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Production of biodiesel from Waste cooking oil using Biochar Based Heterogeneous Catalyst

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ABSTRACT

Biodiesel (mono-alkyl esters) is an alternative fuel which can be made from renewable biological sources such as vegetable oils and animal fats. The aim of the present work is to produce biodiesel from waste cooking oil using bio char based heterogeneous catalyst. The waste cooking oil was collected from near-by hotels and restaurants. The collected oil was pretreated. Then the biochar was produced from sugarcane bagasse. The produced biochar was doped with Zinc Oxide. The characteristic and morphology of the obtained ZnO doped nanocatalyst by using co-precipitation was studied using SEM and FTIR. The doped bio char was used as heterogeneous catalyst for the transesterification process. The optimization of the transesterification process was do neat 60ºC. The weight % of the catalyst was added as 1%, 3%, 5%. The transesterification process was carried out by mixing the pretreated oil with the prepared catalyst to produce biodiesel. The produced biodiesel was analyzed and the presence of the fatty acid ester was checked. The waste which is known as glycerol remained after the production of biodiesel was given to the chemical industries. The motive is to produce biodiesel with 0% waste. The produced biodiesel was characterized by *GCMS*. For the analyses of the *GCMS* sample in three different types of ratio 1:6, 1:9, 1:12. We got the optimum yield of 91% at 60ºC, 5 wt% of catalyst, 1:12 oil to ethanol ratio and reaction time was 1 hour 30 minutes.

Keywords: *Biochar, Zinc Oxide, Impregnation, Doping, vegetable oils and animal fats, Sugarcane Baggase, GC-MS, FTIR.*

1. INTRODUCTION

In the past 30 years, the transportation sector has experienced a steady growth especially due to the increasing numbers of cars around the world. It has been estimated that the global transportation energy use is expected to increase by an average of 1.8% per year from 2005 to 2035.Nearly all fossil fuel energy consumption in the transportation sector is from oil (97.6%), with a small amount from natural gas. The World Energy Forum has predicted that reserves will be exhausted in less than another 10 decades. Biodiesel is a clean-burning fuel currently being produced from grease, vegetable oils, or animal fats. Its chemical structure is that of fatty acid alkyl esters. Biodiesel is produced by the transesterification of oils with short-chain alcohols or by the esterification of fatty acids. The transesterification reaction consists of transforming triglycerides into fatty acid alkyl ester, in the presence of an alcohol, such as methanol or ethanol, and a catalyst, such as an alkali or acid, with glycerol as a byproduct. Chemical reaction at supercritical conditions without the use of a catalyst has also been proposed. (Palligarnai T Vasudevan et al., 2008).

2. REVIEW OF LITERATURE

Our work reported the production of biodiesel from waste cooking oil using biochar based heterogeneous catalyst, catalyst was prepared using biochar and ZnO, transesterificstion process was carried out for the production of biodiesel, yield was compared, each and every process was reviewed, **R.M Mohamed et al., (2019)** developed and evaluated new catalyst, RS-SO3H, for the production of biodiesel from waste cooking oil. The study investigates the factors affecting the transesterification process and the physicochemical properties of the biodiesel produced. The reusability of the catalyst is also evaluated. Additionally, the paper discusses various studies on biodiesel production using different sources and catalysts, as well as the optimization of transesterification processes and the effect of biodiesel on diesel engine emissions.

MufsirKuniyil et al., (2020) developed and characterized a new catalyst made of Zn-CuO and N-doped graphene nanocomposite for the production of biodiesel from waste cooking oil. The study found that the nanocomposite catalyst had high catalytic activity and reusability, making it a promising option for industrial use. The article also discusses various studies on biodiesel production using different catalysts and feedstocks, as well as characterization techniques for catalysts.

Andrew Nosakhare Amenaghawon et al., (2022) studied the potential of the heterogeneous catalyst which is made from crab shell and plantain peels for the transesterification of waste cooking oil to produce biodiesel. And its advantages over conventional catalysts, including reusability, ease of synthesis, stability, high surface area, and ready availability of the precursor materials were studied.

3. MATERIALSANDMETHODS

1. COLLECTION OF WCO: The Waste Cooking Oil was collected from the nearby hotels and restaurants. The Waste Cooking Oil contains plants or animal fatty acids and also contains different types of essential fatty acids.

