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BIODIESEL PRODUCTION FROM BOILED VEGETABLE OIL USING SELF SYNTHESIZED STRONTIUM OXIDE NANO CATALYSTS

Preethi J Aradhya[1,a)] and Mallikarjunnayya C. Math[2, b)]
[1]Assistant Professor, Department of Mechanical Engineering, NitteMeenakshi Institute of Technology, Bangalore..
[2]Assosiate Professor,Department of Thermal Power Engineering, VTU Centre for PG Studies, Mysuru
[a)]preethi.j.aradhya@nmit.ac.in [b)]mcmath1018@yahoo.com

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Abstract. In this work, an attempt has been made to use one time, four times and eight times boiled vegetable oil as source for the production of biodiesel. The work also involves synthesis of Strontium oxide nano particle using combustion method from available strontium oxide and urea. The synthesized nano particle is used as a nano catalyst for the conversion of boiled oil to biodiesel. Finally, investigations on fuel properties and study on performance characteristics of Compression Ignition (CI) engine fueled with biodiesel blends have been conducted and compared with the conventional diesel oil. Experimental results show that the fuel properties of B20 are close to that of conventional diesel oil.Further improvements in fuel properties of B20 have been observed when 20 percentage of kerosene is added.

I. INTRODUCTION

Biodiesel are Mono-alkyl esters of fatty acids obtained from bio-originated feedstock like vegetable oils and animal fats are known as biodiesels. It is a form of clean and renewable and eco-friendly energy[1]. The production of biodiesel is done through transesterification process using methanol and ethanol along with suitable catalysts[2]. Biodiesel have attracted much more attention due to the limitation of traditional fuels like fossil fuels. Biodiesel can be produced from many methods, but the popularly used method for biodiesel production is transesterification process. Transesterification process is the conversion of fatty acids to methyl ester/ethyl ester with the addition of methanol/ethanol along with reacting catalysts.

Catalysts may be homogenous or heterogeneous type, some are commercially available and some could be synthesized in laboratories. Homogeneous catalysts like Sodium Hydroxide (NaOH) and Potassium Hydroxide(KOH) are widely used because of its cheap rate and its easy availability in market. But the end of the process needs water wash for several timers which also leave acidic/basic liquid to nature having toxicity [3-5]. Hence, heterogeneous catalysts are used because of its easy separation and purification properties[6-9].

In this trending modern era a concept of nano particle has already have its usage in many areas of science. In few studies transesterification was done using nano-catalysts with different conditions and effective results were obtained[10, 11]. As per the literature survey, several methods were studies for the synthesis of nano catalyst. Microwave assisted radiation technique was used to synthesize Sr Onano particle by reacting strontium nitrate ($SrNO_3$) with Ocimum sanctum leaf followed by heat treatment at 500^{0}C for 2 hours. It was found that the particle size of Nano particle was 42 nm and found to be cost effective and eco-friendly [12]. Considering this concept an attempt has been made to synthesize and use the Nano catalysts for biodiesel production. In one of the study SrO nano partical for transesterification of soybean oil to biodiesel and found its yield to be 90%. Considering parametric effect of the study, biodiesel production was done [13].

II. SYNTHESIS AND CHARACTERIZATION OF STRONTIUM OXIDE (SRO) NANO-CATALYST

The work involved Boiled oil as a source for the production of biodiesel with reactants as methanol and synthesized Nano-catalysts. For the synthesis of Nano particle strontium nitrate urea and water were taken as a base product and then using heat source Nano particle were synthesized. Transesterification process with heterogeneous catalyst is used for biodiesel production. For synthesis of Nano catalystschemical combustion process is used. Along with the synthesis, characterization of Nano-particle was done using X-Ray diffraction.

The topic deals with the preparation of Nano-catalyst named Strontium Oxide (SrO) which is used for biodiesel production using a rapid, safe and a simple technique called chemical combustion process. High Purity SrOnano particles can be obtained in a short period of time through chemical Combustion process. This chapter also deals with the study of characterization of nano-particle using X-Ray Diffraction Process in which crystalline phased patterns of synthesized SrO can be found [14].

