PhD Thesis-Balajii M

BIODIESEL PRODUCTION FROM CEIBA PENTANDRA OIL USING BIOMASS DERIVED HETEROGENEOUS CATALYST

Biodiesel, an oxygenated renewable fuel, significantly reduces the dependence on conventional fuels and reduces global warming to a greater extent by limiting the emission of harmful gases. The foremost parameters that affect the commercialization of biodiesel are type of raw material, lipid content, round-the-year availability, and harvesting amount per period. Therefore, the choice of lipid source for biodiesel production plays a crucial role in the process economics. Ceiba pentandra (Kapok, or Silk cotton) is a buttressed tree that has large spines in its cylindrical trunk. The fruit of Kapok, which exists in a pendulous form, has several brown seeds embedded in silky hairs. Seeds are often disposed of as waste agro-biomass residues in kapok fiber processing units and contain 25–28% oil, are cheap,easily available, and could be a potential source of biodiesel production .In 2020, around 279775 tonnes of Kapok fruit were produced worldwide . The high oil content and availability at less cost make C. pentandra a viable low-cost lipid feedstock for utilization in biodiesel production. Biodiesel can generally be produced in four ways: (i) direct use or blending with diesel fuel, (ii) pyrolysis, (iii) microemulsion, and (iv)transesterification technique .The most common technique, transesterification, involves a series of chemical reaction between alcohol especially methanol, and various types of lipid feedstocks with appropriate catalyst . However, in non-edible oils, high free fatty acid (FFA) content is unfavorable as it prompts soap formation while performing base-catalyzed transesterification . This can be eliminated by adopting an acid-catalyzed esterification process. Hence, the two-stage esterification-transesterification process was considered for non-edible oil based biodiesel synthesis and the process was strongly influenced by the catalyst loading, ratio of reactants, reaction temperature, and time.The solid heterogeneous catalyst derived from agricultural residues has shown enormous potential in biodiesel production because of its higher catalytic activity and greater availability. In addition, it is associated with the lowest catalyst cost due to its reusability, lack of wastewater discharge, low corrosion, and simplified cleaning procedures .A robust mathematical tool that enables complex process modeling is response surface methodology (RSM). The model depicts the functional relationships between multiple input variables and responses by utilizing experimental data. In addition, it significantly lowers experimental runs since the necessity to perform one factor at a time (OFAT) is eliminated. To improve the contact area between the two immiscible phases (alcohol and oil), vigorous mixing is required . The incorporation of ultrasonic technology into the production of biodiesel improved the yield and reduced the conversion time, intensified turbulence ,as a result, provided an excellent mixing of two immiscible liquids by increasing surface area. Furthermore, it is energy-efficient and technically feasible to synthesize biodiesel. In this study, the three banana peduncles namely 1) Musa spp"Pisang Awak", 2) Musa acuminata Colla "Red" and 3) Musa spp Nendran accumulated as waste in the local markets have been effectively exploited for the production of an eco-friendly, renewable heterogeneous base catalyst in C. pentandra methyl ester (CPME) synthesis using C. pentandra oil (CPO).The calcination of peduncles at higher temperatures was carried out to synthesize the low-cost catalyst and followed by characterization using Fourier Transform Infrared (FTIR) spectroscopy, X-ray Diffraction (XRD),Brunauer-Emmett-Teller (BET) analysis, Field Emission Scanning Electron Microscopy (FESEM) and Energy Dispersive X-ray (EDX) spectroscopy. Two-stage CPME production was carried out under the influence of conventional stirring and ultrasound. In the current research, the impact of esterification and transesterification process parameters such as catalyst concentration, reactants ratio, and reaction time were examined using RSM-based

CCD to enhance the conversion of CPO to CPME. In addition, the stability of the catalysts for commercial effectiveness was tested by performing reusability studies with synthesized catalysts. In addition, the fuel characteristics of synthesized CPME were evaluated.