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Research Article

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Biodiesel Production from Neem Seed (*Azadirachta indica*) Oil Using Calcium Oxide as Heterogeneous Catalyst

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Abstract

Biofuel is an alternative and environment friendly source of energy, originated by the use of fossil fuels and have led to a notable growing demand from the last few decades. As biodiesel are usually acquired from renewable sources like vegetable and animal oils, for example coconut oil is extracted from the coconut and then characterized for further usage. The aim of this study is to investigate the production of biodiesel from neem oil and to characterize the parameters that affect biodiesel performance. The Biodiesel was produced using trans-esterification process resulting in the values of saponification 191 mg KOH/g, iodine 10 mgl^2/g, acid 14.0 mg KOH/g, density 0.91 g, viscosity 23 mm^2/s and flash point 266°C. The biodiesel was also characterized and showed that the it has density of 820 kg/m^3, viscosity 3.5 mm^2/s, saponification value 91 mg KOH/g, iodine value 8.9 mgl^2/g, acid content 30.8 mg KOH/g and flash point 110°C. The physicochemical properties obtained were also compared to standard biodiesel in the range of ASTM specifications.

Keywords: Biodiesel; Fuels; Renewable energy; Neem; Oil

Introduction

Bio-fuel consists of both gaseous and liquid fuel for the transportation and was mainly manufactured from renewable energy sources [1]. The various biofuels include, biogas energy, primary alcohols like methanol and ethanol, vegetable oils, bio-diesel [2]. These energy resources offer several advantages over the nonrenewable fossil fuels but they need to be evaluated on the basis of their advantages, social structure and agriculture development [3]. Today, the population growth and the need for energy together with the fossil fuel depletion and environmental pollution have urged countries to seek for newer and cleaner sources of energy [1]. 89 million barrels consumption of petroleum was estimated per day over whole globe in 2012 and almost half of that got use in gasoline production [1]. At this rate of consumption, the oil resources are predicted to run out within the next 50 years [4]. Furthermore, fossil fuel usage can cause environmental problems such as air pollution, greenhouse gas emissions, and global warming, as shown in equations 1-5 below [2]. Thus, many countries are trying to find renewable resources as alternative which are capable of balancing the GHG emissions [5]. Research showed that every gallon of Biodiesel contains approximately 1.05 pounds of glycerol formed about 10% (w/w) as the main by product. This demonstrates that a 30 million-gallon-per-year's plant will produce around 11,500 tons of 99.9% immaculate glycerine. It was anticipated that the world Biodiesel advertise would reach 37 billion gallon by 2016, which suggested that roughly 4 billion gallons of unrefined glycerol would be deliver [6].

The composition of crude glycerol depends on many factors like transesterification efficiency, type of catalyst, recovery efficiency and impurities. For instance, Hesen et al. premeditated that the samples of crude glycerol from Australian biodiesel producers contained glycerol content about 38% to 96% along with 29% ash and 14% methanol. Consequently, Crude glycerol also comprised soap, salts, non-glycerol organic matter, and water impurities [7]. Conventional method for glycerol purification includes distillation or ion exchange chromatography.

Neem oil can be regarded as vegetable oil pressed from the seed of neem (*Azadirachta indica*) and evergreen tree that is widely spread to the Indian subcontinent and in the tropical Africa such as Nigeria. It is possibly the most important commercially available products of neem. Neem oil can be produced mechanically (hot or cold process) or chemically by solvent extraction from the dried neem seed. Neem oil is rich in essential fatty acids, triglycerides, vitamin E and calcium. Because of its essential fatty acids and vitamins, neem penetrates deep within the skin to heal the minute cracks brought on severe dryness. Fatty acid present in neem oil are: Oleic acid (52.8%), Linoleic acid (2.1%), Palmitic acid (12.6%) and Stearic acid (21.4%). Neem oil is rich in essential fatty acids (EFAs), Triglyeride, vitamin and calcium, because of its EFAs and vitamin E, neem oil penetrates deep within the skin to heal the minutes cracks brought on by severe dryness, neem also stimulates production of collagen and act as an anti-aging product. The aim of this study was to investigate the production of biodiesel from neem oil along with the assessment of its performance in Internal Combustion engine. The physicochemical properties of the biodiesel produced were measured with time and the emissions released from various blends in an internal combustion were determined. The results of this study would form a basis for the development of a database for biodiesel production from this feedstock, especially in countries where this feedstock is in abundance.