2.1 Synthesis of Strontium Oxide

The catalysts used for the Biodiesel is Strontium Oxide. The chemical combustion method is used for preparation SrONanoparticles using easily available Strontium Nitrate ($SrNO_3$) and Urea [14]. FIGURE 1 and FIGURE 2 shows Synthesized Sronano-particles and Muffle furnace. The procedure for preparation is as follows: -

- $SrNO_3$ and Urea is taken in equal proportion in a beaker.
- Little amount of distilled water is added to get homogenous solution
- Say, 10gm of $SrNO_3$ and urea with 20ml of distilled water.

FIGURE1 Synthesized SrOnano-particles in silica crucible

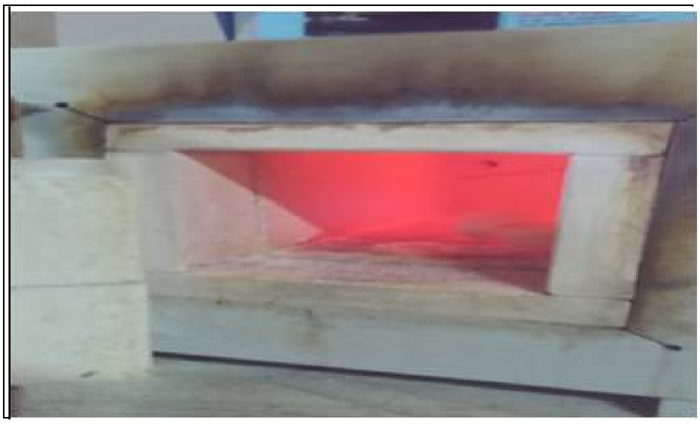

FIGURE 2 Muffle Furnace

- The homogeneous solution is transferred to silica crucible.
- The crucible is kept in a Muffle furnace and is heated up to 900^{0}C.
- After attaining room temperature, a solid powdered like structure is available which is at the final form of SrO.
- Below is the chemical equation for SrO synthesis

$$2Sr\,(NO_3)_2+3NH_2\text{-}CO\text{-}NH_2 \rightarrow 2SrO+ +2NO_2+3CO_2+3N_2+2NH_3+3H_2O$$

2.2 Characterization of SrO Nano-Catalyst

This characterization of nano-particle was done through X-Ray Diffraction (XRD) process. XRD is a technique to obtain the atomic, molecular structure and composition of the crystalline particle by using X-Rays [15].
X-Ray diffractometer consists of X-Ray tube, Sample holder and an X-Ray detector. The sample (anode) to be tested of about 1gm is placed on the sample holder and then it is focused by electrons (cathode) produced by X-Ray tube. Reflected ray from the sample is detected by X-Ray detector and the intensity of the reflected X-Rays are recorded and then converted as a output to device such as printer or computer or monitor. FIGURE3shows X-Diffraction Unit and FIGURE 4 shows X-Ray Diffraction Unit [15].

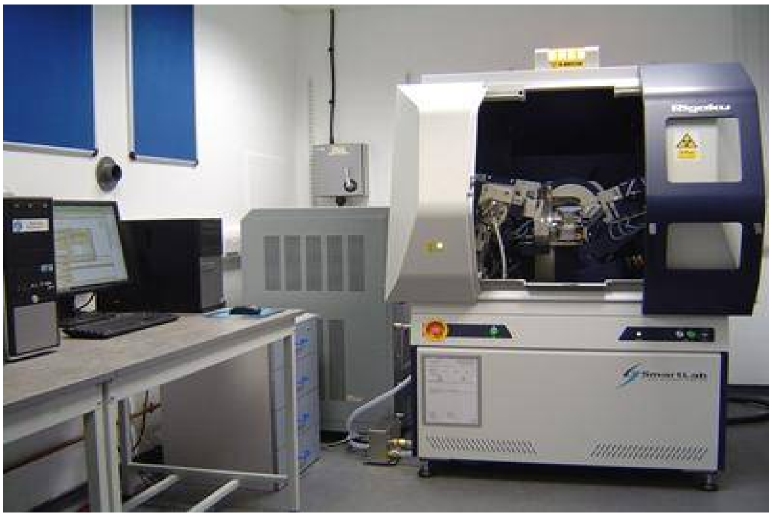

FIGURE3 X-Diffraction Unit

FIGURE4 X-Diffraction Unit

FIGURE5 shows the XRD patterns of SrOnano-particles prepared using combustion method. It was found that for a 1:1 ratio of $SrNO_3$ and urea the SrO particles were synthesized at 30(2Ɵ degrees) and at 900^{0}C for about 3hours. Similarly, in our XRD analysis the highest peak of SrO synthesis was found at approximately at 30(2Ɵ degrees) and at 900^{0}C for 3hours. FIGURE5 shows XRD patterns of SrOnano-particles.

