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Production of biodiesel using C3N4-CaO produced from waste eggshell as a catalyst

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Abstract : The depletion of rock oil supplies, environmental concerns, rising demand for petro-diesel, supply instability, and rising rock oil prices have prompted a desire for alternate fuels. Biodiesel is the most versatile fuel for conventional diesel engines. In our efforts to overcome the limitations of homogeneous catalysis, we prepared a heterogeneous low cost C3N4-CaO catalyst created by exploitation waste egg shells and FFA from soya bean oil is employed as a feedstock. Catalytic performance was assessed with the transesterification of FFA of Soya-bin oil with n-butanol. CaO was found to be the best catalyst with 68% conversion. The catalyst was also found to be active when recycled and reused for two runs without loss of catalytic activity.

IndexTerms - Biodiesel production, Eggshell, Nano-catalysts, Trans-esterification process.

INTRODUCTION

The demand for energy and gasoline is at an all-time high, and as a result, prices are skyrocketing. However, what about vehicles and transportation systems? Using an alternate source is a practical and effective approach to lessen the load on conventional fuels like coal. Fuel sources are fast decreasing due to the massive demands of the transportation system. This condition necessitates the search for a different fuel source. Biodiesel is a promising and efficient type of fuel that may be used directly in a diesel engine without any modifications; the most practical and effective process for producing biodiesel is trans-esterification. Edible oil FFA is a low-cost, low-cost, and promising feedstock Oil with a greater FFA level has a lower total yield. In that instance, esterification must be carried out prior to the transesterification reaction. Homogeneous catalysts like NaOH and KOH are known for completing reactions in less time and under more moderate circumstances, however oils with high FFA can cause soap production, lowering overall yield and making catalyst recovery difficult. Similarly, such homogeneous catalysts have drawbacks in industrial continuous process systems, such as difficulties in regeneration and inconvenient operation.

Heterogeneous catalysts produce superior separation results and product quality, and they may be recycled and reused, making the reprocessing process more efficient. However, producing bio-diesel is difficult, and the resulting fuel is of poor quality, as well as in terms of various efficiencies.

An effective catalyst is also required to generate the desired quality biodiesel. So, in this study, we used CaO catalyst to conduct biodiesel testing because of its high efficiency and the fact that it was made from waste eggshells. Various researchers modify catalyst production parameters such as calcination temperature, heating time, and so on to achieve high-quality outcomes. These changes resulted in various outcomes, so we based our research parameters on them.

In this research, the catalytic activity for biodiesel production of C3N4-CaO catalyst was estimated towards the FFA of soya bean oil with n-butanol. We developed a catalyst out of leftover eggshells, which reduced the cost of our biodiesel and made the catalyst production process pretty simple and inexpensive. We achieved efficiency around 54.68%. The reaction conditions were optimized for studying the influence of catalyst weight, effect of temperature, influence of time and n-butanol: oil ratio for biodiesel conversion.

I. EXPERIMENTAL WORK

1.1 Catalyst Preparation

For this research, we obtain catalyst from waste eggshells. Eggshells are good source of Calcium. Eggshells were washed with water to remove impurities. Then we sundried it and crushed to the powder form. Then egg powder were calcinated that at 900º C for 2 hours. After cooling this powder to room temperature, we stated procedure of loading this CaO on carbon. For this purpose we used melamine as a source of carbon. We prepared solution of 1 gram of melamine, 20 ml isopropyl alcohol and stirred it for 2 hours using magnetic stirrer. After this, we prepared a solution by adding 0.1 gram calcium oxide powder and added 40 ml of distilled water in the solution. Then we dried the solution in an oven at 100º C for an hour. Then we calcinated this dried powder at 500º C for 2 hours.

Figure 1:- Eggshell Catalyst

1.2 Characterization

To study the functional group present in the material Perkin Elmer FT-IR Spectrometer is used. Catalytic reaction progress was monitored by the area normalization method using an HP 6890 GC series connected to a Water Micromass AutoSpec-UltimaTM NT MS. GC-MS Conditions: starting temperature 50°C, hold time 1 min, ramp rate 15 °C min-1, final temperature 280 °C, with a hold time of 20 min; Zebron ZB-5MS column (30 m length, 250 µm internal diameter, column coating thickness 25 µm), electron ionization (EI) source temperature 220°C. To determine the composition of Fatty Acid Butyl esters Gas Chromatography (GC-MS TQ 8050 Shimadzu, Japan) test is carried out.

