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Transesterification of soap nut oil using novel catalyst

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Abstract There is a growing interest in biodiesel (fatty acid methyl ester or FAME) because of the similarity in its properties when compared to those of diesel fuels. Diesel engines operated on biodiesel have lower emissions of carbon monoxide, unburnt hydrocarbons, particulate matter, and air toxics than when operated on petroleum-based diesel fuel. In the present study soap nut oil is used for the production of fatty acid methyl ester (FAME) by using a new catalyst. In this work the catalyst employed for transesterification reaction was the residue collected from coal burnt boilers from industries. Similar to wealth from waste the residue is completely utilised as a catalyst in this study. The physical and chemical properties of the residue catalyst were examined by scanning electron microscope (SEM) measurements, energy dispersive X-ray (EDAX) analysis and Thermo gravimetric analysis (TGA). The maximum yield of methyl ester was obtained as 89 wt% with 3 h reaction time at 60 °C, 3.5 wt% catalyst and 1:15 oil–methanol ratio. The obtained biodiesel was characterised by ^{1}H NMR (Nuclear magnetic resonance spectroscopy). The fuel properties of methyl ester were analysed and found to be within the limit of ASTM.

1. Introduction

In recent years energy demand increased due to the limited source of fossil fuels. Hence research is concentrated towards alternative renewable fuels. Essentially, no engine modifications are required to substitute biodiesel for diesel fuel that can maintain engine performance, since its molecular similarities with biodiesel. It is biodegradable, nontoxic and has low emission problems and so it is environmentally beneficial. And also this renewable fuel has the potential to reduce the level of pollutants and the level of potential or probable carcinogens (Krawczyk, 1996). Biomass has been found to produce low-molecular-weight organic liquids, which can be used or is proposed for a vehicle which is called biodiesel. Biodiesel is a potential substitute for petroleum fuel which consists of methyl esters of fatty acids produced by the transesterification reaction of triglycerides of vegetable oils with methanol with the help of a catalyst (Sarin et al., 2007).

Fats and oils are primarily water-insoluble, hydrophobic substances in the plant and animal kingdom that are made up of one mole of glycerol and three moles of fatty acids and are commonly referred to as triglycerides (Sonntag, 1979). Any fatty acid source may be used to prepare biodiesel. The use of edible vegetable oils and animal fats for biodiesel production has recently been of great concern because they compete with food materials – food versus fuel (Srinivasan, 2009). In addition, biodiesel is better than diesel fuel in terms

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of sulphur content, flash point, aromatic content and biodegradability (Martini and Schell, 1997). When biodiesel is produced from refined edible oils, the cost of biodiesel is very high since the cost of feed stocks is very high (Ali et al., 1995) and the consumption of oil for biodiesel production will deplete the quantity for food requirements (Lam et al., 2009). Because of these reasons it is necessary to choose an inexpensive feedstock for biodiesel fuels. The use of inexpensive, non-edible feedstock and the utilisation of by-products in the biodiesel production may significantly reduce the cost of biodiesel (Ali and Hanna, 1994). Transesterification of vegetable oil to biodiesel (fatty acid methyl ester, FAME) can be catalysed by bases, acids and enzymes (Du et al., 2004). Currently, most commercial processes used for biodiesel synthesis employ a homogeneous base catalyst, such as NaOH or KOH. The consumption of sulphuric acid, separation of sulphates (from neutralisation processing) and purification of the product also involve substantial energy and material use (Ramos et al., 2008). This produces tremendous waste as it consumes more water and increases corrosion due to sulphuric acid. The catalyst of solid types are easily produced that are non-corrosive in nature, leading to safer, cheaper and more environment-friendly operations, and therefore in the recent past has become a centre of attraction. However, majority of the heterogeneous catalysts are quiet expensive or complicated to prepare, which limits their industrial application (Kafuku et al., 2010). Thus, it is desirable to find more efficient and cheap catalysts for the transesterification of vegetable oils for their application in commercial production. In the present investigation a new catalyst was used for biodiesel production. The processing cost of catalyst is very less since it is a waste catalyst collected from thermal industry. In this work soap nut oil which is a non-edible oil was used for the synthesis of biodiesel using a new heterogeneous catalyst.

