Production of Biodiesel from Non-edible Seeds

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ABSTRACT

This study investigated production of biodiesel from non-edible oil seeds of Rubber and neem. This is with a view to compare which of the oils when used for biodiesel production is more environmentally friendly and cheaper. The optimum reaction time for transesterification of Rubber oil to biodiesel was recorded to be 3h while that of neem oil to biodiesel was 2h. This reduces the operating cost of neem biodiesel. Fatty acid methyl esters (FAME) yield of 86.61% with a viscosity of 5.64 cSt was obtained for Rubber biodiesel using the established operating conditions. This viscosity was used as an index for maximum conversion of biodiesel (BD) for neem oil. The viscosity obtained for neem oil biodiesel was 5.51cSt. An attempt to increase the reaction time does not give any significant difference in the viscosity. Experimental investigations of the different blends of biodiesel from the two oils were tested on an internal combustion engine. The emissions of different blends showed that neem biodiesel has lower emissions of CO and NOX than Rubber biodiesel, but CO emissions of Rubber biodiesel are lower than that of diesel fuel. The NOX value of petrol diesel is higher than B10 – B50 and B10 – B80 of Rubber and Neem biodiesel respectively. However, NOX values of B60 – B100 and B90 – B100 of Rubber and neem biodiesel are in the range of 5.27 – 10.74% and 1.39 – 11.93% higher than petrol diesel respectively.

Keywords: Bio diesel, Neem seed, Rubber seed, Heteropolysaccharide, Jelling agent

INTRODUCTION

The major percentages of energy used in the world today are being generated from fossil fuel sources. These fossil fuels are non-renewable resources that take millions of years to form and their reserves are being depleted faster than they are being regenerated [1]. They are the major contributors and sources of greenhouse gases, air pollution and global warming. Some of the emissions generated from these fossil fuels are CO, CO2, NOX, SOX, unburnt or partially burnt HC and particulate. The production and use of these fossil fuels are raising environmental concerns. This rate of depletion and environmental issue is seriously calling for an alternative[2]. Biodiesel, a form of Biofuel is an answer to this call. It is a fuel derived from renewable biological sources to be used in a diesel engine. Biodiesel fuel is recently attracting increasing attention worldwide as a blending component or a direct replacement for diesel fuel in vehicle engines. Bio-diesel blends of up to B20 can be used in nearly all diesel equipment and are compatible with most storage and distribution equipment [3]. These low-level blends generally do not require any engine modifications. Higher blends, even B100, can be used in many engines built with little or no modification. Though biodiesel is gaining popularity, more than 95% of the renewable resources used for its production are edible oils and these have been in conflict with food consumption and also more expensive than petroleum diesel. Due to this fact, it is necessary to look into non-edible oils which are not competitive with consumption and are alsocheap[4].

Biodiesel

Biodiesel, which refers to fatty acid alkyl esters, has attracted considerable attention as an environmentally friendly alternative fuel for diesel engines, and biodiesel has several advantages as a renewable, biodegradable, and nontoxic fuel. In this article, various technological methods to produce biodiesel being used in academic and industrial scenarios are reviewed. Several catalytic transesterification processes for biodiesel fuel production have been developed, among which transesterification using alkali catalysis gives high levels of conversion of triglycerides to their corresponding methyl esters in a shorter reaction time and is widely applied for the commercial production of biodiesel[5]. In this article, further emphasis has been given to enzymatic transesterification by considering its advantages in easy separation of byproduct glycerol and the simple downstream processing steps for the recovery of alkyl esters. Biodiesel can be produced from multiple oil and fat feedstock sources. Most of the nonedible oil sources have the potential to produce biodiesel at low cost. Unfortunately, they have more than 3% of free fatty acid (FFA), which pose challenges in the biodiesel production process via the homogeneous base transesterification. This calls for different FFA pretreatment methods prior to transesterification.

Neem seed and Rubber seed
Neem plant is available in many parts of the world including Bangladesh and is very cheap compared to other sources. The non-edible renewable neem seed oil can play a vital role as a substitute to diesel fuel. Rubber seeds are a by-product of rubber production and are rich in oil and protein [6]. Upgrading of rubber seeds to produce proteins, oils and feedstock can generate additional revenue for rubber production and reduce waste.

Triacylglycerols (TAG)
Triacylglycerols (TAG) are the major storage lipids in plant seeds, and of great nutritional and nutraceutical value as well as, a common source of edible oils for human consumption and industrial purposes (Lung and Weselake, 2006).

