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Enhanced glycerol dry reforming over Ni/SBA-15 synthesized from palm oil ash: Effect of GHSV

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ABSTRACT

The current research investigated the effect of gas hourly space velocity toward the GDR reaction using Ni/ SBA-15 catalyst derived from palm oil ash (P). The SBA-15(P) was prepared by hydrothermal technique and loaded with 3 % Ni via ultrasonic-assisted impregnation technique. The physio-chemical features of the unloaded and loaded Ni on the SBA-15(P) were characterized via BET, FTIR, XRD, H_2 TPR, and TEM. In a vertical reactor made up of stainless steel operating at 800 °C, 1 atm, with various gas hourly space velocities (18000, 24000, 30000, and 36000 mL/g-1 s^{-1}), the catalytic performance of the Ni/SBA-15(P) was investigated. The exceptional inclusion of active Ni particles with the SBA-15(P) support and strong Ni-O-Si interaction were demonstrated by FTIR, H_2 TPR, and TEM, respectively. The highest catalytic activity (glycerol conversion = 43.24 %, H_2 yield = 30.60 % and CO yield = 59.76 %) of Ni/SBA-15(P) was achieved at 24000 mL/$g^{-1}s^{-1}$. The higher the GHSV (30000 and 36000 mL/$g^{-1}s^{-1}$), the lower the syngas yield (H_2 and CO) and glycerol conversion due to the less CO_2 and glycerol molecules adsorbed on the active centers of the Ni/SBA-15(P) catalyst. Moreover, shorter contact time interaction between reactant molecules and the active site would build up the pressure inside the reactor system and favor carbon plugging during the catalytic process. Meanwhile, Ni loaded on SBA-15(P) at lower GHSV (20000 mL/$g^{-1}s^{-1}$) was low catalytic activity due to the limitation of existing molecules interacting with catalyst active sites. At lower GHSV (20000 mL/$g^{-1}s^{-1}$), Ni/SBA-15(P) exhibited poor catalytic performance because of the limited ability of molecules to interact with the catalyst active sites.

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1. Introduction

Numerous problems have arisen because of the prolonged and extensive dependency on fossil fuels as the top energy supply, including rising greenhouse gas (GHG) releases and the decline of petroleum-based power. Syngas (H_2 and CO) have been acknowledged as a viable and effective alternative source of energy to minimize the world's reliance on crude oil. Nowadays, the most common and cost-effective processes for producing syngas are steam reforming, partial oxidation of CH_4 and C_3H_8, and glycerol dry reforming [1,2]. Among these routes, CO_2 reforming of glycerol has drawn extensive interest among researchers because it provides a better approach for syngas production by utilizing waste material from the biodiesel process (glycerol) and converting unwanted CO_2 (GHG) into valuable synthesis gas [3–6]. Moreover, this reaction generates a high yield of H_2 and can be carried out at 1 atm. The overall reaction process of GDR is represented by Eq. (1). This endothermic reaction needed a process temperature > 500 °C to achieve a thermodynamically favorable outcome (H_2 and CO formation). During the decomposition of glycerol, many intermediate chemical compounds such as alkanes, acetone, acetaldehyde, acetic acid, acrolein, ethylene, and alcohol may be generated.

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