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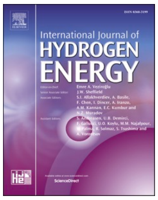

Enhanced hydrogen generation from biodiesel-waste glycerol using Ni/SBA-15 catalyst synthesized from boiler ash

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ABSTRACT

The successful synthesis of the mesostructured SBA-15 derived from extracted boiler ash silica (BA) with distinct Ni loading (15 wt%, 20 wt%, and 25 wt%) towards H_2 production from CO_2 and $C_3H_8O_3$ was explored. The catalysts prepared by the ultrasonic-assisted method were subjected to 8 h of GDR at 800 °C. The XRD and N_2 sorption revealed reduced area and crystallinity in 25 wt% Ni versus 15 wt% Ni catalyst. 20 Ni/SBA-15(BA) exhibited a larger area (234 m^2/g), aperture (8.99 nm), and small NiO crystallite (18.34 nm), implying well-dispersed Ni species on SBA-15(BA) surface. 20 Ni/SBA-15(BA) displayed the highest GDR catalytic activity (57 %), credited to its accessible structure, strong Ni–O–Si bonding, and good Ni dispersion that reduced coke formation (9.8 % carbon). This discovery highlights the excellent performance of 20 wt% of Ni loaded on SBA-15 by using green silica source extracted from waste material for H_2 fuel production.

1. Introduction

The exploitation of fossil fuels has been boosted significantly in recent years, causing extensive environmental problems due to the climate change crisis and the greenhouse effect. This has spotlighted the urgent need for alternate, renewable, and clean energy supplies. Due to the finite reserves and environmental concerns associated with fossil fuels, scientists have been researching this topic for decades, in searching for alternative energy sources, the focus is on identifying a solution that can successfully handle environmental issues, reduce harm, be renewable, and operate at a reasonable cost [1,2]. Hydrogen (H_2) has recently emerged as a possible replacement for depleting fossil fuels. It has numerous advantages, including great cleanliness, high energy density that is suitable for propelling spacecraft and rockets by NASA, and the possibility of high energy conversion efficiency [3]. One of the significant advantages of H_2 is that its combustion does not produce hazardous substances, such as carbon monoxide, nitrogen oxides, and sulfur dioxide with zero carbon emissions, except water vapor. The estimated global H_2 output is 7.7 EJ/year, projected to increase to 10 EJ/year by 2050, followed by an annual demand increase of about 5%–10 % [4]. By 2050, H_2 is expected to meet 18 % capacity of Global Energy Demand (GED) requirements. Most of the H_2 used in industrial applications is generated through the electrolysis of water, gasification of coal, and reforming of fossil fuels [3]. However, there is a growing interest in producing H_2 energy from sustainable biomass sources, like ethanol, methanol, biogas, and glycerol [5]. This is a crucial effort toward reducing the negative environmental impact of fossil fuels and enhancing the sustainability of H_2.

Glycerol, produced as a co-product of biodiesel manufacturing, has been recognized as a promising feedstock in producing clean H_2. Biodiesel has been commercially produced in many countries, such as India, the United States, Malaysia, Turkey, China, and many more for over the last 20 years, and its consumption is likely to expand due to its renewable nature with a significant lessening in CO_2 radiation as contrasted to coal-based fuels [6]. The demand for biodiesel production has caused an increase in glycerol production as 1.05 pounds of glycerol is formed for every gallon of biodiesel produced. However, the proliferation of

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