TAG is the primary component of Seeds, and it is a key feedstock for biodiesel production. Biodiesel is a renewable and sustainable alternative to fossil fuels that can be produced from a wide range of feedstocks [7].

The basic process of producing biodiesel from TAG involves transesterification, which is the chemical reaction between TAG and an alcohol (usually methanol) [8] in the presence of a catalyst to produce fatty acid methyl esters (FAMEs) and glycerol.

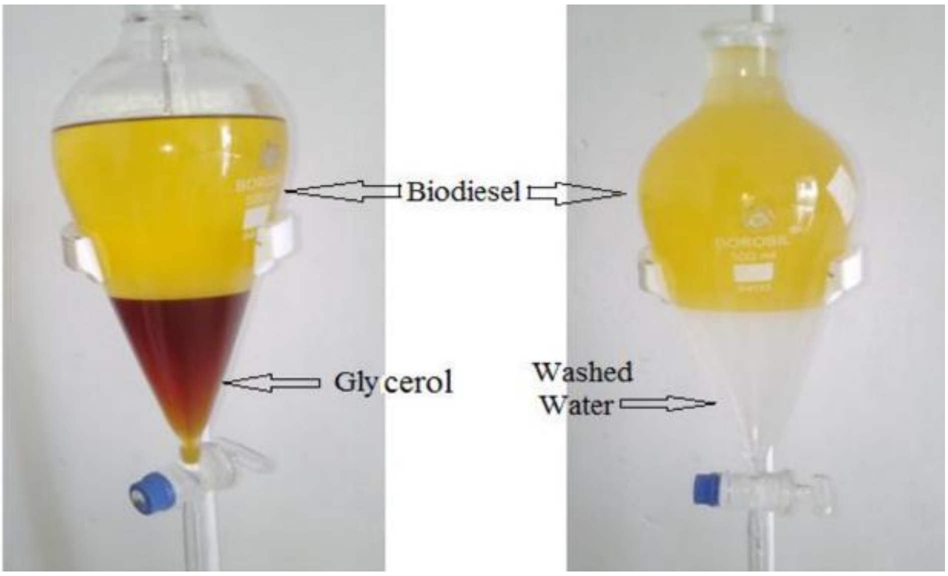
TAG from seeds is preferred for biodiesel production because they have a high percentage of saturated and unsaturated fatty acids that can be easily converted into FAMEs. However, the quality of the TAG feedstock is also important, as impurities such as moisture, free fatty acids, and other contaminants can negatively impact the transesterification reaction and the quality of the resulting biodiesel.

Fatty acid methyl esters (FAME)
Fatty acid methyl esters (FAME) are a type of fatty acid ester that are derived by transesterification of fats with methanol. The molecules in biodiesel are primarily FAME, usually obtained from vegetable oils by transesterification [9]. They are used to produce detergents and biodiesel. FAME are typically produced by an alkali-catalyzed reaction between fats and methanol in the presence of base such as sodium hydroxide, sodium methoxide or potassium hydroxide. One of the reasons for FAME use in biodiesel instead of free fatty acids is to nullify any corrosion that free fatty acids would cause to the metals of engines, production facilities and so forth. Free fatty acids are only mildly acidic, but in time can cause cumulative corrosion unlike their esters. As an improved quality, FAMEs also usually have about 12-15 units higher cetane number than their unesterified counterparts.

METHODOLOGY

Soxhlet Extraction:
The seeds are separated from the fruit and dried in the hot air oven at 130°-133°C for 1 to 4 hrs. Then neem and rubber seed is ground into small particles and placed in a porous cellulose thimble. The thimble is placed in an extraction chamber, which is suspended above a flask containing the solvent and below a condenser. The flask is heated at 30°C-60°C and cooled at cool 0°C. The solvent evaporates and moves up into the condenser where it is converted into a liquid that trickles into the extraction chamber containing the sample [10]. The extraction chamber is designed so that when the solvent surrounding the sample exceeds a certain level it overflows and trickles back down into the boiling flask. At the end of the extraction process, which lasts a few hours, the flask containing the solvent and lipid is removed. The solvent in the flask is then evaporated and the mass of the remaining lipid is measured. The percentage of lipid in the initial sample can then be calculated. Then 1% of NaCl is added, it increases the surface tension of the droplets and increases the density of the aqueous layer, thereby forcing separation. and Then transfer it to the separating funnel and leave it for overnight. Then the extract is taken to perform transesterification method.

