European Association for the Development of Renewable Energies, Environment and Power Quality (EA4EPQ)	International Conference on Renewable Energies and Power Quality (ICREPQ'11) Las Palmas de Gran Canaria (Spain), 13th to 15th April, 2010

Synthesis and characterization of biodiesel obtained from castor oil transesterification

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Abstract. The objectives of this work were to optimize the variables affecting transesterification process for biodiesel production from castor oil, non edible oil, by acid catalysis (sulphuric and phosphoric acid) and basic catalysis (potassium methoxide and potassium hydroxide); and to characterize the biodiesel for its use as fuel in compression ignition motors. The studied operation variables were methanol/oil molar ratio (3:1, 6:1, 9:1, 12:1), temperature (25, 35, 45, 55, 65 °C), and catalyst amount (2, 3, 4 wt.% in acid catalysis, and 0.5, 1.0, 1.5 wt.% in basic catalysis). Evolution of each process was followed by gas chromatography, determining the content of methyl esters at different reaction times. Biodiesel was characterized by a set of parameter according to European Standard, EN 14214. The best conditions for transesterification process were 9:1 methanol/oil molar ratio, 65 °C, and the use of potassium methoxide as catalyst with concentration 1.0 wt.%. In these conditions, obtained biodiesel presents satisfactory values of water content, iodine and saponification values, flash and combustion points, and temperature of 50% of distillate. However, values of density, kinematic viscosity, cetane index and cold filter plugging point, that are heavily dependent on oil, move away from those required by the European Standard.

Key words

Biodiesel, castor oil, non edible oil, potassium methoxide, transesterification.

1. Introduction

Biodiesel is defined by the European Parliament in Directive 2003/30/EC [1] as a "methyl-ester produced from vegetable or animal oil, of diesel quality, to be used as biofuel". Biodiesel is characterized by its biodegradability, nontoxic, renewability, ease of production and agricultural origin [2, 3]. CO_2 emissions of biodiesel combustion can be considered as recyclable by the growing plants, emissions of SO_x, CO, unburnt hydrocarbons, and particulate matter are lower than those of petroleum diesel [4, 5].

Transesterification of vegetable oils and animal fats is the main way to make biodiesel. Transesterification is a three-step reversible reaction of vegetable oils or animal fats with a short-chain alcohol to form fatty acid methyl esters (FAMEs) and glycerol. The presence of a catalyst is needed. Among the alcohols that can be used in the transesterification process are methanol, ethanol, propanol, butanol and amyl alcohol. Methanol is used most frequently because of its low cost and its physical and chemical advantages (polar and shortest chain alcohol). The stoichiometric ratio for transesterification requires three moles of alcohol, however the molar ratio is associated with the type of catalyst used and higher molar ratios result in greater ester conversion in a shorter time [2]. As catalyst can be used basic and acid substances. Basic catalysts lead to higher conversion of methyl esters at low temperature, atmospheric pressure and minimum response time, which reduces the cost of the process considerably. These catalysts are alkaline hydroxides and methoxides, the hydroxides be preferred because they are cheaper [6]. The drawback of these catalysts is that their use is limited compared to raw materials with high content of free fatty acids, they react with the catalyst through the saponification reaction forming soaps. To avoid this fact acid catalysts are useful because prevent the formation of stable emulsions and generate less waste water during the process of removing them [7]. However, unlike the basic catalysts, require greater reaction times, higher values of molar ratio methanol:oil, catalyst concentration and temperature. The most common are sulfuric acid, phosphoric acid and hydrochloric acid [6, 8].

Castor oil, *Ricinus communis L.*, is a member of the tropical spurge family, Euphorbiaceae, and can nowadays be found naturalized and cultivated in all temperate countries of the world. Castor is amongst the plants with the highest oil yield potential because of its high yield of