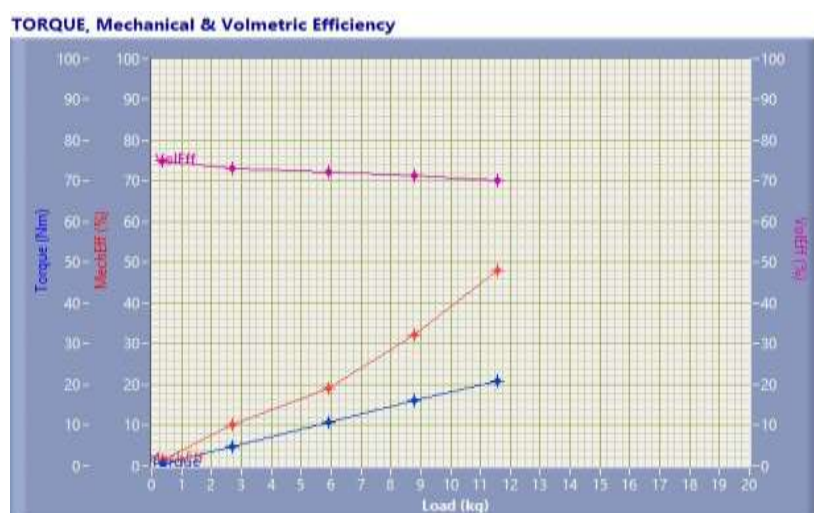


Figure 3

Ionic Liquid Catalysis to Produce Cottonseed Oil by Transesterification and Performance Test in Diesel Engine



Figure 4

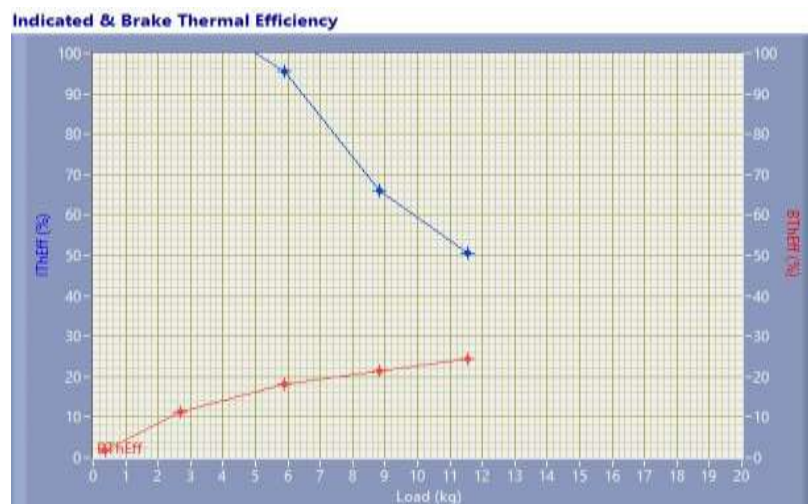


Figure 5



Figure 6

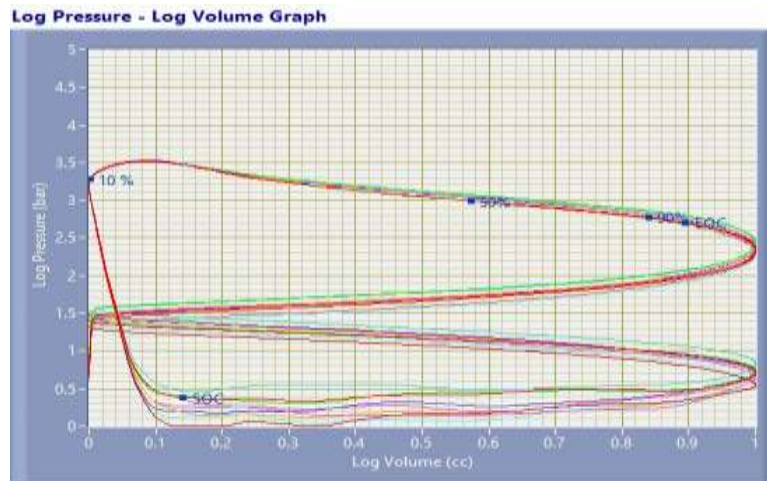


Figure 7

5. CONCLUSION

The optimum blend of biodiesel has been found out by search methods of optimization and the parameters like thermal efficiency, specific fuel consumption and indicated power were differentiated towards reaching their limits before the graphs show that they have tapered off from peak. B30 showed an excellent range of operation where these parameters collectively reached satisfactory values. The biofuel from cottonseed oil had been earlier tested in infrared spectroscopy where light is allowed to pass through it and the percentage transmittance is noted. The brake mean effective pressure had a straight line relation with the load which also indicated positive results.

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