Materials and Methods

Materials and sample collection

The neem oil used for this study was collected from Modibbo Adama University of Technology, Girei local government area of Adamawa State, Nigeria. The conventional diesel fuel was purchased from petrol station in Girei market. All analytical grade chemicals to be used such as Methanol, Sodium methoxide, anhydrous Calcium chloride, sulphuric acid, and sodium thiosulphate were currently available in the departmental laboratory. The seed of the neem was prepared for use by sun drying and grinding [8].

Sample preparation and extraction of oil

The neem seed sample obtained was powdered using milling machine [9]. Extraction of oil was done using solvent extraction method. 150 ml of n-haxane was used for the extraction using a soxhlet extractor where 200 g of the sample was used and was purified by allowing the mixture to stand for 5 hours for the solvent to escape [9].

Base catalyzed biodiesel production

The laboratory scale experiment for the biodiesel synthesis was carried out in an oven chamber in a 250 ml conical flask containing 40 g of neem seed oil. The experimental set-up was placed in an oven chamber at a temperature of 60°C. The pretreated oil was poured into the reaction flask and heated. A solution of CaO in methanol (1%), as catalyst, was dissolved at room temperature and the oil was added. The reaction was allowed to run for various period 2 hours [10]. The resulting mixture was allowed to settle under gravity for 24 h for separation of biodiesel. The lower glycerol layer was tapped off after which the biodiesel layer was washed with warm water three to four times and dried over anhydrous calcium chloride. The viscosity value was used a proxy measure of the extent of reaction with reference to ASTM standard which served as an indicator of completeness of the reaction [10]. The following parameters of biodiesel were analyzed: pour point, flash points, cloud points, Specific gravity at 15°C, water content, color, density, and kinematic viscosity at 40°C.

Analysis of biodiesel produced

Physicochemical analysis: The analysis has been done for physicochemical properties such as iodine concentration, saponification value and acid content by methods described by the association of Official Analytical Chemists (AOAC, 1984) [10].

Characterization of the biodiesel: Characterization is done as followed by Aransiola et al. [10]. The density and the viscosity were measured using the density bottle and the Brooke auto viscometer (DV-I PRIME, Brookfield, USA) respectively, at room temperature. Standardized methods were used to examine the parameters (Figures 1a and 1b).