1.3 Feedstock and Chemicals

Free fatty acid from soya bean oil was purchased from Star oil refinery factory, Ghodawat Group Company Kolhapur and N-butanol (98% purity) was purchased from S.D. fine.

1.4 Catalysis

Transesterification reactions were performed in a glass batch reactor fitted with a water-cooled condenser. A mixture of Free Fatty acid of soya bean oil (0.8 g, 5 mmol), alcohols (15 mmol) and the catalyst (100 mg) was stirred at a desired temperature (363 K) for 3 hr. The progress of the reaction was monitored by withdrawing aliquots of the reaction mixture and analyzing the same with a GC equipped with a FID (Agilent Technologies, model 6890 N, capillary column HP-5, 30 m, and containing 5% phenyl methyl siloxane). The catalyst was recycled in some cases to check its reusability.

1.5 Biodiesel Production Process

The process of obtaining biodiesel from feedstock is known as “transesterification”. Transesterification is defined as the chemical conversion process of triglycerides with alcohol into alkyl esters with the help of catalyst.

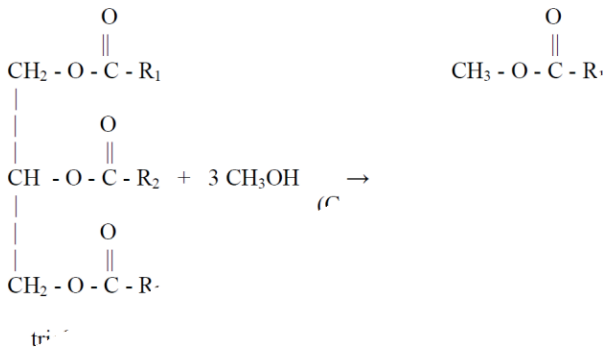

Figure 2:- Trans-esterification reaction

In this study, we took waste free fatty acid of soybean oil as a feedstock. The Trans-esterification method in the presence of calcium oxide nano-catalyst was used for biodiesel production. We put 50 mL of waste oil in the container and used n- butanol as an alcohol source with a 1:10 oil molar ratio. We used 23 mL of n-butanol and 0.5 gms of catalyst in a 3 hour and 5 hour process at 90° C. A dimmer stat was used to keep the temperature consistent.

Figure3:- Trans-esterification set up

1.6 Biodiesel Yield

The efficiency of biodiesel is calculated by using a formula i.e.

$$\text{Biodiesel yield (\%)} = \frac{\text{Weight of the produced biodiesel (g)}}{\text{Initial weight of biodiesel (g)}} \times 100$$

II. RESULTS AND DISCUSSIONS

2.1Gas Chromatography analysis of Biodiesel

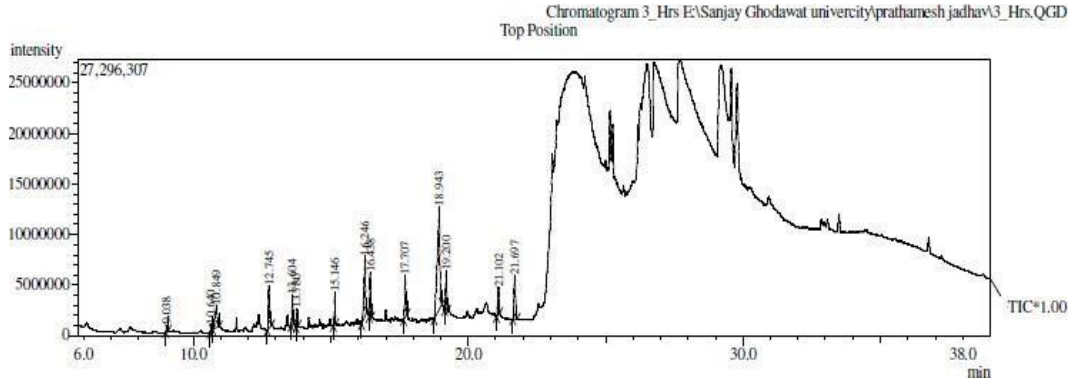

Figure 4:- Gas Chromatography Test results for 3 hours

The trans-esterification method was used in the best possible conditions, and the results were obtained in three and five hours. To determine the composition of Fatty Acid Butyl esters Gas Chromatography (GC-MS TQ 8050 Shimadzu, Japan) test is carried out and the results are given in the above table. The potency achieved by exploitation trans-esterification method is 67.34% and 54.68% respectively. The Pentatonic acid Butyl esters in the solution (C6H12O2), hexanoic acid butyl esters, octanoic acid butyl esters and also the Hexadecqnoic acid methyl ester are confirmed after the reaction.

