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Efficient production and optimization of biodiesel from kapok (*Ceiba pentandra*) oil by lipase transesterification process: Addressing positive environmental impact

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ABSTRACT

Ceiba pentandra, non-edible oil (acid value of 21 mg KOH/g estimated using ASTM D664 methodology) is employed as a source for producing biodiesel using lipase immobilized on mesoporous material as a catalyst. Optimum conditions for maximum yield (96.4%) were the temperature of 33 °C, methanol to oil molar ratio of about 13.3:1 with a water content of 14.5%. From the reusability studies, it can be observed that greater than 85% conversion could be obtained up to 10 cycles, thereby proving the significant efficacy of the catalyst. Density, flash point, cloud point, calorific value, and cetane number of the produced biodiesels were 885 kg/m^3, 152 °C, −3 °C, 38.44 kJ/kg and 57.2, respectively meeting the ASTM standards specified for biodiesel. The performance and emissions characteristics of 20% biodiesel (CIB20) and petroleum diesel were studied in a VCR under varying speeds in a full load condition. Blended biofuel showed a 13% lower mean brake power (BP) and 25% higher mean specific fuel consumption (SFC) compared to diesel fuel. Though NO_x emission of the blended diesel was 31% higher than that of petroleum diesel, Hydrocarbon, CO_2, and CO emissions were 8.4%, 13.7%, and 5.08% lower than that of diesel fuel, respectively.

1. Introduction

The world's dependency on non-renewable fossil fuels is increasing annually for the rapidly growing industries, causing a hike in crude oil prices every single day [1] To limit the uncertainties existing, scientists realized that raw materials from biological sources can be a substitute to produce renewable fuels. Nowadays the production of biodiesel is gaining immense attention and various reports suggest its superiority as an alternative over conventional petrochemical-based fuels [2].

Biodiesel, irrespective of using it alone or blended with diesel offers many advantages related to the properties such as high cetane number, low viscosity, high lubricity, high flash point. Biodiesel can also be termed environmental friendly because of lower toxic gas emissions compared to conventional fossil fuels, thereby play a very important role in reducing air pollution [3]. The biodiesel properties are dictated by feedstock, catalyst as well as the alcohol used, it can be substituted for traditional diesel fuel provided, the standard specifications are satisfied. Certain reports suggested that biodiesel reduces carbon emissions by 78%. Generally, the production of biodiesel is carried out by transesterification using oils, animal fats, and alcohols in the presence of a catalyst [4]. Soya bean, coconut, olive, palm, sunflower, canola, and castor oil are the most commonly used edible sources. Biodiesel production from non-edible sources is getting progressive because the utilization of edible sources might have consequences related to mankind [5]. Kapok oil (*Ceiba pentandra*), a non-edible feedstock considered a better source because of abundant availability and high oil yield among other non-edible feedstock. Cultivated fruit and seeds yield about 1280 kg/ha/y of oil, which is higher for biodiesel production [6,7]. Kapok (*Ceiba pentandra)* belongs to the order Malvales of the family Malvaceae, found in the southern parts of Asia like India, Indonesia, Central America, Mexico, South America, and Central Africa. A tree may produce fruits around 500 to 4000, each fruit possessing 200 seeds.

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