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Two-step biodiesel production from *Jatropha curcas* crude oil using SiO_2·HF solid catalyst for FFA esterification step

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ABSTRACT

A high quality biodiesel was produced from Mexican *Jatropha curcas* crude oil (JCCO) by a two step catalyzed process. The free fatty acids (FFA) were first esterified with methanol, catalyzed by a solid catalyst: SiO_2 pretreated with HF. The catalyst showed a high number of Lewis acid surface sites, and no CO_2 or H_2O adsorption activity. This catalyst showed a high FFA esterification activity and high stability. After 30 esterification runs, the catalyst activity remained unchanged. During the second step, the triglycerides present in the JCCO were transesterified with methanol catalyzed by NaOH. The chromatographic analysis of the biodiesel obtained, revealed that the process proposed in this investigation led to a very high quality biodiesel, meeting the international requirements for its utilization as a fuel. The combustion gas emissions of the JCCO biodiesel were studied by FTIR spectroscopy using a laboratory combustor. These preliminary results showed low amounts of aromatic and sulfur containing compounds. However, halogenated compounds and dicyclopentadiene were also detected at the combustor exhaust.

1. Introduction

Air pollution is one of the most serious environmental problems all over the world. Continuously increasing use of petroleum will intensify local air pollution and accelerate the global warming problems caused by CO_2. In the recent few decades, many efforts to develop a clean fuel have been undertaken in many countries. Among many possible sources, biodiesel fuel derived from vegetable oil has attracted attention as a promising substitute for conventional diesel fuels [1,2]. Biodiesel can be blended at any level with petroleum diesel to create a biodiesel blend. It can be used in compression–ignition engines with little or without modifications. Biodiesel has suitable viscosity, boiling point, high cetane number [3], it is simple to use, biodegradable, nontoxic and free of sulfur and aromatics [4].

Biodiesel has been produced from a variety of vegetable oil sources such as soybean [5], sunflower [6], cottonseed [7], and rapeseed [8]. However, the use of these edible oils increases substantially the production costs of biodiesel. There are several non-edible oil seed species which could be utilized as a source for oil production. Among these, *Jatropha curcas* is a multipurpose species with considerable potential. *J. curcas* is a drought-resistant tree belonging to the Euphorbiaceae family, native to Mexico. This highly drought-resistant species is adapted to arid and semi-arid conditions. It grows almost anywhere, even on gravelly, sandy and saline soils and is often used for erosion control [9]. The oil from these seeds has low acidity, good oxidation stability, low viscosity and good cold properties [10]. Thus, in this investigation, we studied the biodiesel production using Mexican *J. curcas* crude oil (JCCO).

The most common way to produce biodiesel is by transesterification which refers to a catalyzed chemical reaction involving vegetable oil and an alcohol to yield fatty acid alkyl esters (biodiesel) and glycerol (Fig. 1, Reaction 2). Triglycerides, as the main component of vegetable oil, consist of three long chain fatty acids esterified to a glycerol structure. When triglycerides react with an alcohol (e.g., methanol), the three fatty acid chains are released from the glycerol skeleton and combine with the methanol to yield fatty acid methyl esters (FAME). Glycerol is produced as a by-product.

For biodiesel production, chemically catalyzed processes, including alkali catalyzed and acid catalyzed ones have proved to be more practical than the enzyme catalyzed process [11,12].

An alkali catalyzed process can achieve high purity and yield of biodiesel product in a short time (30–60 min) [11–14]. However, it is very sensitive to the purity of the reactants. Well refined vegetable oils with low amounts of free fatty acids (FFA) can be used as the reactant in this process [15].

The analysis of our non refined JCCO revealed a high free fatty acids content (18.05 wt%). Therefore, for the biodiesel production, an acid catalyzed process would have been preferred, but it would

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