Oxidation Stability of Waste Cooking Oil Methyl Ester

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Abstract : Many researchers are attempting to develop an alternative fuel which is economical, environment friendly and a simple technology which is easy to understand and to implement. From the studies of many researchers we came to know that, biofuels are having the potential to serve as a fuel in compression ignition engine. In this review studies of various research pertaining to Oxidation stability of biodiesel is presented in detail. As oxidation stability is one of the major drawback in bringing biodiesel to main stream this review will assist in understanding this problem along with that also provides various solutions to overcome this problem.

***IndexTerms* – Engine, Oxidation, Biodiesel, Economical**

I. Introduction

The heat energy released by combustion of fuels is converted into mechanical energy using heat engine. Biofuel is derived from biomass that is, plant or algae material or animal waste. As this feedstock material can be replenished readily, biofuel is considered to be a source of renewable energy, unlike fossil fuels such as petroleum, coal, and natural gas. Fuel price variation and environmental issues with use of conventional fuels have enhanced the interest of scientific research to look for alternative fuels of bio origin. It is an oxygenated, sulfur-free, biodegradable, non-toxic, and environmentally friendly fuel Biodiesel fuels are derived by transesterification of biomass. The major concern with regard to commercial implementation of biodiesel is its inferior oxidative and storage stability. It is more susceptible to oxidation compared to fossil diesel because of unsaturated fatty acid. Biodiesel, a diesel fuel substitute that can be made from a variety of oils, fats, and greases, is of interest to farmers for a number of reasons, it can provide an additional market for vegetable oils and animal fats, It can allow farmers to grow the fuel they need for farm machinery. The addition of antioxidants to biodiesel blend increases oxidation stability and brake power and reduced brake specific fuel consumption slightly.

II. LITERATURE:

Biodiesel produces less pollutant (except NOx) [1] but is more prone to oxidative degradation. The purpose of this study was to produce biodiesel via transesterification of WCO and verification of the influence of two antioxidants on exhaust emissions from a diesel engine. Transesterification reactions were made applying ultrasound waves within a designed helicoidal reactor in the presence of a sodium hydroxide (0.5% weight) as a catalyst. After production, various blends of biodiesel were prepared including B0, B10, B20, B20 + BHA, and B20 + PrG. BHA (2-tert-butyl-4-methoxyphenol) and PRG (propyl-3, 4, 5-trihydroxybenzoate) are two antioxidants that a 500 ppm concentration of them were blended within B20. The obtained results shows that an effective reduction in NOx emission as well as an ignorable reduction in CO and HC emissions.

Biodiesel produced from chicken and mutton fats using acid catalysis [2] results in higher yield in comparison to base catalysis. Different experimental parameters such as amount of catalyst, temperature and time affected the production of biodiesel. Optimum amount of H2SO4, temperature and time were 1.25 g (on fat weight basis), 50^0C and 24 h for chicken fat, and 2.5g (on fat weight basis), 60^0C and 24 h for mutton fat. Results from this study clearly demonstrated that the use of chicken and mutton fats is very suitable as low cost feed stocks for biodiesel production.

Cost of biodiesel can be reduced by using waste cooking oil as feed stock. High fatty acid content in waste cooking oil could be reduced by pretreating [3] waste cooking oil with acid catalyst. Water produced during the esterification process can inhibit acid catalyst, and this can be eliminated by stepwise reaction mechanism. Methanol is the most suitable alcohol because of its low cost and easy separation from biofuel. Methanol to oil ratio for the acid-catalyzed reaction depends on amount of free fatty acid. For base-catalyzed reaction, 6 is optimum ratio for transesterification reaction. Concentration of catalyst depends on nature of catalyst used either heterogeneous or homogenous. Stirrer speed helps to enhance rate of reaction. In most cases, optimum speed of stirrer was maintained in the range of 200–250 rpm.

