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Progresses in Waste Biomass derived Catalyst for Production of Biodiesel and Bioethanol: A Review

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Abstract

Due to the growing awareness regarding depletion of fossil fuels and increase in harmful emissions, efforts are being made to develop renewable green fuels viz. biodiesel and bioethanol from different waste/ natural resources. This article enunciates that biomass derived catalysts has created a new essence in the field of biofuel production. As revealed from published literature, yield of biodiesel and bioethanol had been appreciable through application of the waste derived solid green catalysts. The environmentally benign catalysts demonstrate immense regeneration attributes coupled with superior catalytic properties. Thus, utilization of bio-waste for development of such promising heterogeneous green catalyst(s) or catalyst support(s) can substantially mitigate the problem of solid waste disposal and facilitate reduction of environmental pollution. This review article is based on critical assessments of different biomass supported catalysts in terms of their efficacy in biofuel synthesis from various biomass feedstocks under varying process conditions.

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Keywords: Bioethanol; biodiesel; waste biomass; heterogeneous catalyst;

1.0 Introduction

Due to the eve-rising concern regarding harmful emanations of petro-diesel engines, contemporary world demands the production of biofuel through sustainable and economic pathways. The most commonly used biofuels are bioethanol and biodiesel which are produced through different protocols meeting international standard specifications (Zhu et al., 2010). Thus, these biofuels serve as an important substitute to petro-diesel resulting low harmful emissions coupled with better engine performance and fuel quality (Huang et al., 2010). Over the past

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decade, biofuels were generally produced from various waste resources viz., biomass, waste cooking oil, animal fats, plant seeds etc. However, production of the biofuels meets several challenges. Biofuel such as bioethanol was produced via enzymatic and catalytic (homogeneous and heterogeneous) hydrolysis of lignocellulosic resources; whereas, transesterification of triglycerides generates biodiesel usually in presence of cost intensive homogeneous and heterogeneous catalysts (Serrano-Ruiz et al., 2012). Due to major short falls regarding usage of homogeneous catalyst, researchers were focusing on application of heterogeneous catalysts for biofuel production. However, these heterogeneous acid or basic catalysts were normally derived from expensive chemical reagents which finally pulled-up the overall production costs. Presently, efforts were made by various researchers regarding utilization of biomass as their support materials for fabrication of cost-effective and proficient catalysts for biofuel production. Thus, the present review article emphasizes on the application of different biomass derived catalyst in biofuel production.

2.0 Waste Biomass derived Solid Catalyst for Biodiesel Production

Several scientific literatures are available demonstrating utilization of wastes viz., animal fat, waste cooking oil, plant seeds etc. for production of biodiesel. However, waste biomass derived catalyst was of little interest for the researchers compared to its utilization as a feedstock for fuel production. Thus, the present work enumerates the application of waste biomass derived catalyst / catalyst support in generation of biodiesel production.

2.1 Solid Base Catalyst

Previously, Wei et al. (2009) stated the use of eggshell, a biowaste as a rich source of CaO solid catalyst for biodiesel production. This catalyst not only showed its efficiency in transesterification of triglyceride but also its eco-friendly recycling property significantly reducing environmental pollutions and diminishing the overall production cost of biodiesel. Furthermore, a pioneering work in the field of waste utilization for development of efficient catalyst carried by Chakraborty et al. (2011) attracted many researchers in application of similar waste biomass resources either as a catalyst or catalyst support. The work was focused on the development of calcined waste fish scale as a heterogeneous catalyst in production of biodiesel from refined soybean oil. The catalyst sustained for six experimental runs (each 5h batch time) retaining more or less similar catalytic activity generating 97.73% FAME yield at optimum reaction conditions. This reveals excellent stability and recyclability of the developed catalyst. It was also observed that the major active phase viz., β-$Ca_3(PO_4)_2$ contributed to the high FAME yield.

Another competent calcium based solid catalyst was developed by Viriya-empikul et al. (2012) via application of shells of egg, golden apple snail, and meretrix venus for biodiesel production. The major constituent of the catalyst was $CaCO_3$ which contributed CaO as the active catalytic phase. Table 1 enumerates a comparison between the three naturally derived catalysts. It has been observed that maximum yield of FAME from palm olein oil was achieved using egg shell waste due to presence of strong base sites. However, this catalyst consumed high methanol to oil ratio (12:1) due to relatively much lower BET area (Table 1) and lower recyclability compared to the waste fish scale derived base catalyst with much higher BET area 35 m^2/g (Chakraborty et al., 2011).

Table 1: Physicochemical properties and catalytic activity of waste shell-derived catalysts calcined at 800°C for 4 h (Viriya-empikul et al. 2012)

Catalyst Source	BET Surface Area (m^2/g)	% Ca	Total Basic Site (µmol/g)	% FAME in 1h
Meretrix-Venus shell	0.9	98.6	157	74.0
Golden apple snail shell	0.9	99.0	187	85.5
Egg shell	1	99.2	194	93.1

Other calcium based catalyst has been enunciated with the help of radar plot (Figure 1) and it has been observed that amongst the all naturally derived CaO catalyst from animal shells, chicken eggshell waste exhibited promising result in terms of FAME yield around 100% (Navajas et al., 2013). This can be accredited to the larger surface area of chicken eggshell compared to the catalyst derived from other animal shells.