2.3 Production of Biodiesel and its blends

3ltrs Biodiesel production was done using transesterification process. The parameters selected had a molar ratio of 6:1, catalyst loading 1.8w/w% and a reaction time of 45minutes. Procedure for the preparation is given below:

- 1000gm oil was heated up-to 80^{0}C -100^{0}C in a three neck flask.
- In a 500ml beaker 214ml of methanol and 18gm of SrO nano-catalyst were added and stirred for a mixed solution.
- As the oil reaches 80^{0}C -100^{0}C, the mixture of methanol and catalyst is added oil and maintained at 65^{0}C for 45minutes.
- After 45minutes it is shifted to separation funnel and then left for settling for 30-60 minutes.

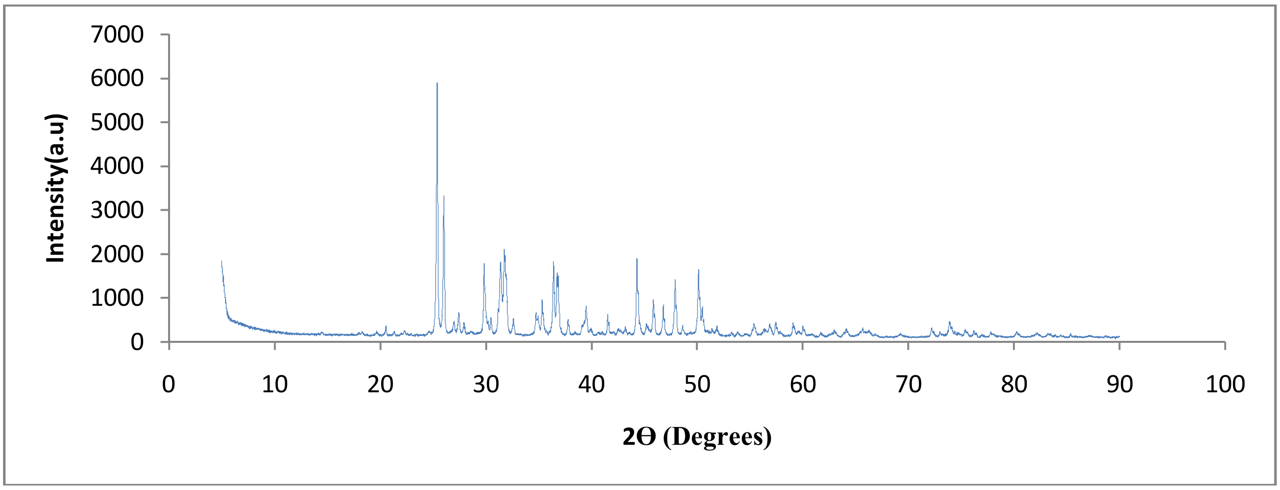

FIGURE5 XRD patterns of SrO nano particles.

- After settling the catalyst were removed and could be recycled for further reactions. (The catalyst need to be washed and calcinated for further use).
- Hot Water wash is done after removing catalyst till the pH of the water gets neutral.
- Biodiesel after washing is heated for about 120^0 C.
- After cooling the biodiesel is ready to use.

The work involved three blends preparation, Biodiesel (B100) with Diesel oil (D100).

1. **B20 -** B20 contains 20% Biodiesel and 80% Diesel. Here for 500ml blend 100ml of Biodiesel is added to 400ml of Diesel
2. **B40 -** B40 blend contains 40% Biodiesel and 60% Diesel. Here for 500ml blend 200ml of Biodiesel is added to 300ml of Diesel.
3. **B60 -**B60 blend contains 60% Biodiesel and 20% Diesel. Here for 500ml blend 300ml of Biodiesel is added to 200ml of Diesel.

