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Synthesis and characterisation of cement clinker-supported nickel catalyst for glycerol dry reforming

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Abstract

Glycerol dry reforming was performed in a packed-bed reactor containing 20 wt.% nickel catalyst employing CO_2-to-$C_3H_8O_3$ feed ratios of 0.6 ≤ CGR ≤ 5.0 and reaction temperatures between 923 and 1023 K for syngas (H_2 and CO) production studies. Liquid N_2 physisorption revealed a significant 32-fold increase in the Brunauer–Emmett–Teller (BET) specific surface area upon the incorporation of nickel metal onto the cement clinker support, which was also corroborated by field emission scanning electron microscopy (FESEM). In addition, NH_3- and CO_2-temperature programmed desorption (TPD) analyses exhibited the presence of a strong pair of acid (1061.4 μmol g_{cat}^{-1}) and basic (1.53 ×10^4 μmol g_{cat}^{-1}) sites on the catalyst. A bunsenite (NiO) species with a crystallite size of 15–18 nm and calcium silicate were successfully identified from the X-ray diffraction (XRD) pattern. Subsequently, the results appraised from the reaction studies confirmed the absence of a direct interaction between CO_2 and the glycerol compound during the glycerol dry reforming and that the H_2 was primarily produced from the glycerol decomposition. This finding could be ascribed to the chemisorption of both compounds at different active sites, which resulted in glycerol decomposition as the primary reaction pathway. The optimum condition for H_2 production via glycerol dry reforming was at a carbon dioxide-to-glycerol ratio (CGR) of unity (at constant P_{gly} = 14 kPa) and 973 K. Moreover, the glycerol conversion ranged from 70% to 80% at a CGR of 1–1.67. Glycerol dry reforming was discovered to be more feasible for Fischer Tropsch synthesis, as the H_2:CO product ratios were <2.0. The post-characterisation of the used catalysts confirmed the presence of whisker-type carbon, which fortunately can be easily removed via oxidation with O_2.

Keywords: Dry reforming, Glycerol, Syngas, Reaction, Carbon deposition

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