Waste catfish oil generated by fish processing plants in Vietnam [5] was used to produce biodiesel by a co-solvent transesterification method. The properties of the purified B100 derived from cat fish oil (CFO) was measured and compared to that of commercial B100 derived from waste cooking oil (WCO). The results indicate that the composition of B100 CFO is different from that of B100 WCO, which contributes to differences in their physicochemical properties and low-temperature qualities. Generally, the B100 CFO is more stable than the B100 WCO, as the unsaturated FAMEs of B100 CFO account for approximately 60 wt%, which is 7%(absolute) lower than that in B100 WCO. The better stability of B100 CFO is also due to the lower composition of FAMEs with polyunsaturated double bonds. However, B100 CFO has inferior low-temperature qualities compared to that of B100 WCO owing to the higher composition of saturated FAMEs. The influence of oxidation on B100 CFO Properties was investigated by conducting modified ASTM D5304 and D2274 tests. Both ASTM D5304 and D2274 tests have provided significant changes in physicochemical properties (viscosity, density, AN, PV, HHV) and reduced low-temperature qualities. The oxidation reaction in both tests has showed significant increase in oxygen content of B100 CFO.

A three-level experimental design [6] with four variables including reaction temperature, catalyst concentration, oil-to-methanol volume ratio, and residence time was used to determine the optimum production point precisely. Based on the results, the highest purity of produced biodiesel was 97.45% at reaction temperature of 65 °C, catalyst concentration of 8.1 wt%, oil/methanol volume ratio of 2.25:1 and residence time of 13.4 minutes.

Biodiesel micro emulsions were formed by different surfactants, and the cold flow properties and ignition delay (activation energy) of the biodiesel were improved after micro emulsification. Biodiesel micro emulsions were stable without any phase separation in 60 days at normal temperature or decreased one (4 °C) except Span 80 based micro emulsion, which experienced precipitation (phase separation). After the phase separation or purification process, the total fatty acid methyl esters content in biodiesel was increased considerably from about 90% to 96% not including probably ~3% of Span 80 (also fatty acid ester) in the purified biodiesel. Solid product of about 7.4% was separated and characterized. The solid which includes glycerides may account for some of the reasons for the poor cold flow properties and low oxidation stability of biodiesel. The purified biodiesel was found to have better cold flow properties and oxidation stability, and at the same time, acceptable activation energy level.

III. OBJECTIVES

- Determine the following fuel properties of WCO and its biodiesel blends such as viscosity, density, calorific value, flash point and fire point.
- Find out the overall fuel efficiency of WCO biodiesel and compare that to conventional diesel at varying percentages.
- To find out the effect of different blends of WCO biodiesel on the performance and emission characteristics of CI engine at different load.
- To determine the performance parameters like BP, BSFC & ISFC as well as emissions like CO, HC and NOx for all cases and comparing them with each other and also with pure diesel results.

IV. METHODOLOGY

The selection of raw material play a major role in many researches as far as biodiesel is concerned as waste cooking oil selection and the way the oil has to be processed for the manufacture of biodiesel are most important aspects. The raw material is collected from 'Vasa scientific company', malleshwaram, Bangalore location and stored in storage cane.
The Pyrogallol is an antioxidant used to prepare blend with Waste cooking oil biodiesel. Pyrogallol is used to stabilize oxidation stability.

The determination of free fatty acid content of raw oil becomes the most critical aspect of the biodiesel manufacturing. Listed below are the steps taken and the method to arrive at the free fatty content of raw oil.

- If the free fatty acid content of raw oil is less than 4% single stage process (alkali base) should be undertaken.
- If the free fatty acid content of raw oil is more than 4% double stage process (alkali base +alkali base catalyst) should be undertaken.