After mixing the ingredients in the proper proportions, it is stirred using mechanical stirrer for about 15minutes.

2.4 Performance and combustion characteristics of biodiesel and its blends

In this section performance and combustion characteristics of CI engine fueled with Biodiesel blends with conventional diesel oil is experimentally investigated. Performance characteristics of each test fuels are compared and curves of each comparison is plotted further.

Brake Power- The output power of the engine which is available at the output engine shaft is called as Brake Power (BP). It is measured in kilo watts (kW).Comparisons of BP for different blends at different loading conditions are shown in Table 1.

Table 1 Brake power (kW) of biodiesel blends and diesel at different loads

Test Fuels	B20	B40	B60
Load(kg)			
0	0.475	0.402	0.4
3	1.208	1.277	1.323
6	2.242	2.445	2.48
9	3.573	3.669	3.581

Brake Thermal Efficiency- Brake thermal efficiency (BTE) is a measure of how well the energy conversion or transfer process can be accomplished in heat engine. Table 2 shows the Brake thermal efficiencies of biodiesel blends and diesel at different loads.

Table 2 Brake thermal efficiencies (%) of biodiesel blends and diesel at different loads

Test Fuels	B20	B40	B60
Load			
0	16.1	15.89	10.87
3	29.05	29	28.56
6	42.79	42.44	41.93
9	48.96	48.35	47.81

Brake Specific Fuel Consumption- Fuel efficiency of engine is called as Brake Specific FuelConsumption (BSFC). It is a measure of mass consumption of fuel (kg) per unit of work done by the engine. The unit of BSFC is kg/kW-min or kg/kW-hr. Table 3 shows the Brake specific fuel consumption (kg/kW-min) of biodiesel blends and diesel at different loads.

Table 3 Brake specific fuel consumption (kg/kW-min) of biodiesel blends and diesel at different loads

Test Fuels / Load	B20	B40	B60
0	0.0131	0.009	0.009
3	0.005	0.0056	0.0056
6	0.0034	0.0034	0.0034
9	0.0029	0.0029	0.0032

III. RESULTS AND DISCUSSION

3.1 Effect of Load on BP

FIGURE 6 shows the effects of load on BP for biodiesel blends and diesel oil. With the increase in load, BP increases for all test fuels. FIGURE 6 it is clear that Diesel oil (D100) has maximum BP (3.64kW) and B60 has minimum BP (3.62kW) at maximum (9kg) loading condition. For D100, from load 0 to 3 kg there is an increment of BP by 0.65times, from load 3 to 6 kg there is an increment of BP by 0.47times and from load 6 to 9 there is an increment of BP by 0.35 times. The similar trend is followed by all other test fuels.This is due to the fact that at higher engine loads there may be better utilization of air.