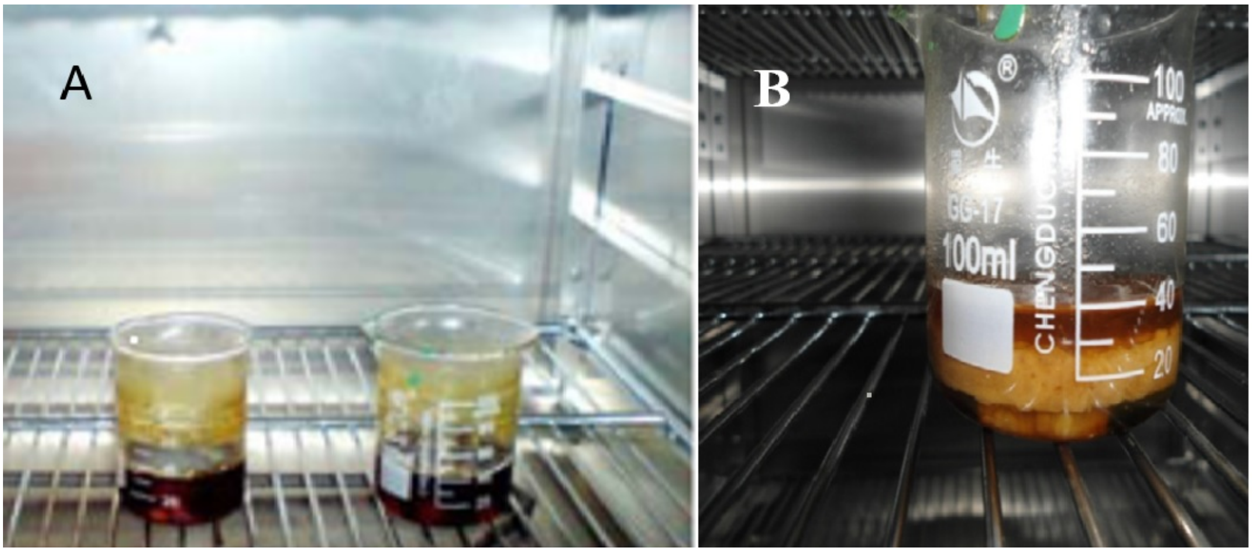

Figure 1: (a) Biodiesel production in oven chamber; **(b)** Shows the different layers after reaction with the oil at the top.

Results and Discussion

The physicochemical properties (density, flash point, pours point, cloud point, and viscosity) of the biodiesel produced were determined and the parameters are shown in Table 1.

Table 1 shows the properties of biodiesel produced in comparison with the standard value. The value of density obtained lies within the limit set by ASTM standard, the oil obtained has similar value with the oil obtained by others following different methods of production. Flash point of the biodiesel obtained 147°C shows significant variation with the literature value, the biodiesel is not flammable compared to fossil based in fuel, this perhaps reflect the density difference observed between the properties oil obtained and ASTM standard. The Pour point of the diesel produced is 16°C it shows that there is significantly difference with the standard value. The values of cloud point and viscosity became 26.8°C and 3.5 mm^2/s respectively, lied in the range of ASTM standard.

S/N	Properties	Experimental value	ASTM standard
1	Density	820 kg/m^3	845 kg/m^3
2	Flash point	147°C	130°C
3	Pour point	16°C	18°C
4	Cloud point	26.8°C	1-4°C
5	Viscosity	3.5 mm^2/s	0.9-5 mm^2/s
6	Iodine Value	8.9 mgl^2/g	-
7	Acid value	30.8 mg KOH/g	-
8	Saponification	91 mg KOH/g	-

Table 1: Physicochemical properties of biodiesel obtained from neem seed.

The quantity of base used to titrate the sample depicts the acid value and it is the measure of free fatty acid present within the biodiesel. Higher acid values or excess of fatty acids indicated the presence of H_2O in fuel which cause oxidative degradation, also inhibit the trans-esterification process. The high acid value for the neem seed oil biodiesel was 30.8 mg KOH/g referred to the predetermined high moisture content present in the diesel oil according to ASTM standard. The saponification value of diesel oil was 191 mg KOH/g which reduces to 91 mg KOH/g for the biodiesel which is very reasonable range in comparison with the ASTM standard. Iodine value is a degree of unsaturation of vegetable oils, as low iodine value refers to low content of unsaturated fatty acids. Hence, reduced vacant bonds which interpreted to less reactivity, affect polymerization tendency, and better storage stability. The iodine values were also according to ASTM standard, 10 mgl^2/g and 8 mgl^2/g for the oil and biodiesel respectively.

Conclusion

Biodiesel is a better alternative to the domestic fuel and can exhibit a steady supply of energy. The biodiesel fuel production process has evolved considerably to minimize the original problems with viscosity. Today, biodiesel is an increasingly attractive, non-toxic, biodegradable fossil fuel alternative that can be produced from a variety of renewable sources. Neem seed oil has potential as an alternative energy source. But it is not possible for oil alone to solve dependency on foreign oil within any particular time frame. Significant commitment of resources would require increasing production of Neem oil. These needs are being met with recent advances in instrumentation technology. The characteristics of the biodiesel analyzed in this study compared favorably with the values prescribed by American Standard Testing Method. The results obtained in this study would be relevant in the development of biodiesel production from neem oil especially in countries where this feedstock is abundant.

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