

Evaluation of La-promoted Ni/Al₂O₃ Catalyst for Ethanol Dry Reforming

Mahadi B. Bahari¹, Nguyen Huu Huy Phuc²,
Nurul Ainirazali¹, Dai-Viet N. Vo^{1,*}

¹Faculty of Chemical & Natural Resources
Engineering, Universiti Malaysia Pahang,
Lebuhraya Tun Razak, 26300 Gambang,
Kuantan, Pahang, Malaysia

²Department of Electrical and Electronic
Information Engineering, Toyohashi
University of Technology, 1-1 Hibarigaoka,
Tempaku, Toyohashi, Aichi 441-8580, Japan

*E-mail: vietvo@ump.edu.my (D.-V. N. Vo)

Greenhouse emissions from combustion of fossil fuels have led to undesirable environmental issues. Hydrogen as a clean and renewable energy is therefore demanded urgently for petroleum-based energy substitution. Although the common method for H₂ production is reforming of hydrocarbons which are unsustainable, ethanol has been considered as an economically attractive feedstock for replacing hydrocarbons due to its high availability, renewability and low toxicity [1]. Ethanol steam reforming has been widely researched whilst the knowledge about dry reforming of ethanol (DRE) is still limited, especially rare-earth promoted Ni-based catalyst. Thus, investigating the physicochemical attributes, activity and selectivity of 3%La-10%Ni/Al₂O₃ catalyst for DRE was the purpose of this research.

Co-impregnation using La(NO₃)₃, Ni(NO₃)₂ precursor solutions and thermally pretreated γ -Al₂O₃ support was utilized for catalyst preparation. DRE runs were conducted in a quartz fixed-bed reactor (O.D. = 3/8 in) at 873-973 K and 1 atm with catalyst loading of 0.1 g_{cat} per run, gas hourly space velocity, GHSV = 42 L g_{cat}⁻¹ h⁻¹ and catalyst particle size of 100-140 μ m for minimizing the transport resistances. The effect of CO₂ and C₂H₅OH partial pressure on DRE was examined by varying CO₂:C₂H₅OH ratios of 1:1 to 2.5:1 at reaction temperature of 973 K. N₂ gas was fed in the system as the diluent gas for ensuring the total flowrate of 70 ml min⁻¹.

3%La-10%Ni/Al₂O₃ catalyst has BET surface area of 86.09 m² g_{cat}⁻¹ close to that of

calcined γ -Al₂O₃ support indicating the fine dispersion of metal oxides on support surface. X-ray diffractogram (cf. Fig. 1) of La-Ni/Al₂O₃ catalyst detected the presence of NiAl₂O₄, NiO and NiLa₂O₄ phases in line with results obtained from temperature-programmed calcination. C₂H₅OH and CO₂ conversions increased from 24.7% to 39.3% and from 16.5% to 21.9%, respectively with growing CO₂ partial pressure, P_{CO₂} from 20 to 50 kPa as seen in Fig. 2. Ratio of H₂/CO was greater than unity and rose from 1.1-1.5 reasonably due to the presence of ethanol dehydrogenation reaction. H₂, CO and CH₄ formation rates also increased considerably with rising P_{CO₂}.

The authors acknowledge the financial support from Ministry of Education (MOE), Malaysia for Fundamental Research Grant Scheme (FRGS), RDU140138.

REFERENCES

- [1] T.N. Veziroglu and D. Das, Int. J. Hydrogen Energ., 26 (2001) 13.

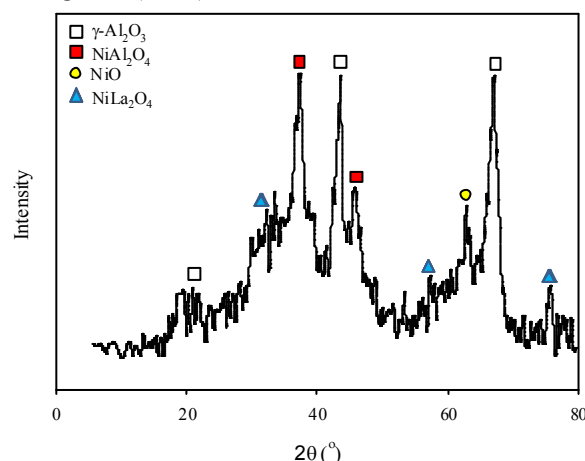


Fig.1 XRD pattern of 3%La-10%Ni/Al₂O₃.

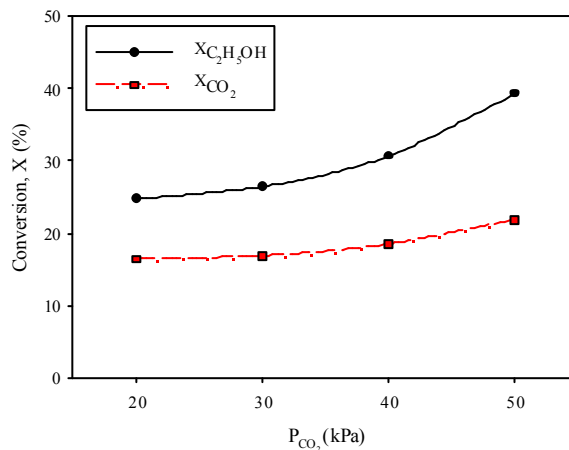


Fig.2 C₂H₅OH and CO₂ conversion profile at P_{C₂H₅OH} = 20 kPa and T= 973 K.