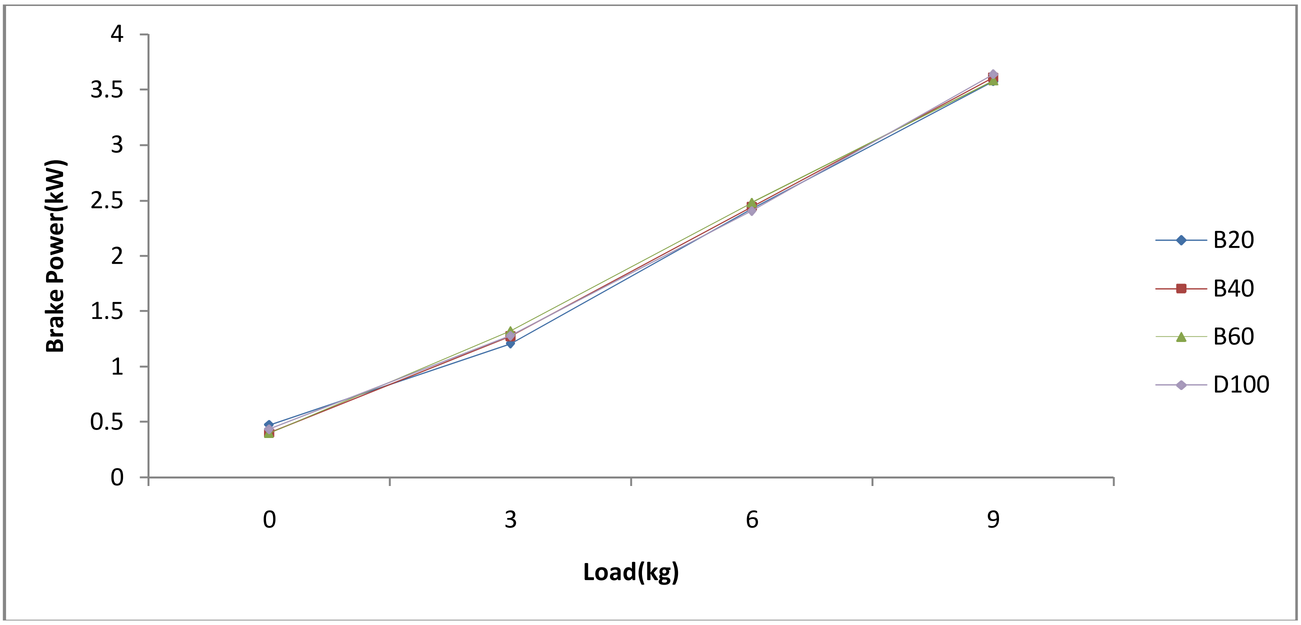

FIGURE 6 Effect of Load on BP for blends and diesel oil

3.2 Effect of Load on BSFC

FIGURE 7 shows the effects of load on BSFC for biodiesel blends and diesel oil. With the increase in load BSFC decreases, reaching minimum value at 9kg load for test fuels. It is clear from FIGURE 7 that Diesel oil (D100) has the minimum BSFC (0.0025 kg/kW-min) and B40 and B60 has maximum BSFC (0.0029kg/kW-min) at maximum (9kg) loading condition. B20 has minimum BSFC as compared to B40 and B60 because B20 has higher calorific value than other blends. At instant for D100, from load 0 to 3 kg there is decrement of BSFC by 0.58times, from load 3 to 6 kg there is a decrement of BSFC by 0.18times and from load 6 to 9 there is a decrement of BSFC by 0.30 times. The similar trend is followed by all other test fuels.The main reason for greater BSFC for B20 is the lower heating values of the fuels.