Figure1 Waste cooking oil

2. PRETREATMENT OF THE WASTE COOKING OIL: The collected waste cooking oil was pretreated to increase the yield. Two methods were carried out for the pretreatment of the collected waste cooking oil. Those two methods are filtration and heating. filtration of waste cooking oil, heating of waste cooking oil, preparation of biochar based heterogeneous catalyst.

3. COLLECTION OF RAW MATERIAL: We used sugarcane bagasse as raw material to produce biochar. First we collected sugarcane bagasse from juice shop. The collected sugarcane bagasse was dried in sunlight for 2 days to remove moisture content. Then we chopped the sugarcane bagasse in to smaller pieces. The collected biochar is showed in figure 2.

Figure2 Sugarcane bagasse

4. PRODUCTION OF BIOCHAR: We produced biochar by using pyrolysis process. The chopped sugarcanebagassewaskeptinakilnwhichisplacedinmufflefurnace.Thetemperaturewaskept at 300ºC for 3 hours. The process was carried out in the absence of oxygen. Then the produced biochar was made into fine powder using piston and mortar.

5. CO-PRECIPITATION: Co-precipitation is a method of synthesizing materials in which two or more substances are precipitated simultaneously from a solution. 4 grams of ZnO was mixed in the 100 ml of ethanol using magnetic stirrer. The temperature was kept at 40ºC. After 30 minutes8 grams of biochar was slowly added to the solution which contains ZnO. The solution was kept for 1 hour of mixing in the magnetic stirrer. After 1 hour of mixing the precipitate was formed. The precipitate was separated by using filtration process. The mixture of precipitate was passed through the whattman filter paper while the liquid was passed through the filter paper and the solid particles are separated. After the separation process the precipitate was dried at 100ºC using microwave oven. Then the prepared catalyst was stored in an air tight container. Followed by characterization of the catalyst like Scanning electron microscope, Fourier transform infrared spectroscopy and Gas chromatography mass spectrometry.

4. RESULTS

From the various observations recorded during experimentation, the relevant results are being represented below.

1.BIOCHAR PREPARATION and BIOCHAR BASED HETEROGENEOUS CATALYST: From

sugarcane bagasse biochar was produced. To produce biochar pyrolysis process was employed. The solution containing ZnO and biochar was kept for 1 hour of mixing in the magnetic stirrer. After 1 hour of mixing the precipitate was formed. The precipitate was separated by using filtration process. The mixture of precipitate was passed through the Whattman filter paper while the liquid was passed through the filter paper and the solid particles are separated. After the separation process the precipitate was dried at 100ºC using microwave oven. Then the prepared catalyst was stored in an air tight container.

Figure 3 SEM image of 10000x magnification of ZnO doped bio- char catalyst

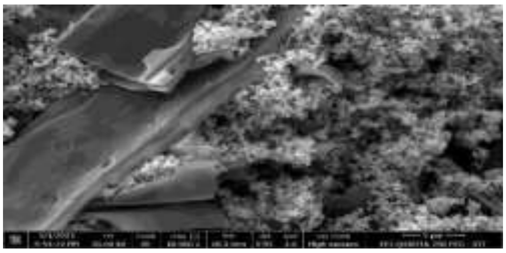


Figure 4SEM image of 50000x magnification of ZnO doped bio- char catalyst

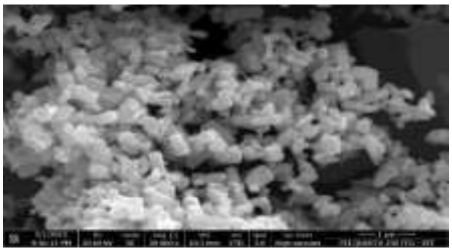


Figure 5 SEM image of 60000x magnification of ZnO doped bio-

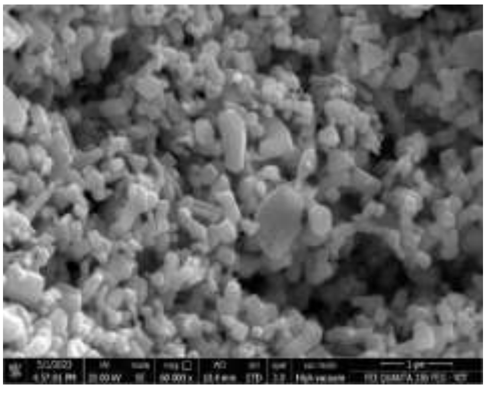
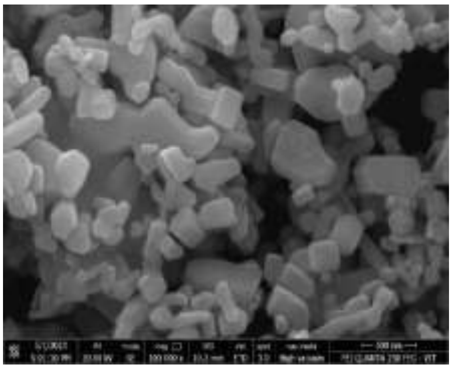


