PRODUCTION OF BIODIESEL FROM GINGELLY OIL USING METAL OXIDE NANOPARTICLES

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ABSTRACT

Nanomaterials have attracted great interest due to their intriguing properties, which are different from those of their corresponding bulk state. Recently much attention has been paid on the preparation and applications of metal oxide nanoparticles are much more active than larger particles because of their larger surface area. They also display unique physical and chemical properties. Biodiesel is defined as a domestic and renewable fuel for diesel engines, derived from vegetable oil. Biodiesel consists of alkyl esters, which are produced from the trans esterification reaction between triglycerides and alcohol. This project work involves the synthesis of biodiesel using Metal oxide nanoparticles. The catalyst was prepared by simple precipitation method using Calcium chloride, magnesium sulphate, Zinc nitrate and sodium hydroxide. The synthesized nanoparticles were calcined at 400°C for 3 hours. Structural, morphological, chemical properties of synthesized nanoparticles were investigated by X-ray diffraction (XRD), scanning electron microscopy (SEM) and Fourier transform infra-red microscopy (FT-IR), respectively. The characterised catalyst was used for the production of biodiesel using gingelly oil and ethanol via transesterfication reaction. Under the selected reaction conditions: Gingelly oil and ethanol molar ratio of 1:10, the addition of 0.1 g Metal oxide nanoparticles as catalyst with reaction time of 5 hours, the reactions were carried out at different temperatures like 60°C, 80°C and 100°C. Among the various temperatures high yield was observed in 100°C by using MgO nanoparticles. The product conversion was monitored by Gas Chromatography.

1. INTRODUCTION

Biodiesel is mostly outlined as a mono-alkyl organic compound of long chain fatty acids derived from edible oils, non-edible oils, waste cooking oil or animal fat. In the synthesis of biodiesel different feedstock's are used, which are normally classified as either first or second generation [1-4]. First

generation biodiesel is derived from edible vegetable oils such as, palm oil, rapeseed oil and sunflower oil. Second generation biodiesel is normally considered to be obtained from non-edible oils like castor, genus Jatropha and neem, microalgae, animal fats or waste oils [5-8]. These oils are composed of triglycerides that can be converted into biofuels using three main processing techniques viz. pyrolysis (thermal cracking), micro-emulsification and transesterification. The transesterification is the most popular method for the biodiesel production [9-11].There are several reports on plant species which are evaluated for their Potential as an alternative source of energy and hydrocarbons [9]. However, no detailed systematic study of plant species Sesamum indicum L. is available for biodiesel potential with reference to environmental emissions. Sesame oil (also known as gingelly oil and til oil) is an organic oil, noted to have the distinctive aroma and taste of its parent seed. It is an impartant cultural commodity in terms of value in the world trade and it plays an important role in the international market. Sesame oil contains significant amount of both saturated and unsaturated fatty acids, which can be converted into methyl/ethyl esters (biodiesel) by transesterification [10]. In this study, laboratory experiments were carried out to ascertain the environment-friendly biodiesel potential of sesame oil.

2. EXPERIMENTAL METHODS

2.1. Materials

Chemicals such as Zinc nitrate, Magnesium sulphate, Calcium chloride, Sodium hydroxide and absolute ethanol were purchased from E-Merck. Idhayam gingelly oil was bought from V.V.V & SONS Edible Oils Limited. The glasswares used in all the experiments were made up of Schott Duran.

2.2. Methods of preparation

Synthesis of metal oxide Nanoparticles

All the experiments were performed under atmospheric conditions. Take 50 mL of 0.5 M solution of magnesium sulphate in a 250 mL beaker heat it at 50°C – 60°C with stirring. Add drop by drop of 0.5 M solution of NaOH solution to the magnesium sulphate solution with continuous stirring. After the addition of sodium hydroxide solution white precipitate was obtained. The obtained product was filtered using whatman filter paper and dried at 100°C. Then the dried sample was sintered at 400°C for 4 hours to obtained

magnesium oxide Nanoparticles (figure 1). Similar method is used to synthesis of CaO and ZnO nanoparticles