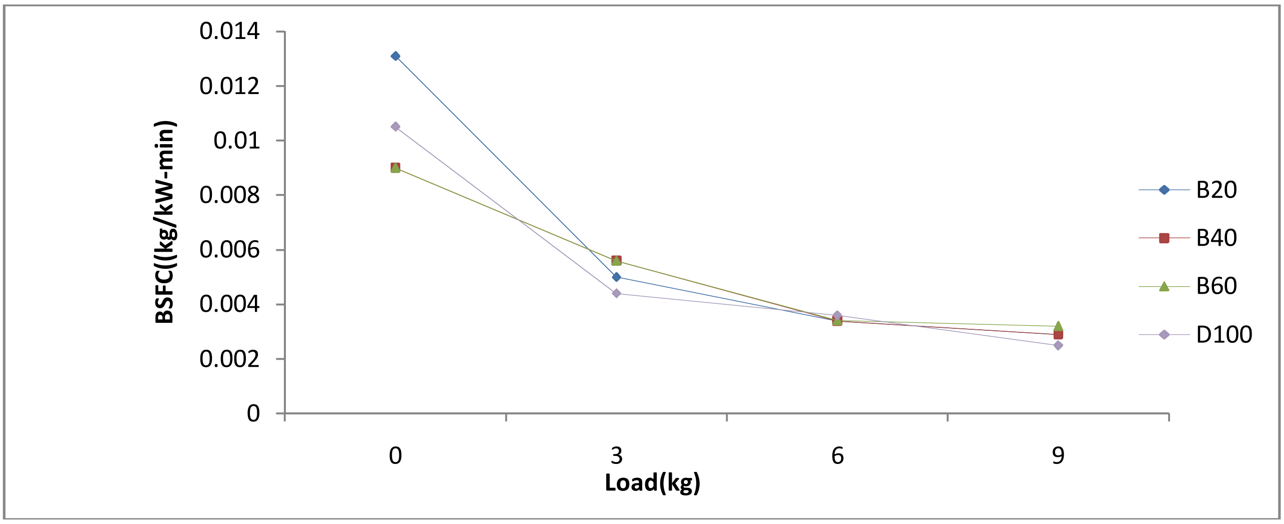

FIGURE 7 Effect of Load on BSFC for blends and diesel oil

3.3 Effect of Load on BTE

FIGURE 8 shows the effects of load on BTE for biodiesel blends and diesel oil. BTE increases with the increase in load which is due to the availability of more oxygen content at higher engine loads which plays an important role in enhancing the combustion rate resulting in maximum efficiency. It concludes that Diesel oil (D100) has the maximum BTE (56.64%) and B60 has minimum BTE (47.81%) at maximum (9kg) loading condition. At instant D100, from load 0 to 3 kg there is anincrement of BTE by 0.58times, from load 3 to 6 kg there is an increment of BTE by 0.23 times and from load 6 to 9 kg there is an increment of BTE by 0.26 times. The similar trend is followed by all other test fuels. BTE is maximum at higher engine loads because at higher load, there will be better in cylinder heat transfer.

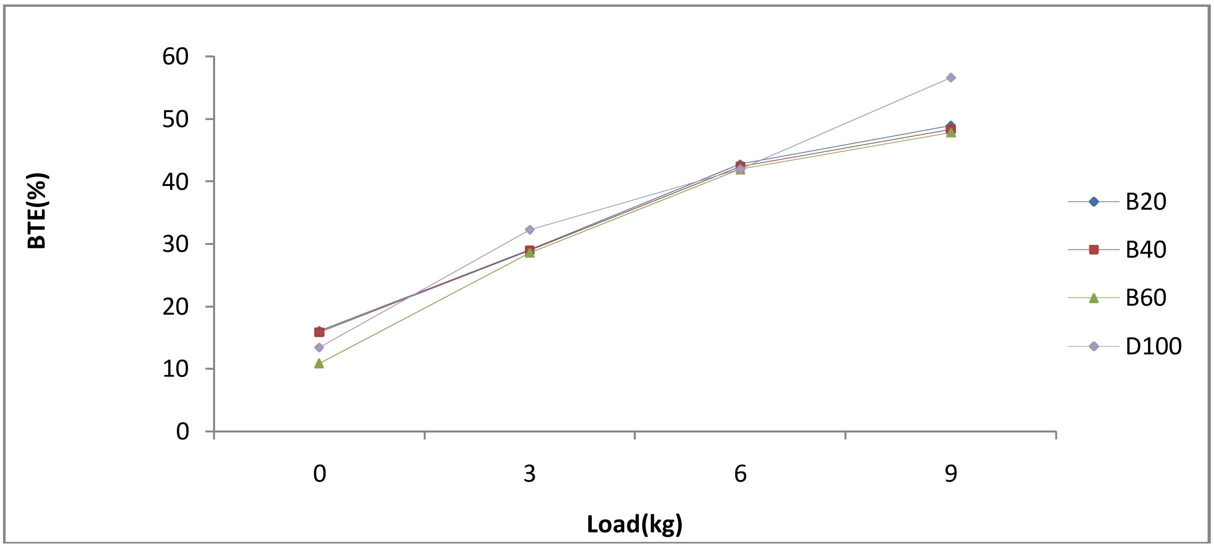

FIGURE 8 Effect of Load on BTE for blends and diesel oil

Over all conclusion of the performance study is stated as below

- On increasing load BP increases.
- On increasing load BSFC decreases.
- On increasing load BTE increases.

Also, it is clear from the results that B20K20 gave similar performance as that of diesel, hence can be used in CI engines.

VI. CONCLUSION

The main aim of the project work is to synthesize Strontium Oxide Nano-particle and to use it for Biodiesel Production and to fuel CI Engine with the produced Biodiesel blends and to check for its performance. The main conclusions of this project work is as below

- Synthesis of Biodiesel was carried out successfully with the help of chemical combustion method.
- XRD analysis done for the characterization resulted in obtaining highest peak at approximately 30(2Θ degrees) and at 900^{0}C for 3hours.
- Biodiesel of 20% can be blended with conventional diesel oil and this blend can be used in unmodified diesel engine without losing BTE and minimum BSFC.

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