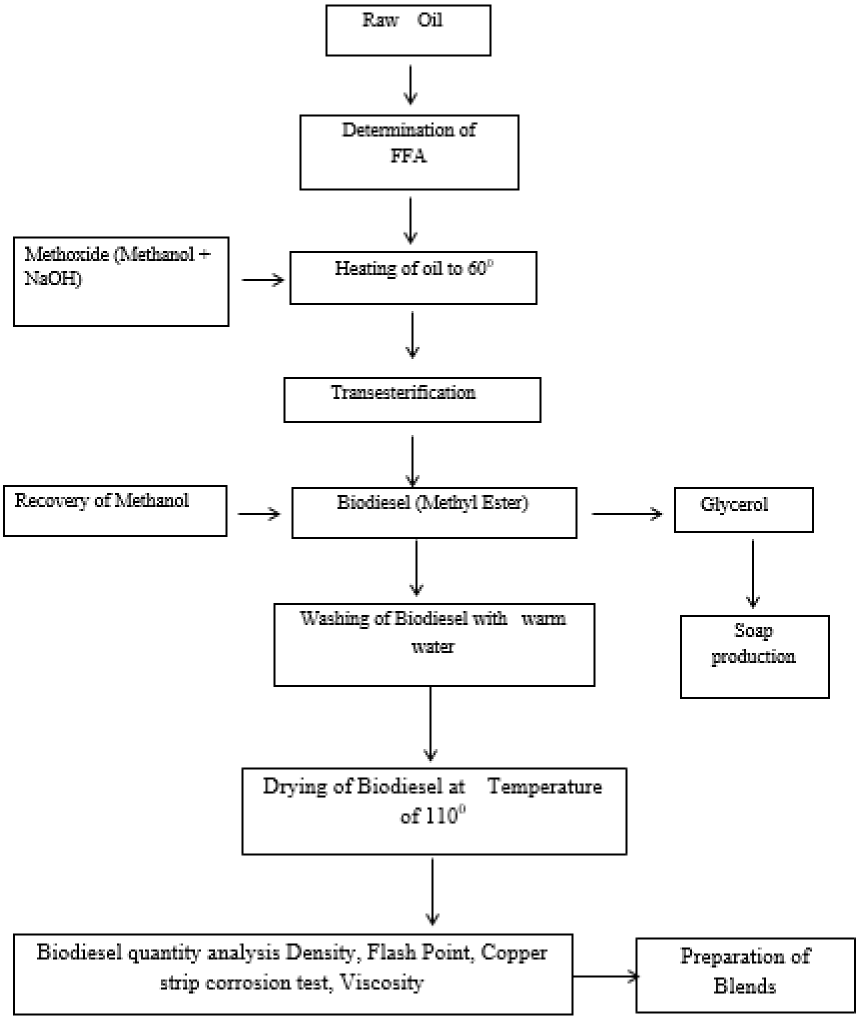


Figure 1 Schematic diagram of biodiesel production

MIXING OF PYROGALLOL INTO BLENDS

The enhancement in the extraction of bioactive compounds achieved using sonication is attributed to cavitation in the solvent, a process that involves nucleation, growth, and collapse of bubbles in a liquid, driven by the passage of the ultrasonic waves. Ultrasonic frequencies (>20 kHz) are usually used, leading to the process also being known as ultra sonication. This antioxidant Pyrogallol blend mixed with the help of mixer.

The engine tests were conducted on a computerized single cylinder, 4-stroke water cooled CI engine test rig. It was directly coupled to an Eddy current dynamometer that permitted the engine motoring either fully or partially loaded. The engine and Dynamometer were interfaced to a control panel which is connected to a digital display of the test parameter, such as fuel flow rate, temperature, air flow rate, load, etc, and calculating the engine performance characteristics such as Brake Power, BSFC and Brake Thermal efficiency. The calorific value and density of the particular fuel was for calculating the above said performance parameters for different pressures. At the same time the exhaust gas analyser is used to find emission parameters such as HC, CO and NOx.

Once, the performance and emission test is carried out for pure diesel and blends of biodiesel the antioxidant Pyrogallol is added to the best blend. Antioxidants are added amount is 3 grams, further tests are carried out and are compared with and without additive.