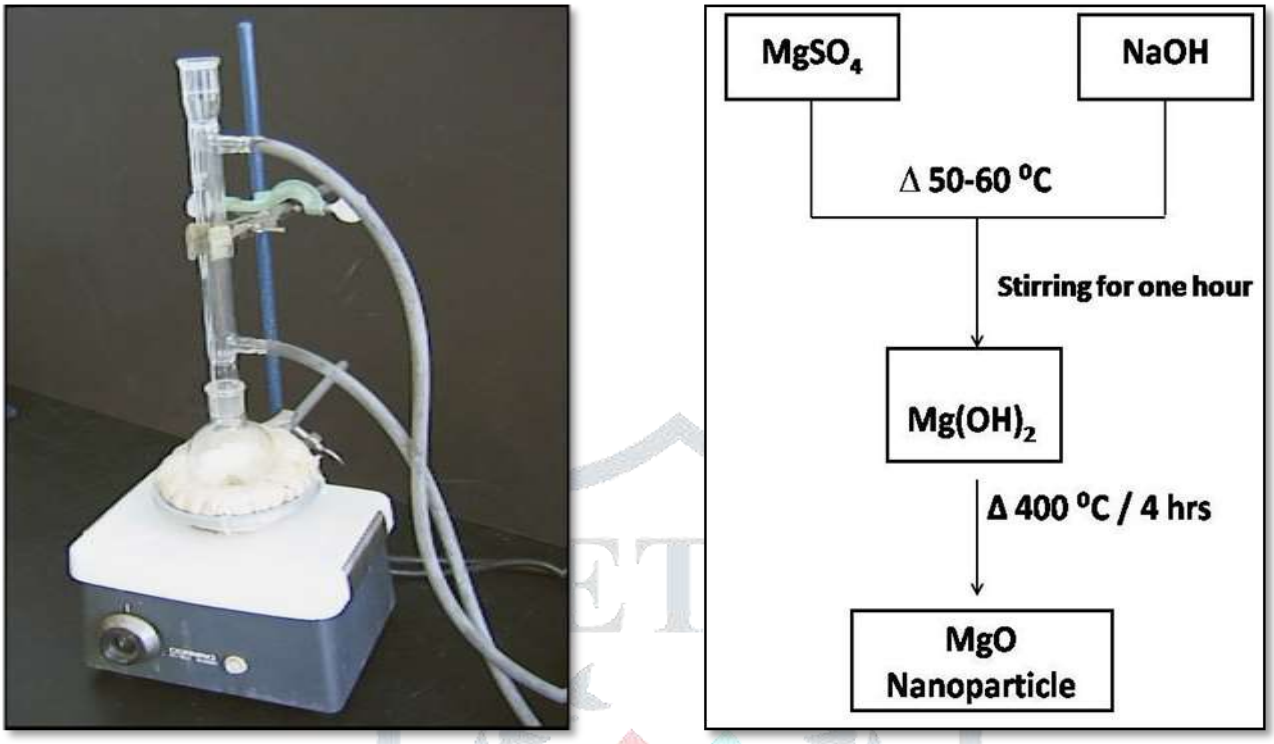

Figure 1: Schematic Representation of synthesis of Biodiesel and Metal oxide Nanoparticles

2.3. Transesterification of gingelly oil

Biodiesel was produced on bench scale by transesterification using gingelly oil at reflux of ethanol employing metal oxide nanoparticles as heterogeneous base catalyst (figure 1). The reaction was performed using with 12 mL gingelly oil and 7.5 mL of ethanol (Oil to Ethanol molar ratio is 1:10) using 0.1 g of Metal oxide nanoparticles at 60ºC, 80ºC, 100ºC for 5 hours with reflux condenser and magnetic stirrer as illustrated in Figure 1. At different intervals of time, the samples were drawn out from the round bottom flask (after cooled to room temperature). The reaction mixture was carefully transferred to the centrifuge tube and the metal oxide nanoparticles were separated by centrifugation [12-14]. The oil mixture was then subjected to GC analysis.

3. RESULTS AND DISCUSSION

3.1. Characterization of metal oxide nanoparticles

SEM of MgO Nanoparticles: The SEM image shown in figure 2, which has smaller and more uniform MgO nanoparticles were synthesized at 60°C. The fact that growth rate, nucleation rate and agglomeration rate are suitable for formation of optimum nanoparticles at this temperature. Therefore, the temperature

60°C was selected as the optimum temperature for synthesis of MgO nanoparticles. As shown in figure 2 nanoparticles were synthesized in excellent and more porous nanostructure (moss shape). Finally, it can be concluded that using the suggested method to prepare MgO nanoparticles in the diameter ranges of 35 nm. Similarly 60 nm and 75 nm ranges were obtained for ZnO and CaO nanoparticles.