The soap nut tree can be used for multiple applications such as rural building construction and oil and sugar presses, and agricultural implements would help community forestry to produce more seeds as potential sources for the biodiesel feedstock. Among others, the plant grows very well in deep loamy soils and leached soils so cultivation of soap nut in such soil avoids potential soil erosion. Soap nut is a fruit of the soap nut tree generally found in tropical and sub-tropical climate areas in various parts of the world including Asia, America and Europe. Two different species (*Sapindus mukorossi* and *Sapindus trifoliatus*) are widely available in India, Nepal, Bangladesh, Pakistan and many other countries (Arjun et al., 2008). The oil from soap nut has been considered as a non-edible oil having a significant potential for biodiesel production from the material which otherwise is a waste material. The main aim of this study is utilisation of industrially used coal burned boiler waste as a catalyst for the production of biodiesel, hence lowering the production cost of biodiesel as well as reducing environmental issues.

2. Experimental

2.1. Materials and catalyst preparation

All chemicals were purchased from known chemical companies. Methanol and potassium hydroxide (98%) were purchased from Merck. Soap nut seeds (*S. mukorossi*) were collected from various parts of Tamilnadu, India. The kernels were separated from the shells for oil extraction. The seeds were selected according to their condition, where damaged seeds were discarded and seeds in good condition were cleaned, de-shelled and dried at high temperature of 100–105 °C for 60 min. Seeds were grounded using a grinder prior to extraction. The bottom ash was collected from various thermal industries in and around the Tuticorin district, Tamilnadu. The oversized particles were removed by simple filtration and the catalyst was crushed well and sieved. The finest particles were collected and used for the production of biodiesel. The prepared catalyst was dried and stored under ambient conditions before being placed in the reactor.

2.2. Catalyst characterisation

The scanning electron microscope (SEM) was used to examine the surface morphology at a higher magnification. SEM micrographs were obtained using JEOL-6360 (Japan) microscope.

The catalyst was analysed by thermo gravimetric analyser using Mettler Toledo Switzer instrument. A typical TGA instrument consists of a precision mass balance, which records the initial and instantaneous mass of a sample, and a furnace, which increases the temperature in a linear relationship with time (the range of temperatures between 50 °C and 900 °C). Mass measurements are performed in nitrogen medium. A mass of 1.5 mg was heated at a constant rate of 10 °C/min with a nitrogen purge rate of 20 ml/min in a pan. The component present in the catalyst was analysed by Edax.

2.3. Extraction of oil

Extraction is carried out in a batch process by the solvent extraction method. The seeds were collected and dried in an oven to remove the moisture. The process was repeated several times to attain a constant weight. The seed coat was removed from the seed and the seed was crushed to pass through a 40 mesh sieve. The oversized particles were crushed again and made to pass through the 40 mesh sieve. The undersized particles were taken to extract oil. Seed and the solvent are taken by products side since the reaction is reversible

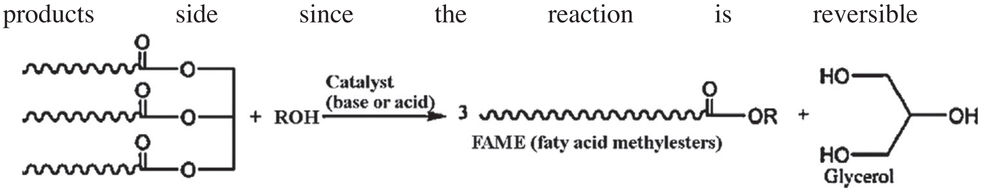

Figure 1 Triglyceride alcoholysis.

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