The complete experimental setup to determine the effects of the waste cooking oil biodiesel fuel on the performance and emission characteristics of compression ignition engine. It consists of a single cylinder 4-stroke water cooled compression ignition engine connected to an eddy current dynamometer. It is provided with temperature sensors for the measurement of jacket water, calorimeter water and calorimeter exhaust gas inlet and outlet temperature. It is also provided with pressure sensors for the measurement of combustion gas pressure and file injection pressure. The built in program in the system calculates break power, break thermal efficiency and break specific fuel consumption.

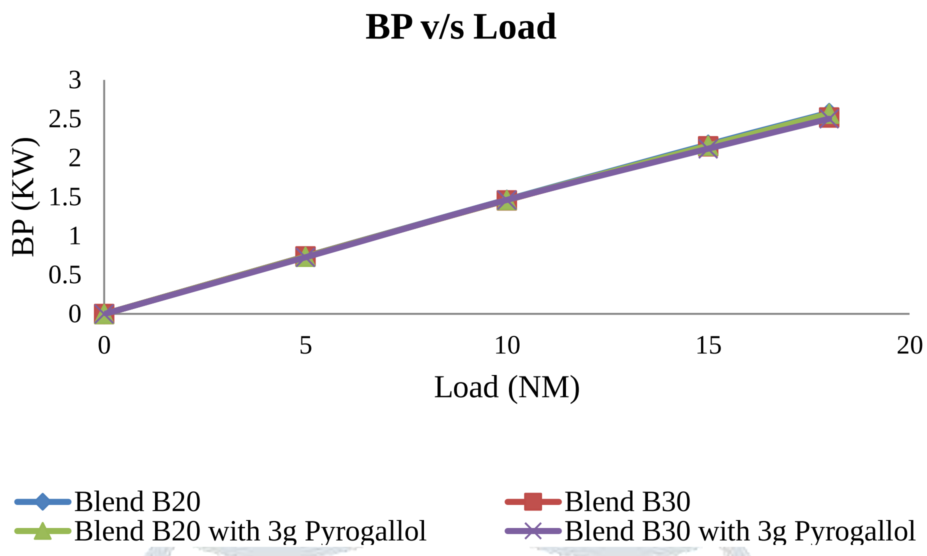
V. RESULTS

In this work the performance and characteristics are studied and experiment is carried out by testing the single cylinder 4-stroke CI engine fuelled with diesel with waste cooking oil blends namely B20+D80, B20+D80(with Antioxidant), B30+D70 and B30+D70(with Antioxidant). This antioxidant blend mixed with the help of mixer. The amount of antioxidant added is 3gm for both B20 and B30 Blends shows the following results.

The tests were made at different torque at the condition of 5Nm, 10Nm, 15Nm and 18Nm. The corresponding BP, BSFC, BTE and emission such as HC, CO and NOx were determined.

BP v/s LOAD

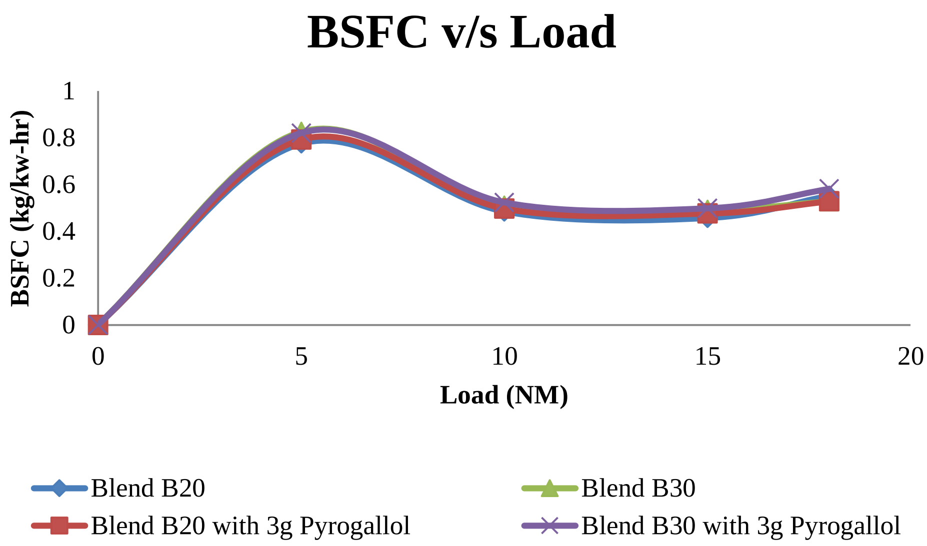
Fuel Type: B20, B20 (3gm Pyrogallol), B30 and B30 (3gm Pyrogallol)