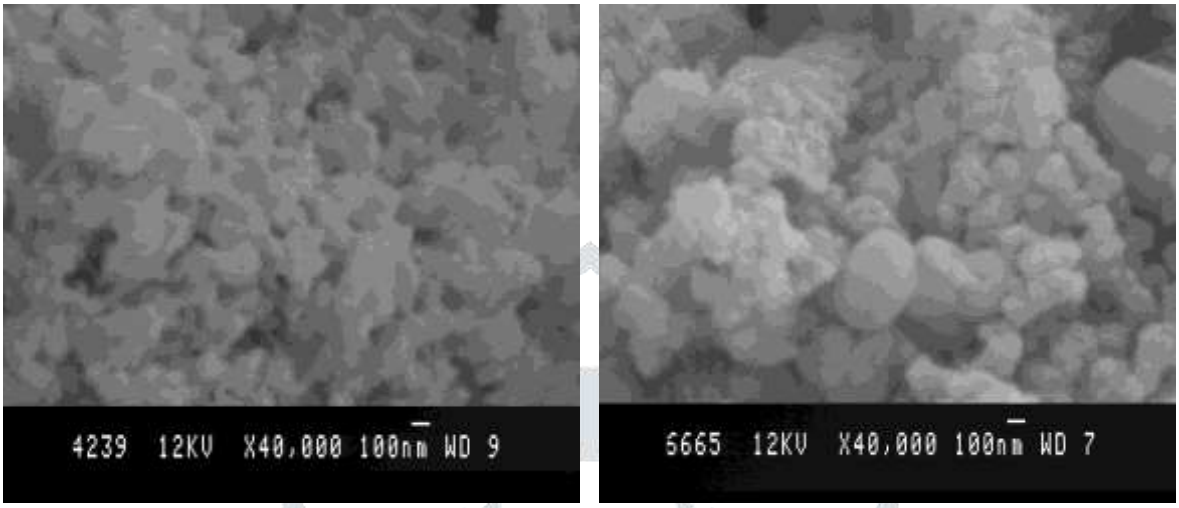

Figure 2: SEM Image of MgO Nanoparticles

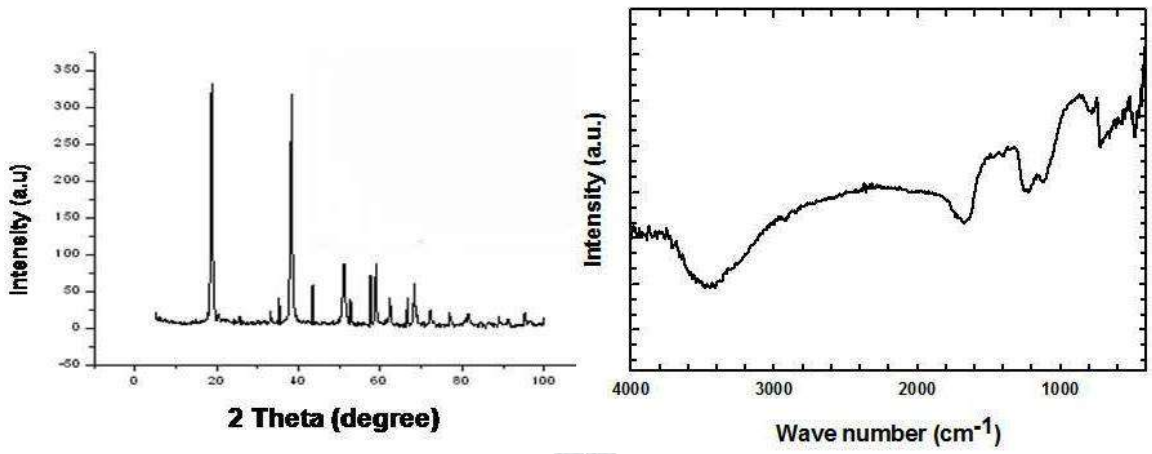

Figure 3: XRD Pattern of MgO Nanoparticles and FT-IR spectra of MgO Nanoparticles

XRD Pattern of MgO Nanoparticles: The XRD spectra, which is presented in Figure 3 reveals that the nanoparticles are single crystalline and can be marked as cubic-phase (a = 0.421nm) MgO (JCPDS card 45-0946). There are no peaks detected for other phases, indicating that a single phase of MgO with high purity has been prepared. The ZnO and CaO nanoparticles showed hexagonal and cubic shapes, and peaks are confirmed by XRD analysis

FT-IR Spectrum of MgO Nanoparticles: The FT-IR spectrum of MgO nanoparticles is shown in Figure 3. The spectra represent the absorbance characteristic of high purity MgO nanoparticles. The formed MgO

phases are characterized by intense and very broad IR band which could be assigned to Mg-O vibrations with poor resolved shoulders at about 500 cm^{-1} [16] and ZnO vibrational peaks observed in 676 and 559 cm^{-1} and CaO vibrational peaks observed in 553 and 427 cm^{-1} , so it confirmed metal oxide peaks[15,16].

