

Productions and Characterization of Biodiesel by Base Catalyzed Transesterification Reaction from Dairy Waste Scum of DEI Dairy, Agra

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Abstract

With the increase in prices and rapid depletion of petroleum-based fuels, the investigation is being done to look over an alternative fuel source. Presently, the biodiesel is mainly produced from vegetable sources such as jatropa oil, karanja oil, rapeseed, soybean, and others that could overlap with nutritional requirement of the society if produced at large scale. Also, the production cost of biodiesel from vegetable and animal sources is very high comparing to petroleum fuels because of the high value feed stock being used. This study is based on the production of biodiesel from dairy waste scum with minimal production cost, no conflicting nutritional requirements and reducing environmental impact of dairy effluent disposal. The current study is concentrated on the usage of base catalyst in the transesterification process of producing biodiesel. NaOH was examined as a potential basic catalyst. The fuel thus produced was characterized for its cloud point, pour point, viscosity, and flash point, and was found to be as per the ASTM standards for biodiesel.

Keywords: Dairy Scum, biodiesel, transesterification, effluent, scum oil

INTRODUCTION

Biodiesel is a form of fuel derived from biological resources consisting of polymeric chain of fatty acid esters [1]. It is a substitute for diesel and petroleum and used as a vehicle fuels [2]. These biodiesels are derived from natural resources are biodegradable, non-toxic, ecofriendly in nature [3]. In general, fossil fuels are energy producing substance formed from decomposition of plant and animals [4]. These are categorized as non-renewable source of energy which may impoverish after certain period [5]. Some problems involving their utilization are growing price of petrol and diesel which makes them no longer economically sustainable [6]. Burning of fossil fuel releases large

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number of harmful gases in air causing global warming and adversely affecting human health [7]. Biodiesel is renewable substitute for petroleum, is environmentally friendly and possesses similar properties from that of petrol and diesel [8]. The global market size of biodiesel is highly expected to grow in the upcoming years [9]. There is a huge market for biodiesel in developing countries like India, where growing population needs immense fuel for transport sector [10]. Biodiesel production does not require vast land area or other valuable resources hence making it economically, politically, and morally acceptable in India's biofuel option. Benefits of biodiesel, like clean fuel, clear substitute of petro-diesel, clean emission and others has received much attention in the present era [11]. Using biodiesel as a substitute

reduces 47% of particulate matter and 67% of hydrocarbon emissions [12] and lowers down the hazardous waste produced by other fuels, thus encouraging its application [13].

Biodiesel is alternative fuel for diesel made from animal fat or vegetable oil [14]. It is produced because of transesterification process, containing monoalkyl esters of long chain fatty acids [15]. Presently, the biodiesel is mainly produced from vegetable sources such as jatropa oil, karanja oil, rapeseed, soybean, and others [16] that could overlap with nutritional requirement of the society if produced at large scale [17]. The waste as a feed stock to produce biodiesel makes an ecofriendly fuel thus sustaining environment. Despite all advantage, biodiesel production from vegetable oils has some limitations, viscosity of biodiesel produced from vegetable oil are much higher when compared to diesel fuel, which can be problematic when used in engines. Also, it has lower volatility than that of diesel fuel. Hence incomplete combustion forms deposits in fuel injector of diesel engines [18]. Some methods which can reduce the problem are blending of biodiesel from vegetable oil with diesel are microemulsions, pyrolysis, esterification, or transesterification [19]. The most common method to produce biodiesel is by transesterification process [20]. Transesterification is a chemical reaction where fat reacts with alcohol to produce esters of fatty acids and glycerol while reaction taking place in the presence of catalyst. Rudolph Diesel 1st envisioned vegetable oil as a fuel source [21]. Biodiesel was discovered by G. Chavannein 1937, who was granted patent of transformation of vegetable oil into fuels, a process which is now called as transesterification [22].

Peanut oil has been reported to run compression engine [23] International Biodiesel Day is known to be on 10th August as diesel engine was demonstrated to be run on peanut oil at Paris exhibition in 1900 [24]. Biodiesel can be blended with diesels to run engines without any modifications [25]. Therefore, waste as a material is currently creating interest among researchers to produce biofuels.

