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Clean Energy hydrogen production by steam reforming of biodiesel By-product using Nickel-based catalysts with different supports

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Abstract:

Rising prices of petroleum fuel and environmental issues turns researcher's attraction towards production of new renewable fuel sources. Biodiesel can be most prominent solution. Production of biodiesel via transesterification of vegetable oil produces glycerol as major by-product. Glycerol can be utilized for clean energy carrier: hydrogen production via steam reforming. This study focuses production of hydrogen in fixed bed reactor utilizing nickel based catalyst supported by MgO, Al_2O_3, SiO_2 with 1:9 feed ratio of glycerol to water varying temperature range in between 550 °C to 800 °C. 15wt % Ni loaded on Al_2O_3 at 800 °C shows highest hydrogen yield and almost completes glycerol conversion. It was found that activity of supported nickel catalyst as follows: Al_2O_3> MgO> SiO_2. X-Ray powder Diffraction (XRD) and Thermal Gravimetric Analysis (TGA) was used for characterization of catalysts.

Keywords

Biodiesel, Glycerol, Hydrogen, Nickel, Steam Reforming

1. Introduction

In 21st century to overcome from addiction of fossil fuels is major issue. Biodiesel can be solution because it possess environmental favorable characteristic, which produced by transesterification of vegetable oil in which 10wt% of glycerol produced as major by-product. Due to hike demand of a biodiesel, glycerol stock increases which leads to environmental issues. Reducing glycerol into useful chemical compounds is favorable [1]. Many researcher pays their attention to solve this problem. Conversion of glycerol into hydrogen is most interesting way of reduction of glut stock [2-3]. Various water reforming processes [4] used for conversion of glycerol to hydrogen. Amongst all steam reforming process is more benign over supercritical and liquid water reforming processes [5] which provide 7 hydrogen moles using single glycerol mole, however in practice 5.7 to 6 moles of hydrogen can be produced.

2. Steam reforming of glycerol is largely endothermic and favors atmospheric pressure. The major reaction pictured as follows [6]:

3. $C_3H_8O_3+3H_2O \rightleftharpoons 3CO_2+7H_2$, ($\Delta H^0$=128KJ/mol)

Table 1. Method used in production of hydrogen from glycerol

Sr. No.	Various Method Used in Hydrogen Production from Glycerol	
	Method	***Energy Requirements***
1	Liquid phase reforming	High pressure, T< 400 °C [7]
2	Steam Reforming	Atmospheric pressure, T> 450 °C [8-9]
3	Partial oxidation gasification	Highly endothermic, T> 900°C [10]
4	Supercritical water reforming	P>Atmospheric pressure, T>384°C [11]
5	Auto thermal reforming	540^0C < T <1000°C [12]

Several studies have been done using nickel catalyst in alcohol steam reforming with magnesium, cerium, and lanthanum as promoter [13]. By analyzing the action of impetus metals loaded on oxides (ZrO_2, La_2O_3, CeO_2, Y_2O_3, SiO_2, Al_2O_3, MgO), the lineup of catalyst Ru > Ni > Co > Pd was best supported on La_2O_3. Amongst all 3wt. %Rh/Y_2O_3 was found more