Figure 6 SEM image of 100000x magnification of ZnO doped bio-



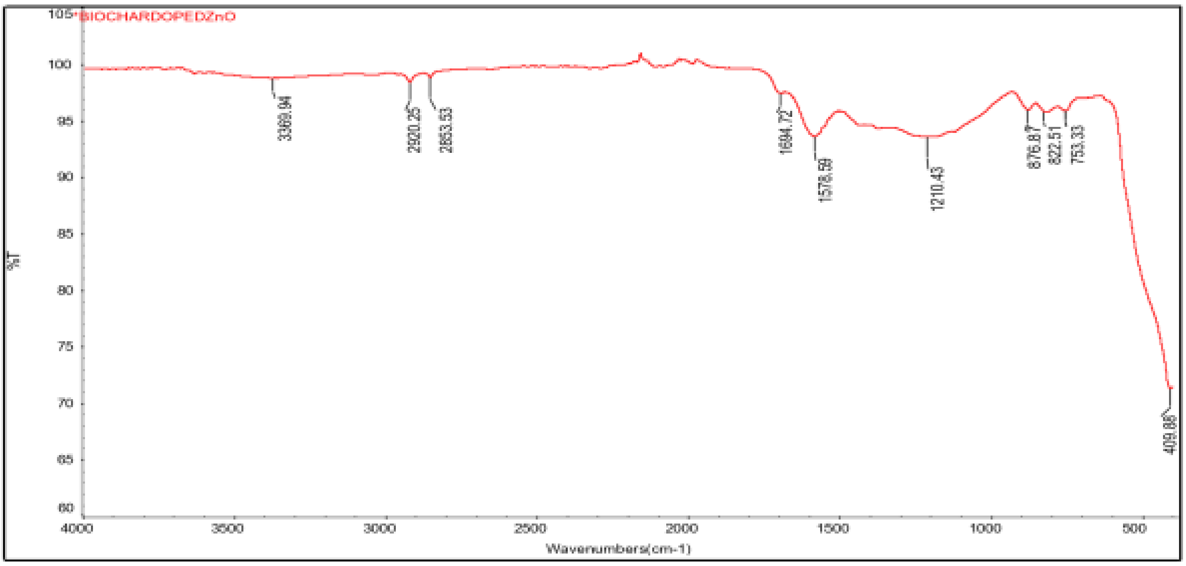
2. SEM ANALYSIS OF THE CATALYST: The catalyst were identified and marked in a magnitude of 100 000x at an amplitude of 20kv in a 500nm scale. At this magnification the catalyst has larger surface area and high porosity. Therefore the obtained images confirms that the catalyst has larger surface area and high porosity. The prepared catalyst's characteristics were analyzed using Scanning Electron Microscope(SEM) and three dimensional images were obtained. The catalyst were identified and marked in a magnitude of 100 000x at an amplitude of 20kv in a 500nm scale. At this magnification the catalyst has larger surface area and high porosity. Therefore the obtained images confirms that the catalyst has larger surface area and high porosity. Then the characteristics of catalyst were analyzed by using Fourier Transform Infrared Spectroscopy (FTIR). The graph was plotted based on the process in which the ratio of light passing through the light incident on the specimens and the refelectance the ratio of the light reflected to the light incident. The transmittance range 60 to 105% and wave number ranges from4000 to 400 cm^{-1}. In the plotted graph we were discussed about the wave number Vs transmittance of the doped heterogeneous catalyst. As a result of the observation of the plotted graph confirmed that the targeted catalyst was produced.

Char catalyst   Char catalyst

3. FTIRANALYSISOFTHECATALYST

The FTIR was carried out to identify whether the targeted catalyst was produced or not. The graph was plotted based on the process in which the ratio of light passing through the light incident on the specimens and the refelectance the ratio of the light reflected to the light incident. The transmittance range 60 to 105% and wavenumber ranges from 4000 to 400 cm^{-1}. In the plotted graph we were discussed about the wavenumber Vs transmittance of the doped heterogeneous catalyst. As a result of the observation of the plotted graph confirmed that the targeted catalystwas produced.

