Biodiesel Production using Trans-Esterification Process and Investigation of Fuel Properties: A Review Study

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Submission: April 01, 2017; Published: June 07, 2017

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Abstract

Biodiesel is a renewable fuel that, due to increasing environmental pollution and global warming caused by fossil fuels, its production is increased. Nowadays, low prices renewable sources like waste edible oil which has been disposed from restaurants, is used to produce the biodiesel. One of methods for biodiesel production is trans-Esterification. In the trans-Esterification process, the reaction takes place in the presence of catalysts such as alkaline, acidic and enzymatic catalysts. Finally, properties of biodiesel such as flash point, kinematic viscosity, density, cloud point and pour point will obtain based on the international standard ASTM D6751 and the properties are compared with diesel fuel.

Keywords: Biodiesel production; Trans-esterification; Catalyst; Fuel properties; ASTM D6751

Introduction

Fossil fuels such as oil, coal and natural gas, supply the major part of the world's energy. Fossil fuel resources are limited and will end in the near future [1]. After the oil crisis in 1970, extensive researches were conducted on the alternative, renewable, easily accessible and cleaner fuels than the fossil fuels for internal combustion engines [2]. Biodiesel is an alternative fuel that can be produced from renewable biological sources such as vegetable oils and animal fats [1]. This fuel is biodegradable, non-toxic and renewable and produces fewer pollutants in compared with the petroleum-derived fuels [3]. Biodiesels produced from vegetable oil sand animal fats have been shown to have higher viscosity than diesel and can be used as fuel in diesel engines without significant changes [4-6].

Biodiesel containing greater amounts of oxygen compared to diesel and its usage in diesel engines has shown that the amount of smoke, noise, carbon monoxide, sulfur compounds, poly-aromatic hydrocarbons is fewer in comparison with the fossil fuels [7,8]. Various ways such as micro emulsion, dilution and trans-esterification can be applied to produce biodiesel, which is the latter method is mainly used to produce biodiesel [9]. In the process of Trans-Esterification, the chemical reaction occurs between free fatty acids and the alcohol chains, in which methanol is used as the alcohol because of its low commercial price [10,11]. In this process, the reaction takes place in the presence of catalysts such as alkaline [12], acidic [13] and enzymatic catalysts [14]. In biodiesel production, the cost of raw material used is more than 70% of the total cost of the process and the product [15,16]. To produce biodiesel, crude vegetable oils are mainly used which in return, increase operating costs and the price of the final product. Thus, to minimize the total cost, using of low-value resources of triglyceride oils such as animal fats and food waste oils is taken into consideration [17].

To produce biodiesel by trans-Esterification process, oil, catalyst and alcohol (preferably methanol) with different ratios are mixed. After producing the biodiesels, they pour into a separating funnel for 24 hours until the biodiesel and the glycerol phase were separated. After the glycerol phase was separated from the solution, they pour into the beaker and about 10g of sodium sulfate was added and stirred for 40 minutes to absorb the water contained in the product. The resulting product is filtered through
the filter paper and vacuum pump to separate sodium sulfate from the solution. Thereafter filtering, the biodiesel was poured into plastic bottles made of polyethylene terephthalate and was stored at room temperature [18].

**Characterization of the Produced Biodiesel**

Fuel properties such as viscosity, density, flash point, cloud point, pour point, acid value and Cetane number are analyzed based on the international standards of ASTM D 6751. These properties are defined as follows.

**Kinematic Viscosity**

Kinematic viscosity is a critical feature for motor fuel. It plays an important role in the fuel injection, mixing and combustion of fuels [19]. The viscosity of the fuel is effective in softening system. If the fuel viscosity is low, it can’t supply effective softening properties to provide a fuel injection system, which in return, lead to increase the erosion and leak of the fuel system. If the fuel viscosity is high, the fuel injection system requires more energy to inject fuel and also the fuel distribution cannot be done well. As a result, the amount of energy production reduces and the exhausted particulate emissions and fumes increases [20]. Therefore, considering the advantages and disadvantages of the fuel kinematic viscosity, viscosity of the produced biodiesel should be in such a manner to prevent reduction of fuel injection and also, to decrease the erosion of injector pump parts and exhausted particulate emissions and fumes. The standard amount of viscosity must be 1.9-6mm²/s according to the ASTM D6751.

**Flash Point**

The flash point is the temperature at which it can vaporize to form an ignitable mixture in air. Flash point is a very important parameter for biodiesel and other fuels, since this parameter represents the safety, storage and transportation of the fuel. The biodiesel flash point is affected significantly by the amount of methanol in fuel. If the amount of methanol in biodiesel increases for 5%, the flash point for biodiesel is reduced by about 52 °C [21]. Flash point for fuels derived from oil is 52 °C while, as the according to ASTM D6751-2standard, flash point is reported to be higher than 132 °C. As reported in many researches, the flash point of biodiesels is reported to be higher than of the ASTM D6751estimated flash point and is in the range of 160 °C to 200 °C [22-25].

**Pour point**

Pour point is another physical property of the fuels. Pour point of biodiesel is independent of the type of catalyst and the reaction conditions. The Pour point of biodiesel depends on the amount of saturated fatty acids in the oil [26]. Pour point is one of the fuel flow characteristics at different temperatures. This feature limits the use of biodiesel in a different climate and different geographical conditions. The pour point of a liquid is the temperature at which it becomes semi solid and loses its flow characteristics and subsequently, it leads fuel system to be in trouble. Using of a fuel with a temperature lower than its pour point leads to reduce the engine performance.

**Cloud point**

Cloud point is one the temperature-dependent parameters that affect the use of biodiesel in different geographical and climatic conditions. The permissible limit for cloud point isn't reported according to the ASTM D6751 standard and this parameter should be determined for each special climatic conditions of each region, separately. But in some recent studies, the cloud point of the biodiesel produced in accordance with EN ISO 3016 standard has been reported and this parameter varies for different produced biodiesels and is in the range of -20 to 284 °C [27].

**Density**

Biodiesel is a fuel that is made of long hydrocarbon chains and thus, by increasing the amount of biodiesel blended with diesel, the density of the samples increases [28]. The relative density of the produced fuel plays a significant role in the fuel injection by the fuel injection system. When the density of the fuel is high, the fuel delivers by the fuel injection system, slowly according to the EN 14214.

**Conclusion**

In recent years, due to raising world oil prices, increasing environmental pollution caused by the burning of fossil fuels, increasing the world population and their demands for energy, biodiesels became more attractive than past for many governments. In biodiesel production, about 70% of the production cost is for preparing the primary resources. Therefore, to decrease the final cost of the biodiesel production, using of low cost oil waste and fat resources is suggested.

**Acknowledgment**

The authors are grateful to the Islamic Azad University of Bushehr for supporting this research.

**Conflict of Interest**

Author has declared that no any economic interest or any conflict of interest exists.

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