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The synthesis of biodiesel from vegetable oil

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Abstract

Biofuels intended to replace the fuel from petroleum. They are a sustainable alternative to fossil fuels because they are renewable and less toxic to the environment. This work aims, firstly, to eliminate one of the major pollutants olive residue and waste vegetable oils such residues have become a double necessity; ecological and economic, transforming them into value-added, namely biodiesel. And, secondly, to contribute to sustainable development by offering a renewable energy source meeting the energy issues of the day as the mastery of greenhouse gas emissions and preservation of non-renewable fossil resources.

The use of reclaimed vegetable oil from restaurants, for use as a fuel for road vehicles, has received a lot of attention in recent years. Used vegetable oils contain solids and free fatty acids due to oil breakdown during the frying process. The synthesis of biodiesel by transesterification of vegetable oils was carried out in this study. Two varieties of oils are used in this work, the first type is the waste oils used in frying and the second are olive-pomace oils. Waste oil residue becomes harmful to the environment. To remedy this, recovery becomes a necessity. In this experiment we determine some physicochemical properties of the oils used and biodiesel obtained. At the end of this study, a comparison of our results with the Algerian standard showed that biodiesel has properties of diesel and biodiesel addition improves cetane number and some other parameters.

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1. Introduction

World energy consumption doubled between 1971 and 2001 and the world energy demand will increase 53% by the year 2030. The second reason is that fossil-fuel resources are non-renewable, and they will be exhausted within 40–60 years if the consumption pace remains constant (Andreani et al., 2012). Finally, the price instability of fossil fuel crude oil is considered as a serious threat to countries with limited financial and economic resources (Isahak et al., 2011). Several alternatives of energy sources such as wind, solar, hydro, nuclear, biofuel (Isahak et al., 2011 ; Dawodu et al., 2014 ; Labib et al., 2013 ; Gendy et al., 2013 ; Tewfik et al. 2013) and biodiesel are already used and elevating progress is still in concern.

Biodiesel is an alternative fuel for diesel engines which is defined as a fuel comprised of mono alkyl ester of long chain fatty acids produced by chemically reacting a vegetable oil or animal fat with an alcohol such as methanol. It is a non-toxic, biodegradable, relatively less inflammable fuel compared to the normal diesel. Biodiesel is also essentially free of sulfur and aromatics that produces lower exhaust emissions than normal diesel (Gerpen et al., 2005; Ma et al., 1999 ; Nas et al., 2007 ; Meher et al., 2006).

Many techniques and different carriers have been employed for immobilization of lipases to produce biodiesel (Ranganathan et al., 2008). Common immobi-lization techniques include physical adsorption and covalent bonding onto a solid support. Lipases have been successfully immobilized on many different types of supports, such as Nylon-6 (Pahujani et al., 2008), cellulose fabric (Akhil et al., 2010) and wool fibers (Monier et al., 2010). Also several oils such as soybean, palm, kernel, grease and tallow have been used for biodiesel production with enzymatic transesterification using primary or secondary alcohols (MiroIsawa et al., 2009).

Chemically, biodiesel is the mixture of fatty acid alkyl esters(FAAEs), most often methyl or ethyl esters (FAMEs and FAEEs, respectively) obtained by the alcoholysis of triacylglycerols (TAGs) from vegetable oil and animal fats, or more precisely alcoholysis, with an alcohol (methanol or ethanol). In the reversible and consecutive alcoholysis reaction, one mole of acylglycerols reacts with one mole of alcohol and one mole of ester is formed at every step in the absence or presence of a catalyst.

The cost and environmental impact of biodiesel production processes is discussed by a few researchers (Kumar et al., 2011; Atadashi et al., 2010 ; Basha et al.,2009 ; Hasheminejad et al., 2011 ; No et al., 2011 ; Helwani et al., 2009 ; Juan et al., 2011 ; Koh et al., 2011; Shahid et al., 2011; Vyas et al., 2010 ; Janaun et al., 2010). A special attention has been paid to biodiesel production from jatropha oil in India, Malaysia and Indonesia (Juan et al., 2011 ; Koh et al., 2011 ; Jain et al., 2010 ; Kumar et al., 2012 ; Silitonga et al., 2011). However, the methods of biodiesel production, the impact of reaction conditions on the overall process rate and the ester yield as well as the optimization, kinetics and improvement of biodiesel production from non-edible oils have not yet attracted the attention they deserve. Two varieties of oils are used in this work, the first type is the waste oils used in frying and the second are olive-pomace oils. Waste oil residue becomes harmful to the environment. To remedy this, recovery becomes a necessity.

2. Experimental

2.1. Materials

2.1.1. Fuels description

Waste vegetable oils collected from fried food companies. Reaction conditions to produce biodiesel were selected from previous kinetic studies (Pinzi et al., 2011; Dorado et al. 2004). Olive pomace oil transesterification was performed in a stirred tank reactor at 60 °C using a solution of 1.2% KOH and 30% methanol (wt reagent/wt

oil), equivalent to 8.6:1 (molar ratio), after 40 min of vigorous stirring. Reaction was then stopped and settled to decant. To remove the alcohol and catalyst residues from biodiesel, the ester phase was washed with the aid of distilled water.

Olive pomace oil methyl ester B₁₀₀ and its blends with diesel fuel, i.e. 20% biodiesel/80% diesel fuel (B₂₀), 50% biodiesel/50% diesel fuel (B₅₀) and 80% biodiesel/20% diesel fuel (B₈₀) blends, were used to carry out performance tests in a diesel engine. Results were compared to those obtained by the use of straight diesel fuel in the same engine.

