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Hydrogen production via glycerol dry reforming over fibrous Ni/KCC-1

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ABSTRACT

The research intended to evaluate the catalytic activity of Ni-doped on KCC-1 to produce hydrogen thru the reforming process of glycerol and CO_2 (GDR). A hydrothermal microemulsion approach was applied to synthesize mesoporous silica KCC-1, which was then impregnated with 10 wt% Ni using an ultrasonic-assisted impregnation technique. XRD, BET, and FTIR were used to analyze the physicochemical characteristics of KCC-1 and Ni loaded on KCC-1. A stainless-steel vertical reactor fixed with a catalyst bed inside was used to run the GDR process at 800 °C, $P_{atm,}$ and a 1:1 ratio of glycerol to CO_2. KCC-1 exposed sphere fibrous feature bordered with dendritic fibre observed by TEM with a 268 m^2/g in specific surface area and 200–400 nm in particle size. The Ni/KCC-1 catalyst achieved 45.25 %, 33.71 %, and 65.64 % glycerol conversion and syngas (H_2 and CO) yields, respectively. The high catalytic performance was credited to the fibre-like structure of KCC-1, which facilitates the access of bulky mass glycerol and CO_2 to the Ni active species. Thus, this finding has proven that the exceptional structure of the support material could promise catalytic performance in various applications, particularly glycerol dry reforming.

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1. Introduction

Fossil fuels, which make up more than 80% of all energy consumption, for instance, natural gas, coal, and petroleum are currently used to supply most of the earth's energy demands [1]. However, the rising costs of fossil fuel processing, socioeconomic effects of global warming brought on by CO_2 accumulation, and environmental consequences have increased efforts toward research, development, and market use of energy technologies and renewable fuels. Biodiesel is gaining popularity among renewable fuels because of its environmental benefits, such as low CO_2 emissions as contrasted to existing diesel fuels [1]. In addition, it can be easily generated from low-cost, readily available feedstocks, increasing the economic value of biodiesel [2]. Biodiesel is produced by transesterifying agricultural oils, animal fats, and recycled cooking oil with ethanol or methanol [3]. The fast advancement of biodiesel production technology has resulted in the generation of vast amounts of glycerol by-product, statically at 1.05 lb per one gallon of biodiesel produced [4]. Glycerol production was driven in response to rising biodiesel demand. This surplus has resulted in an overstock dilemma, which has hampered the growth of the biodiesel business, especially in terms of economic sustainability [5]. Exploiting glycerol as a feedstock for syngas will aid in lowering the cost of refining in biodiesel synthesis and can resolve environmental issues.

In recent years, additional ways were reported to utilize glycerol in the creation of syngas (H_2 and CO) via various reforming synthesis routes, such as aqueous phase [6], autothermal [7], dry [8], partial oxidation [9] and steam [10]. Among those routes, the CO_2 reforming route became a favorable choice for glycerol valorization because this route utilizes GHGs (CO_2) and glycerol waste as reactants, reducing severe economic and environmental issues. The presence of carbon in reforming reactions can poison the catalyst's active metal sites. However, carbon production can be minimized by using an appropriate catalyst in glycerol dry reforming (GDR) [11].

Mesoporous silica, such as mesoporous fibrous nano-silica (KCC-1), has attracted interest among researchers due to its unique features. KCC-1 had a distinctive spherical morphology surrounded

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