2.2 Effect of reaction time on the biodiesel yield

The time is the important parameter which we observed during reaction. To determine the effect of time on biodiesel yield, we conducted test in two different time sets with same oil molar ratio and catalyst quantity. At 3 hours the efficiency was highest i.e. 67.34% while after increasing time efficiency depleted to 54%. The reaction time above 3h lead to more saponification and also causes backward reaction of the fuel. Thus it creates more free fatty acid and loss of esters.

III. CONCLUSION

The major goal of this research project is to develop an alternative fuel that is efficient, has numerous resources, and is relatively inexpensive since the price of traditional fuels is at an all-time high, this fuel should be comparatively inexpensive. We attempted to produce a fuel that met these needs by taking into account the above parameters. The price of biodiesel is determined by the catalyst used in its production. The yield obtained is 67.34 % after 3 hours of reaction and 54.68 % after 5 hours of reaction, owing to the high quality of the catalyst we generated. It is observed that, the time is the crucial parameter which directly hampers the quality of the biodiesel. Based on the research completed prior to selecting the catalyst, we discovered that CaO is a highly inexpensive and reliable catalyst.

IV. REFERENCES

[1] Jabbar Gardy, Mohammad Rehan, Ali Gassanpour, Xiaojun Lai, Abdul sattar nizami " Advances in nano- catalyst based biodiesel production from non-food feedstocks" journal of environmental management 249 (2019) 109316

[2] FevziYaşar "Biodiesel production via waste eggshell as a low-cost heterogeneous catalyst: Its effects on some critical fuel properties and comparison with CaO" Fuel 255 (2019) 115828

[3] BharadwajA.V.S.L.Sai , NijuSubramaniapillai , Khadhar Mohamed MeeraSheriffa Begum , Anantharaman Narayanan "Optimization of Continuous Biodiesel Production from Rubber Seed Oil (RSO) using Calcined Eggshells as Heterogeneous Catalyst"

[4] S. Balamurugan, C. Gokul , S. Abith Tamil Dheen, S.J. Eashwar, N. Arun Kumar "Application of grey relational analysis in biodiesel production from linseed oil using novel eggshell catalyst"

[5] Paula LigockiGraziottin, Morgana Rosset , Dirleia dos Santos Lima , Oscar W. Perez-Lopez "Transesterification of different vegetable oils using eggshells from various sources as catalyst"

[6] RupamBhartia , AbhishekGuldhea , DipeshKumarb , BhaskarSingha "Solar irradiation assisted synthesis of biodiesel from waste cooking oil using calcium oxide derived from chicken eggshell"

[7] Nagesh S. B. , N. R. Banapurmath , Chandrashekhar T. K. &Sanjeevkumar V. Khandal "Biodiesel production from goat fat using calcium oxide nanocatalyst and its combination with diesel fuel to improve fuel properties"https://doi.org/10.1080/19397038.2020.1780335

[8] N P Asri, B podjono, R Fujiani and nuraini "Application of waste eggshellas low-cost solid catalyst for biodiesel production" doi: 10.1088/1755-1315/67/1/012021

[9] Ziku Wei a,b, Chunli Xu a,b,*, Baoxin Li c "Application of waste eggshell as low-cost solid catalyst for biodiesel production" Bioresource Technology 100 (2009) 2883–2885

[10] Ebrahim Fayyazi, B. Ghobadian, Henk H. van de Bovenkamp, Gholamhassan Najafi, Bahram hosseinzadeh samani, Hero Jan Heeres, and Jun Yue "Optimization of biodiesel production over chicken eggshellderived CaO catalyst in a continuous centrifugal contactor separator"Ind. Eng. Chem. Res., Just Accepted Manuscript • DOI: 10.1021/acs.iecr.8b02678