Hindawi
Journal of Chemistry
Volume 2017, Article ID 1489218, 20 pages
https://doi.org/10.1155/2017/1489218

Research Article

Active Razor Shell CaO Catalyst Synthesis for Jatropha Methyl Ester Production via Optimized Two-Step Transesterification

A. N. R. Reddy,[1] A. A. Saleh,[1] M. S. Islam,[2] and S. Hamdan[1]

[1] *Department of Mechanical and Manufacturing Engineering, Faculty of Engineering, Universiti Malaysia Sarawak, 94300 Kota Samarahan, Sarawak, Malaysia*
[2] *Department of Chemistry, Bangladesh Army University of Engineering & Technology, Qadirabad Cantonment, Natore 6431, Bangladesh*

Correspondence should be addressed to A. N. R. Reddy; amarnadha@gmail.com

Received 26 December 2016; Revised 23 February 2017; Accepted 7 March 2017; Published 12 April 2017

Academic Editor: Arghya Narayan Banerjee

Calcium based catalysts have been studied as promising heterogeneous catalysts for production of methyl esters via transesterification; however a few were explored on catalyst synthesis with high surface area, less particle size, and Ca leaching analysis. In this work, an active Razor shell CaO with crystalline size of 87.2 nm, S_{BET} of 92.63 m^2/g, pore diameters of 37.311 nm, and pore volume of 0.613 cc/g was synthesized by a green technique "calcination-hydro aeration-dehydration." Spectrographic techniques TGA/DTA, FTIR, SEM, XRD, BET&BJH, and PSA were employed for characterization and surface morphology of CaO. Two-step transesterification of *Jatropha curcas* oil was performed to evaluate CaO catalytic activity. A five-factor-five-level, two-block, half factorial, central composite design based response surface method was employed for experimental analysis and optimization of Jatropha methyl ester (JME) yield. The regression model adequacy ascertained thru coefficient of determination (R^2: 95.81%). A JME yield of 98.80% was noted at C (3.10 wt.%), M (54.24 mol./mol.%), T (127.87 min), H (51.31°C), and R (612 rpm). The amount of Ca leached to JME during 1st and 4th reuse cycles was 1.43 ppm ± 0.11 and 4.25 ppm ± 0.21, respectively. Higher leaching of Ca, 6.67 ppm ± 1.09, was found from the 5th reuse cycle due to higher dispersion of Ca^{2+}; consequently JME yield reduces to 76.40%. The JME fuel properties were studied according to biodiesel standards EN 14214 and comply to use as green biodiesel.

1. Introduction

The sustainability "strengthening the mechanisms for redistribution from the present to the future" has become a motto of all nations around the world, for promoting intrinsic scientific research methodologies into agriculture, materials, energy, economy, and even urban planning [1]. Despite multiphase research in energy, rising global warming and air pollution issues instigated by fossil fuel combustion besides limited petroleum fuel reserves have led to research for sustainable renewable energy sources. Fatty acid methyl ester (FAME), commercially known as biodiesels, introduced in the 1980s as a sustainable fuel energy resource for reducing greenhouse emissions [2]. FAME comprises monoalkyl ester of long fatty acids, typically produced by the transesterification of biologically produced feedstocks such as vegetable oil (VO), animal fats, and microalgae oils in the presence of methyl alcohol (MeOH) and a suitable catalyst [3, 4]. Transesterification reaction is a combination of three sequential catalyzed reactions (1)–(3) in which triglycerides (TG) of a VO were transformed to diglycerides (DG) and monoglyceride (MG) and finally as glycerol and methyl ester (ME) known as biodiesel [5]. *Jatropha curcas* Linnaeus, an euphorbia family member, has attained the researcher's attention as one of the best suited nonedible VO feedstock types due to its agromedical tangible interests as well as pro human food cycle nature, for biodiesel fuel (BF) production via transesterification [4]. Acid or base catalyzed transesterification of VO was largely reported in literature and also concluded on the use of heterogeneous catalysts for sustainable BF production [6, 7].

$$\text{TG} + \text{MeoH} \xleftrightarrow{\text{Catalyst}} \text{DG} + \text{ME} \quad (1)$$

$$\text{DG} + \text{MeoH} \xleftrightarrow{\text{Catalyst}} \text{MG} + \text{ME} \quad (2)$$