- As we can analyse in the BP v/s Load graph, that the BP for all the fuel type is the same up to 14Nm torque and after which the BP of blend B20 with 3g Pyrogallol slightly increases in torque compare to other blends.
- There by we can conclude that there is better BP with addition of Pyrogallol antioxidant.

BSFC v/s LOAD

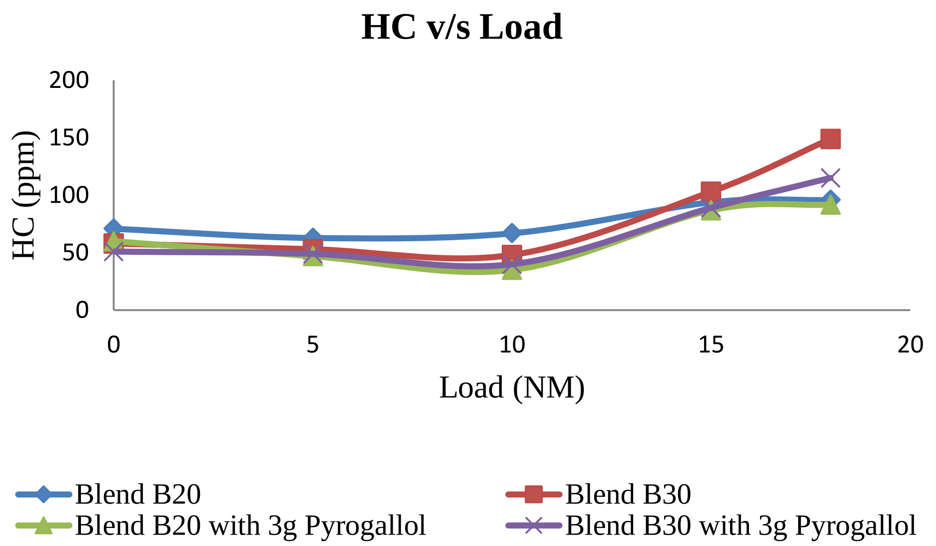
Fuel Type: B20, B20 (3gm Pyrogallol), B30 and B30 (3gm Pyrogallol)



- From the graph above we can analyse that the curve of B30 with 3g pyrogallol blend has more BSFC when compared to other blends.
- The curve of blend B20 shows less BSFC than other blends.This could be due to more percentage of diesels.