As suggested by some recent researcher's dairy waste biodiesel production is a suitable alternative for diesel also biodiesel blends are being used in some parts of India like Karnataka which is using biodiesel blends for running state buses [26]. Many large and small dairies are involved in handling and production of milk and products across the country generates tones of dairy waste [27]. This dairy waste is produced from cleaning of equipments like butter churner, cream separator, pasteurizer, homogenizer etc., cleaning of silos, tanks, floors, and others which later gets collected as scum by skimming in dairy effluent treatment plant. Scum is a floating film solid mass which contains milk fat, oil, grease, protein, dust particle and impurities [28]. Generally, about 250–370 kgs of effluent scum are produced per day by the dairy industries handling about 5–7 lakh of milk on daily basis [29]. These waste scums are difficult to dispose and creates contaminant in the nature thus polluting environment [30]. Most dairies dispose their waste in land fill, waste disposal sites, water bodies or by incinerating [31]. By practicing such methods generates pollutants and contaminate water. It also economically wastes a value of resources. So, one possible solution is to convert the dairy waste scum into biodiesel and use as a fuel thus enhancing value of waste and contributing to waste to wealth projects.

Waste scum was collected from small scale student run DEI dairy and scum oil was extracted from it, later biodiesel from scum oil was obtained by the process of transesterification. The process is more efficient and commonly used method for biodiesel production. Transesterification is the chemical reaction of converting triglycerides with alcohol into esters [32]. Catalyst speeds up the rate of reaction, mostly used catalyst for the biodiesel production are acid, base or enzymes [33]. Acid catalysts are not much used for the process as they are very slow in nature for the reaction to take place [34]. Enzyme and catalyst are very costly and produced at high scale [35]. NaOH as a base catalyst is used widely in large scale of biodiesel production [36] because it easily gets dissolved in methanol and has high speed of reaction. Base catalyst transesterification reaction occurs faster than acid catalyst thus taking less time in completing the reaction [37]. A clear separation of methyl ester and glycerol can be obtained at low cost by using base catalyst transesterification reaction.

MATERIALS

Milk Scum

The milk scum is a waste product obtained by sequential washing of dairy equipment, silos, tanker etc. The washed water of various equipment (like pasteurizer, cream separator, butter churner) was collected from the DEI dairy (Dayalbagh Educational Institute), Dayalbagh, Agra (Figure 1). The collected water was then incubated for 48–50 hrs which results in the formation of a top layer of fatty acids.

Chemicals: Propanol, Phenolphthalein, Sodium hydroxide, Potassium hydroxide, Methanol (99.8% pure)

METHODOLOGY

Preparation of Scum Oil

The scum collected (Figure 1) was first purified and floating impurities were removed which was then heated at 100°C for approx. 1 hr to remove the moisture content followed by filtration. After the filtration process, we got orange coloured thick oil called scum oil (Figure 2). The scum oil thus produced was stored at room temperature in reagent bottles to prepare biodiesel.

Analysis of Scum Oil and Free Fatty Acid Test

Free fatty Acid Test and acidity of scum oil was analyzed by following procedure as explained hereafter. 10 ml of propanol with 1 ml of phenolphthalein taken and 1 gram of scum oil was then added to it. Titration was done by KOH solution of 0.01N with an end point of slight pink colour which stays for 5–10 sec. KOH solution consumed to get pink color was noted down. Fatty acid present in the sample was estimated by amount of KOH utilized. KOH (0.01) solution consumed to get pink color is noted down. FFA was calculated by using following equations:

$$(v-b) * N * 28.2 / w$$

Where;