2.2. Biodiesel fuel properties

For commercial applications in the compression-ignition engines, biodiesel should meet ASTM D6751 standard specification. The key properties of biodiesel were analyzed as per standard methods described in ASTM D613 for cetane number, ASTM D93 for closed-cup flash point, ASTM D445 for kinematic viscosity, ASTM D1480 for relative density, ASTM D664 for acid number, ASTM D2500 for cloud point and ASTM D97 for pour point.

3. Results and Discussion

3.1. Flash point

Flash point is the most important property that must be considered in assessing the overall flammability hazard of a material. At this temperature, vapor stops burning if the source of ignition is removed. Each biodiesel has its own flash point. Many factors affect the change in biodiesel flash point, with residual alcohol content being one of them (Boog et al., 2011).

3.2. Density

The molecular weight of biodiesel is one of the factors that contribute in the increase in biodiesel density (Alptekin et al., 2008). Biodiesel density is measured using the ASTM standard D1298 and EN ISO 3675 test method. According to these standards, density should be tested at 15°C (Masjuki et al., 2010). Table 2 shows that biodiesel density is usually higher than that of ordinary diesel fuel.

Table 1. Olive–pomace oil properties

Property	Olive–pomace oil
Density (15°C) kg/m	904
Kinematic viscosity (4°C) mm ² /s	45.27
Acid value mg KOH/g	0.5
Iodine number g I ₂ /100 g	99.8

Table 2 Characteristics of Diesel fuel

Color	Density at 15 °C kg/m ³	Pour point	Viscosity at 20 °C mm ² /s	Water content	Cetane number	Flash Point ° C
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0.5	827.1	-18	5.12	-	50.95	72
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3.3 Pour point

Biodiesel has higher pour point than conventional diesel fuel (Fernando et al., 2007; anford et al., 2011). Pour point is measured using the ASTM D2500 and D97 test methods, respectively. Table 3 and Table 4 illustrates that methyl esters from Waste vegetable oils is higher than methyl esters from Olive pomace oils.

3.4 Cetane number (CN)

CN is the most important property of fuel that directly affects its combustion quality. Ignition quality of fuel in a power diesel engine is measured by CN. Higher CN implies shorter ignition delay. The CN of pure diesel fuel is lower than that of biodiesel (Pinzi et al. 2009; Krishna et al., 2009). The CN of biodiesel is higher because of its longer fatty acid carbon chains and the presence of saturation in molecules.

Some of the important physico-chemical properties of methyl esters produced from different Olive–pomace oil resources and waste vegetable oils are shown in Table 3 and Table 4.

Table 3. Physico-chemical properties of methyl esters from different Olive–pomace oils.

	B ₅	B ₁₀	B ₁₅	B ₂₀	B ₃₀	B ₅₀	B ₁₀₀
Color	0.5	1	0.5	0.5	1.5	1.5	2
Density at 15 °C kg/m ³	833	834	840.1	842.8	845.2	853	876
Pour point	-22	-21	-17	-15	-13	-10	-7
Viscosity at 20 °C	4.04	4.21	4.63	4.70	5.12	6.43	8.97
Water content	–	–	–	–	–	–	Trace water
Cetane number	50.87	51.23	53.10	52.02	51.68	50.22	41.21
Flash Point °C	69	71	76	82	84	96	143

Table 4. Physico-chemical properties of methyl esters from different Waste vegetable oils

	B ₅	B ₁₀	B ₁₅	B ₂₀	B ₃₀	B ₅₀	B ₁₀₀
Color	0,5	1	1	0,5	1,5	1,5	2
Density at 15 °C kg/m ³	832	835.4	839.7	840.1	843.6	859	893.4
Pour point	-24	-18	-17	-17	-15	-12	-3
Viscosity at 20 °C	4.25	4.34	4.67	4.81	5.61	7.44	10.82
Water content	–	–	–	–	–	–	Trace water
Cetane number	51.68	52.51	54.85	53.10	53.02	49.39	43.21
Flash Point °C	76	79	83	84	85	103	156

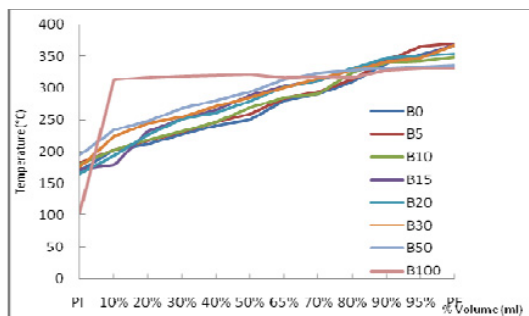


Fig.1 Influence of the percentage of biodiesel fuel on the distillation yield

Fig. 1 shows that there is an increase in biodiesel curves (0% up to 30%) in parallel with the pure diesel depending on the temperature the disappearance of products. However, the biodiesel B₁₀₀ its variation with temperature involves two steps: ♣ 1st step: The changing rapidly boiling temperature of 105 ° C occurred until 313 C. ♣ 2nd step: slow growing 10% to 50% and then decrease or paragraphs 65, 70 and 80% and then a further increase until the disappearance of the produced PF to 331 ° C.

4. Conclusions

Biodiesels parameters are high relative to those of diesel but they are in the standards, if a B_x mixture. The best percentage diesel-is obtained from Waste vegetable oils is B₁₅: 0.8397 kg / l density, 4.67 mm² / s Viscosity, -17 ° C flow point 83 ° C flash point and the cetane number (54.85) higher than that of diesel (50.95). Biodiesel fuel remains a safe, non-toxic, biodegradable and renewable that can be easily used in unmodified diesel engines and in various fuel-based applications.

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