HC v/s LOAD

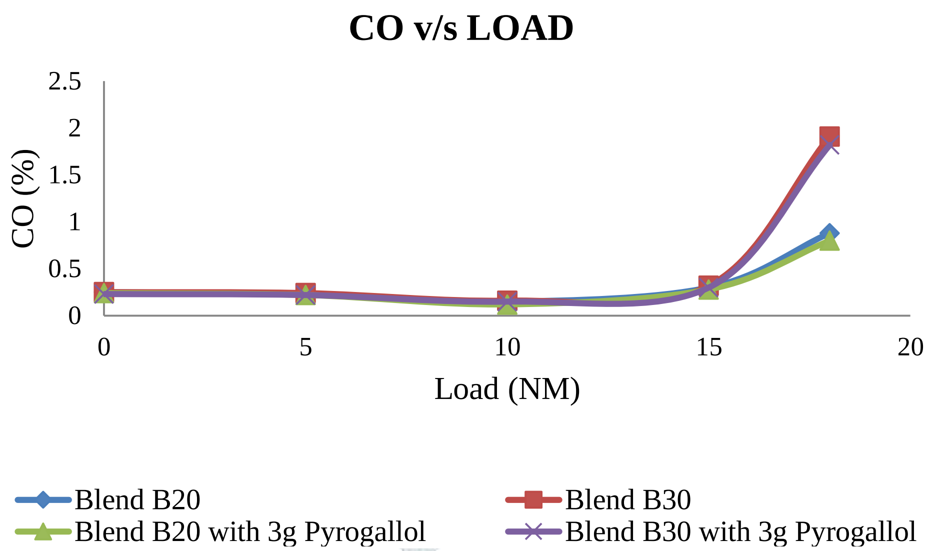
Fuel Type: B20, B20 (3gm Pyrogallol), B30 and B30 (3gm Pyrogallol)



From the above graph it is clear that blend B20 with 3g pyrogallol has less HC emission compared to other blends this may due to amount of diesel content and pyrogallol addition.

CO v/s LOAD

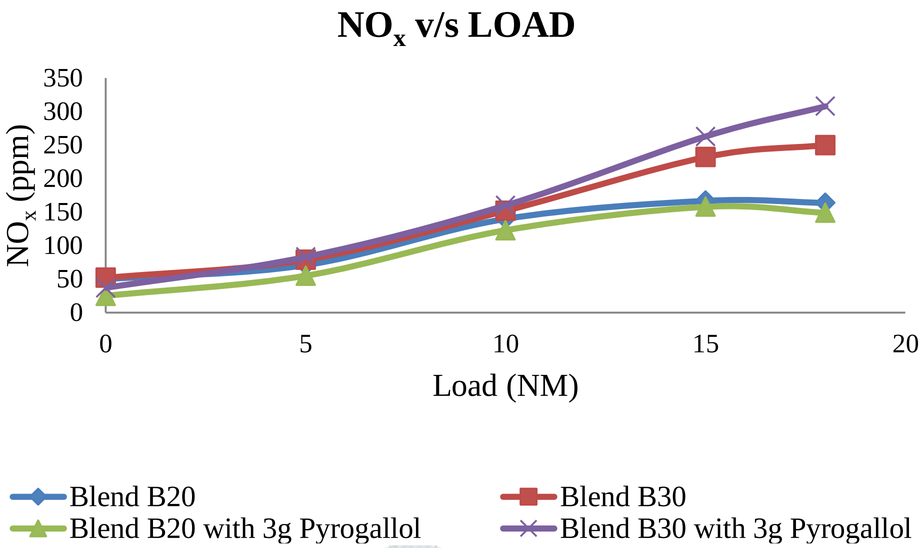
Fuel Type: B20, B20 (3gm Pyrogallol), B30 and B30 (3gm Pyrogallol)



From the above graph it is clear that blend B20 with 3g pyrogallol has less CO emission compared to other blends this may due to amount of diesel content and better oxidation.

NOX v/s LOAD

Fuel Type: B20, B20 (3gm Pyrogallol), B30 and B30 (3gm Pyrogallol)



From the above graph it is clear that blend B20 with 3g pyrogallol has less NOx emission compared to other blends this may due to reduced combustion temperature in terms of compromise in BTE.

VI. CONCLUSION

From this study following conclusions is drawn:
1. Blend B20 has better BTE compared to other samples.
2. Blend B20 exhibited less BSFC compared to other blends.
3. Blend B20 with 3g pyrogallol has low CO, HC and NOx emission.
4. From our study we suggest B20 with pyragallol blend is the best out of all blends considered even though a small amount of efficiency is compromised. This is because less pollution is always a key to have a sustainable environment.

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