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Original Research Article

Optimization of Biodiesel Production from Seeds of Cotton and Calabash Via In Situ Transesterification using CaO as Catalyst

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ABSTRACT

Utilization of fossil fuels results to toxic emissions that adversely affect the environment. In order to arrest this challenge it is pertinent to rely more on cleaner fuels. This study evaluates the potential of producing clean and affordable fuel, biodiesel, in line with United Nations Seventh Sustainable Development Goal. Cotton and calabash seeds were used to produce biodiesel in this study. The seeds were mixed at different ratios and the catalyst concentration was controlled at 1% for two hours under a temperature of 60°C. About 70% of the cost of producing biodiesel rests on feedstock alone. To reduce cost, cheap and underutilized seeds were chosen for this study. In addition, the biodiesel was produced via a technique, in situ transesterification, which lowers production cost. In this process the oil from the seeds were extracted and converted to biodiesel in a single step. The highest yield of 61.33% was obtained at a ratio 1:5 of the cotton to calabash seeds respectively. The physicochemical parameters analysed for are: saponification value (210.38 mg KOH/g); iodine value (59.14 mgI_2/100g); acid value (1.68 mg/g); free fatty acid (0.84); cetane number (58.93); ester value (208.7); high heating value (39.91 MJ/kJ) and specific gravity (0.87). The results of the properties were compared with standards and this shows that the biodiesel produced has very good properties.

Keywords: biodiesel, in situ transesterification, underutilized seeds, physichochemical analysis: iodine value, cetane number.

Introduction

Transportation of goods and services influences the world's economy and transportation relies mostly on energy from petroleum fuels.[1] The 1970s oil crisis gave rise to the search for clean and sustainable fuels that are better than fossil fuels.[2] Continuous utilization of fossil fuels leads to toxic emissions.[3] The burning of fossil fuels releases carbon dioxide which influences the increase in the heat concentration on the earth.[4] In Nigeria, depletion of fossil fuels, environmental concerns and ever-changing prices has necessitated the search for alternative by researchers.[5] One of such alternatives is biodiesel.

Biodiesel is an alkyl ester of long chain fatty acid that is usually obtained from alkyl glycerides of animal fats and vegetable oils.[6] The worldwide concern about air pollution from combustion engines has led to the search for oxygenated fuels like biodiesel which can replace petro-diesel.[7] Biodiesel can be used in diesel engines without changes and is considered to be sulphur-free, less toxic, biodegradable, oxygenated and environmentally friendly.[8] Biodiesel has no aromatic compounds, about 10-11% of biodiesel is oxygen and it has lower emissions of hydrocarbons, carbon monoxide and carbon dioxide.[9] Biodiesel can be used in diesel engines without modification and conventional diesel is miscible with biodiesel. Usually, BX is used to represent biodiesel blended with diesel where X is the percentage of biodiesel. For example, B20 contains 20% biodiesel and 80% diesel.[10]

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In transesterification, the molecules of the triglycerides are broken down by alcohol in the presence of a catalyst to yield biodiesel (alkyl esters) and glycerol which is the by-product.[11] The transesterification reaction, the chemical structure of the triglycerides in the oil is broken down by exchanging alkyl groups between the alcohol and the triglyceride.[12] In situ transesterification involves the extraction of the oil from the seed and its conversion to biodiesel in a single step.[13] Almost every oil-bearing material can be subjected to in situ transesterification.[14] Extraction and transesterification are done simultaneously in situ transesterification.[15] In situ transesterification reduces cost and it is time effective.[16] Heterogeneous catalysts are more advantageous than homogeneous catalysts due to their simple separation process, great catalytic activity, environmentally benign, reusability of catalyst, fewer washing steps, less toxicity and less cost.[17] Calcium oxide is an encouraging heterogeneous basic catalyst that is renewable, cheap, and easily available.[18]

Cotton belongs to the *Malvaceae* family and it is used to weave garments.[19] Cotton seed oil has 55.2-55.5% of linoleic acid, 19.2-23.6% of oleic acid and 11.67-20.1% of palmitic acid.[20] Calabash is amongst the crops cultivated in north-western Nigeria with no large-scale application and it has a short maturity time of 3-4 months that produces about 50% inedible oil.[21] According to Ibrahim *et al.*[22] calabash seeds have 59.98% of saturated ester and 40.02% of unsaturated ester. This work presents a study on the optimal production of biodiesel from a mixture of underutilized seeds. The idea is to check for the potential of producing biodiesel that will replace conventional diesel. Cost-effective methods and processes were employed in this study to complement the seventh Sustainable Development Goal "clean and affordable energy".

Materials and Methods

Sampling

Cotton and calabash seeds were purchased in March 2019 from markets in Kaduna State, Nigeria. The cotton seeds were identified by U.S. Gallah of the Kaduna State University as *Gossypium hirsutum*