Transesterification method
Transesterification is defined as the process in which triacyl glycerides from a variety of feedstock such as nonedible oil seeds, vegetable oils, animal fats or tallow, waste cooking oil, and microbial lipids or single cell oil (from algae, oleaginous yeast, filamentous fungi and bacteria) are converted into fatty acid methyl esters (biodiesel) in the presence of alcohol (methanol or ethanol). This reaction has been extensively used to reduce the viscosity of feedstock or nonedible oil and improve its compatible fuel properties to a level similar to fossil-based diesel oil [11]. There are two alternatives in which transesterification reaction can be carried out, viz. catalytic and noncatalytic transesterification (supercritical transesterification) depicts the techno-economic and environmental aspects of the transesterification process as well as the flow chart diagram of different transesterification reactions.



ANALYSIS

The biodiesel yield was calculated from the FAME and oil weights:

$$\text{Yield, \%} = \frac{\text{Total weight of FAME} \times 100}{\text{Total weight of oils in the sample}}$$

Fourier transform infrared spectroscopy

There are various method to produce biodiesel, and one of the method that being used widely is transesterification. In this study, was used lipids from neem and rubber seeds to produce biodiesel via transesterification process. In order to determine the functional group and the compositions that presence in the biodiesel, Fourier Transform Infrared Spectroscopy (FTIR) analysis of the biodiesel produce was conducted thoroughly in this study. The comparison of FTIR analysis between lipids, which is the feedstock that being used to produce biodiesel, with biodiesel produced, and also conventional diesel from the petrol station was examined in order to know the difference between those three substances.

Gas chromatography

GC is a common instrument used in the quantitative and qualitative analyses of liquid and gaseous molecules. GC-MS is a hyphenated analytical technique that comprises two instruments combined in series to output robust analytical results. In this instrument, gas chromatography separates the components in a sample and the results are displayed in the form of a chromatogram, where the band intensity informs about the quantity of the analytes and the number of bands represents different molecules in the mixture. Mass spectrometry, on the other hand, gives out the discrete number in the form of peaks that either represents the mass of the molecule or its fragments, which is characteristic to individual components in the mixture. Combining these techniques one can quantitatively and qualitatively analyze the compounds in a given mixture. The separation of the compounds in a mixture is carried out by the GC portion of the instrument [12]. The sample can be introduced to the GC manually or through an autosampler. The injected sample enters the instrument through a port called the inlet. 9 Inlets are kept at a temperature of 200°C to ensure that the sample is quickly vaporized as a gaseous phase. The mobile phase, such as helium, carries the sample through the column, where the individual compounds are separated because of different strength of intermolecular interactions with the stationary phase. The column is held in an oven that can ramp the temperature gradually to aid successful compound separation. As the temperature remains constant or temperature increases, low boiling compounds elute first from the column and so on. Control of temperature and the type of stationary phase in a GC column are the two important conditions for efficient separations in GC.

RESULTS AND DISCUSSION

After extraction of oil from neem seeds and rubber seeds, the physicochemical properties of the oil were determined according to the standard procedure. Oils derived from plant seeds and microalgae comprise mainly triacylglycerols (TAG) molecules with very high energy density, making them an ideal source for biofuels. These renewable energy sources for transportation are increasingly in demand by societies because they do not raise global carbon dioxide levels. The most common biofuel derived from seed oils is biodiesel, which consists of the fatty acid methyl esters (FAME) produced from the TAG molecules. Transesterification is the reaction of a triglyceride such as oil with an alcohol, usually methanol, in the presence of an acidic or alkaline catalyst to produce fatty acid esters and glycerol.

A base-catalyzed transesterification process is normally alkaline metal alkoxides such as sodium methoxide and hydroxides are more effective than acid catalysts [13]. Reaction rates under acid catalysis are slower than those under alkaline conditions Triglyceride is converted stepwise to a diglyceride, a monoglyceride and finally, to glycerol by removal of an alkyl in each step [14,15].

The effect of the quantity of methanol and sodium hydroxide and reaction time were studied to optimize the esterification process. Diesel, blends of biodiesel, and neat biodiesel were tested in a twin-cylinder, water-cooled, four-stroke direct injection diesel engine [16,17]. Performance and emission of the engine with conventional diesel fuel was used as the basis for comparison.

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