Ain Shams University

Faculty of Science

Biojet Fuel: Production and Characterization using Catalytic cracking of natural oils

A Thesis submitted for
The Award of the Ph.D. Degree of Science in Chemistry

By

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Abstract

In this study, two catalysts which are activated carbon and SO_4^{2-}/CuO-ZnO were prepared from palm leaves and according to the procedure reported in ***[Minli et al., 2012]*** respectively. The prepared two catalysts were characterized using different spectroscopic and surface analysis to determine their chemical and morphological structures. The prepared activated carbon was characterized using FTIR spectroscopy, surface analysis and SEM spectroscopy. While, SO_4^{2-}/CuO-ZnO catalyst was characterized using surface analysis, TEM and SEM spectroscopy, XRD, Raman spectroscopy and TGA analysis.

The prepared activated carbon and SO_4^{2-}/CuO-ZnO were used as heterogeneous catalysts at different ratios in catalytic cracking of castor oil to produce biofuel. The parameters controlling the production of the biofuel were determined and the reaction condition was optimized.

The fuel properties of the produced biofuel were determined including: density, viscosity at 40 ^oC, flash point, cloud point, pour point, cetane number, sulfur content, ash content, and carbon residue. The ASTM distillation of biofuel from catalytic cracking of castor oil in the presence of activated carbon and SO_4^{2-}/CuO-ZnO salts at different ratios used to calculate the cetane number as a property of the biofuels.

The measurements of the reactivity of the used two catalysts were determined by the amount of the distillates that obtained after 1 h of the catalytic cracking reaction.

The chromatographic analyses for both of castor oil and produced biofuel were represented. The reusability of the different catalysts was determined by repeating the cracking reaction using one catalyst sample for several rounds and the properties of the obtained biofuel after each round were determined.

Engine test has been done for the mixture of petroleum diesel/castor oil biofuel using three blends of the obtained biofuels (B10, B20, and B40) from catalytic cracking of castor oil.

Keywords: activated carbon; biofuel; castor oil; catalytic cracking; heterogeneous catalyst; SO_4^{2-}/CuO-ZnO.

Aim of the Work

1. Synthesis of activated carbon and SO_4^{2-}/CuO-ZnO catalysts.
2. Catalytic cracking of the castor oil using the synthesized two catalysts.
3. Determination the suitable conditions to obtain the maximum biofuel product including: time of reaction, temperature and amount of catalyst.
4. Determination the properties of the produced biofuel according to density, viscosity, flash point, cloud point, pour point, cetane number, sulfur content, ash content, and carbon residue.

I. INTRODUCTION

In recent years, many researchers are concentrating on developing biofuels from alternative and renewable sources to replace commercial petroleum products. The suitable properties of plant oils and animal fats (renewable and low sulfur, nitrogen and heavy metal content), which are made up of triglycerides with long chained fatty acid groups 16 to 24 carbon atoms in length, makes them ideal sources for the production of synthetic fuels and useful chemicals. At present, the most successful class of biofuels is biodiesel, which is produced from plant oils or animals fats by a liquid-phase catalyzed transesterification process at low temperature or a solid catalyzed catalytic cracking process at high temperature. However, the process requires large investments for the production units in order to ensure high efficiency. Also biodiesel product is not stable compared with the petroleum fuel because of its low oxidation stability and poor cold flow properties. Recently, an alternative method of converting plant oils and animal fats into biofuel products has been studied by using a catalytic hydrotreating process similar to what is found in the oil and gas industry. Two important chemical steps occur during the conversion of oils into biofuel products: oxygen removal (hydrodeoxygenation, hydrodecarbonylation, and hydrodecarboxylation) and hydrocracking. Both of these chemical processes are included in a larger group of processes generally referred to as hydroprocessing. During the process, a dual function catalyst composed of a metallic part and amorphous mixed oxides of acidic nature or proton exchanged crystalline zeolites is required, where metallic sites are required for hydrogenation and dehydrogenation reactions and the acid sites are necessary for isomerization and cracking activities. Therefore, it is very important to design the acidic sites and metal components as well as tailor the balance between the metal and acid for the product selectivity, catalyst activity and stability.

At present, two types of catalysts have been reported as effective hydrotreating catalysts in converting vegetable oils to biofuels, especially green diesel: supported noble metal catalysts (Pd and Pt) and sulfided bimetallic catalysts (usually Mo- or W-based sulfides promoted with Ni or Co). However, there are disadvantages of using these catalysts. On one hand, the rarity and high price of noble metal catalysts has made the process economically unfeasible. Furthermore, since noble metal catalysts are very sensitive to catalyst poisons, impurities (such as sulfur, heavy metals and oxygenated compounds) in feedstock can cause significant deactivation of the catalysts. Therefore, it is necessary to remove impurities from the biomass feedstock before the reaction. On the other hand, conventional γ-Al2O3 supported sulfide bimetallic catalysts (usually Mo or W based sulfides promoted with Ni or Co) as presently used for desulphurization of