v = volume in ml of titration solution

b = volume in ml of the blank

N = normality of the titration solution

w = weight of the sample of oil in g

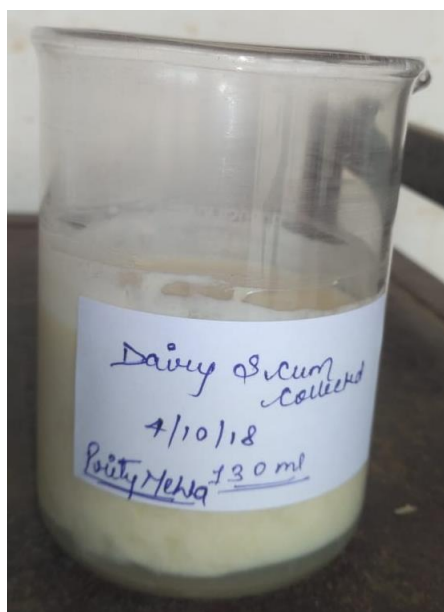


Figure 1. Milk scum collected from dairy waste of DEI dairy.

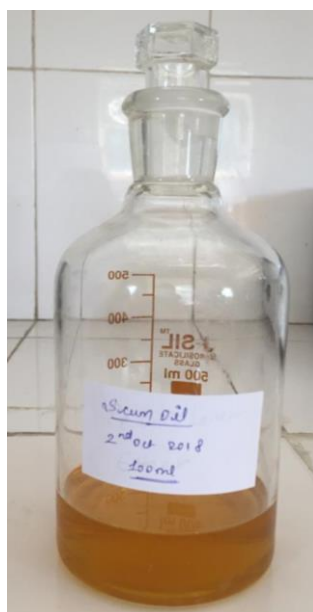


Figure 2. Scum oil produced from milk scum of DEI dairy.

Production of Scum biodiesel

Transesterification process was studied of the scum oil by base catalysed esterification process. Scum is subjected to heating at around 60°C and 15% of methanol was added with continuous stirring. 2% of NaOH as a base catalyst was then dissolved in methanol. The stirring was done for the mixture of scum oil, methanol, and base, thereby not allowing the mixture to solidify. The stirring was carried on continuously at 60°C for 3 hours. After the reaction was completed, the solution was left for 24 hrs for the gravity separation in a separating funnel. A clear separation of methyl ester and glycerin was observed (Figure 3). The methyl ester was separated and washed.

Biodiesel Washing

Methyl ester which was separated as result of transesterification reaction was then washed to remove impurities, glycerol, catalyst, soaps, and chemicals. Equal volume of water was added to methyl ester and stirred continuously for 15–20 min at 100°C. It was then incubated for 4 hours. Washed biodiesel was now used for testing.

RESULTS

Yield of Scum oil produced from dairy waste scum yields 5% of the total waste collected. Yield of Biodiesel produced from scum oil was 85%. Characterization of biodiesel was done and following values were obtained (Table 1).



Figure 3. Clear separation of methyl ester and glycerin observed after transesterification reaction.

Table 1. Characterization of Biodiesel.

Characteristics	Biodiesels obtain from scum oil	ASTM standard for biodiesel	Petrol-diesel standard
Viscosity in cSt at 40°C	5.80	1.9–6.0	1.3-4.1
Flash point in °C	120	100.0 (min)	50
Fire point in °C	125	130	56
Cloud point in °C	11	-3 to 12	-15 to 5
Pour point in °C	10	-3 to 12	-35 to -15
Acid value (%)	0.74	0.80 (max)	0.12
Colour	Light golden	Light golden	Golden
Solubility in water	Insoluble	Insoluble	Insoluble

CONCLUSION

Biodiesel is a good substitute for petro-diesel and an environmentally friendly alternative biofuel for the power generation. Dairy waste as a feed stock not only reduces the cost of biodiesel production but also maintains environmentally sustainable ecology. It also contributes towards meeting National Biofuel Policy of India aiming to meet 20% of country's biodiesel demand. The biodiesel produced from dairy waste was characterized. The properties of biodiesel obtained from dairy waste were found to be within limits of standard of biodiesel. Cost of producing alternative fuel like biodiesel can be reduced by using waste like dairy scum as a feed stock. Biodiesel can be blended with petrol, which serve as a means for vehicle fuel. Dairy Industry can use such kind of projects to solve waste disposal and other ecological problems and to improve their economy.

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