Figure 7 FTIR of biochar doped ZnO



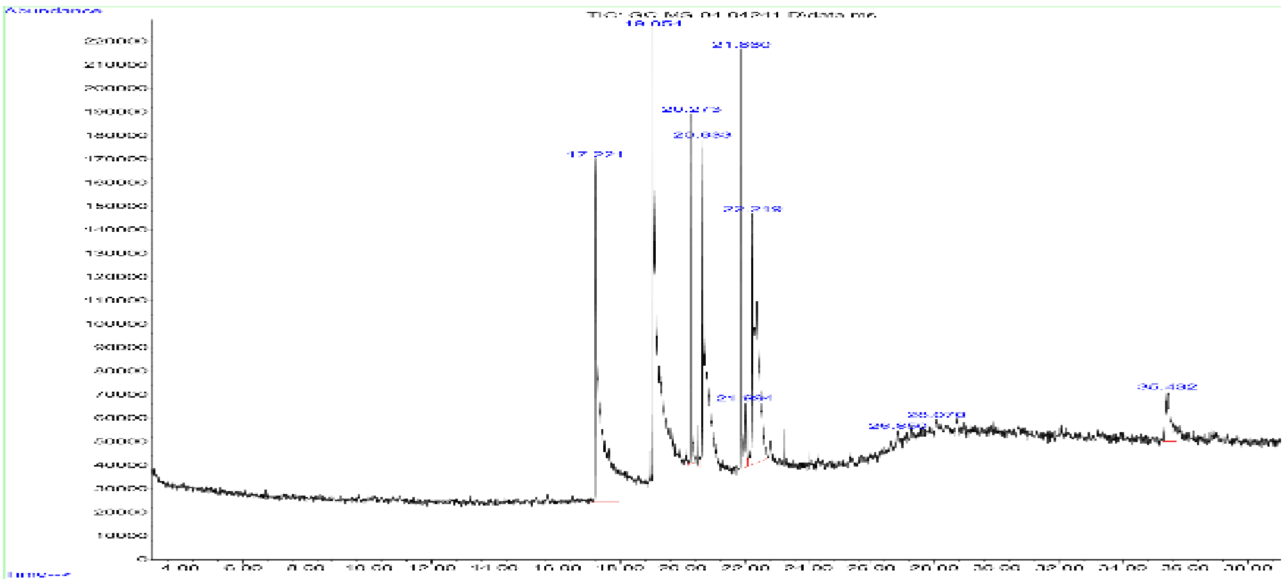
4. TRANSESTERIFICATION; WCO is becoming more popular in the transesterification process used to produce biodiesel. Reaction duration, temperature, catalyst concentration, and the methanol: oil molar ratio were evaluated as parameters impacting the transesterification process. The highest bulk output of biodiesel was 90.37%. Fatty acid methyl ester (FAME) concentration is about 97.71 weight percent, the raw material conversion efficiency is 90.38 weight percent, and free fatty acid (%FFA) conversion is 91.1% under ideal circumstances, which call for a 10 weight percent catalyst and a 20:1 molar ratio of oil to methanol. By using gas chromatography (GC), the FAME content% was calculated (R.M. Mohamed etal., 2019).One of the cost-effective sources for producing biodiesel is used cooking oil. The transesterification reaction and the characteristics of biodiesel can be impacted by frying byproducts such as free fatty acids and certain polymerized triglycerides. (M. Kulkarni and A. Dalai., 2006)

Figure8 Separating glycerol from ethanol-biodiesel **Figure9 Biodiesel mixture**

5. GC-MSANALYSIS: The produced bio diesel was analyzed using Gas Chromatography Mass

Spectroscopy technique. This technique was used to determine the fatty acid methyl esters (FAMEs) and for identification of impurities. The graph was plotted between time and abundance.

Figure11 GC-MS Analysis of Biodiesel



From the above plotted graphs we found the presence of fatty acid methyl esters (FAMEs) from our sample. The produced biodiesel was analyzed using Gas Chromatography Mass Spectroscopy technique. This technique was used to determine the Fatty Acid Methyl Esters (FAMEs) and for identification of impurities. The graph was plotted between time and abundance. The observation of GC-MS results confirmed the presence of Fatty Acid Methyl Esters (FAMEs).

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