3.2 Catalytic Activity study of Metal oxides Nanoparticles for Biodiesel synthesis

Effect of catalysts: Transesterification reactions were carried out using gingelly oil with ethanol (oil to ethanol molar ratio 1:10) and metal oxide nanoparticles as a catalyst. The reaction was carried out at selected temperature at 60°C for 5 hours. The obtained product was characterised by using Gas chromatography (Agilent 6850 series system). The fatty acid ethyl ester conversion obtained was shown in figure 4.

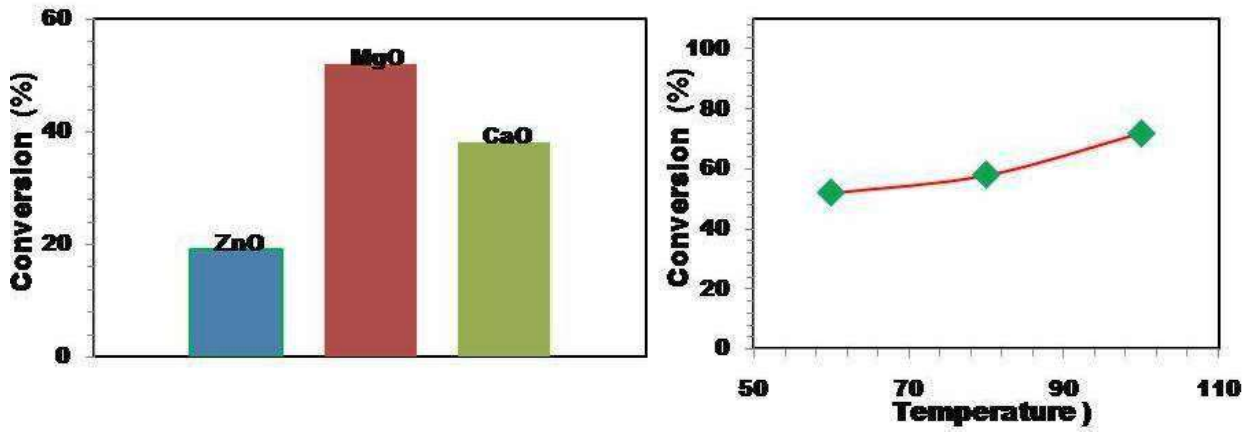

Figure 4: Effect of catalysts in transesterification reaction and Effect of temperature in transesterification reaction in MgO NPs with different temperatures

The result shows that conversion of biodiesel using gingelly oil was found to be 19%, 38% and 52% with respect to different catalysts such as ZnO, CaO, MgO with trace amount of glycerides and water as byproducts were also detected. The results showed that MgO nanocatalysts gave the better yield compare with CaO and ZnO, MgO catalysts gave 52% of biodiesel yield whereas only 19% and 38% of biodiesel yield obtained using ZnO and CaO as catalyst.

Effect of temperature: Transesterification reaction carried out using gingelly oil with ethanol (oil to ethanol molar ratio 1:10) and MgO nanoparticals as a catalyst at various temperatures such as 60°C , 80°C , 100°C and conversions as follows 52 %, 58 %, 72 %. Figure 4. A common trend in conversion over catalyst is increase of oil conversion with increase with temperature. Since transesterification involves establishment of equilibrium, it is evident from these results that the shift in equilibrium towards ester side occurs with

increase in temperature due to increase in activation energy and also conversion increased with increased in temperature ascribed to increase in the removal of by-product water formed in the reaction.

4. CONCLUSION

Nanoparticles MgO, CaO, ZnO was synthesized by means of a novel and simple one-step method. The synthesized material was well characterized using various physicochemical techniques like XRD, SEM and FT-IR. In this biodiesel synthesized using gingelly oil and ethanol via transesterfication reaction. For this reaction metal oxide nanoparticles was used as a catalyst. The reaction has been carried out using various catalysts. Among the catalysts MgO gave the better yield at 60°C. In this work biodiesel synthesis using gingelly oil and ethanol via transesterfication reaction using MgO nanoparticles at various temperatures such as 60°C, 80°C, 100°C. The conversions are 52 %, 58%, 72 % respectively, but the highest conversion when the reaction was carried out at 100°C. In this reaction we are used ethanol not methanol because of toxicity of methanol.

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