Deciphering the imperative role of ruthenium in enhancing the performance of Ni/Nd2O3.Gd2O3 in glycerol dry reforming

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ABSTRACT

Glycerol dry reforming (GDR) turns glycerol and CO2 into valuable syngas. The present work aims to decipher the imperative role of Ru metal in enhancing the performance of Ni/ Nd2O3.Gd2O3 in GDR. The unpromoted 15%Ni/Nd2O3.Gd2O3 and promoted 3%Ru-Ni/ Nd2O3.Gd2O3 catalysts are synthesized via the ultrasonic-assisted impregnation method while XRD, FESEM-EDX, H2-TPR and CO2-TPD analyses are used to characterize the catalysts. In this study, the influence of reaction variables such as temperature and the CO2 to glycerol ratio (CGR) was investigated. In accordance with XRD and FESEM-EDX analyses, the promoted catalyst exhibited a more refined morphology and more uniform Ni dispersion than the unpromoted catalyst. From the reaction study, the promoted 3%Ru-15%Ni/ Nd2O3.Gd2O3 gives higher glycerol conversion (91%), H2 yield (65%) and CO yield (80%) at a reaction temperature of 800 C and CGR of 1. This is due to the higher number of available active sites as well as the excellent diffusion of Ni metal across the surface of the catalyst. However, as Ni metal is susceptible to carbon formation and is easily sintered, the production of carbon is unavoidable for the catalysts. The XRD and TPO analyses shown that the addition of Ru reduces the amount of carbon that accumulates on the site of the catalyst, which in turn reduces the rate of deactivation.

KEYWORDS: Glycerol dry reforming; hydrogen; lanthanide support; Ni-based catalyst; Ru promoter; syngas

DOI: https://doi.org/10.1080/00986445.2022.2116324

ACKNOWLEDGEMENT

The authors would like to acknowledge the Ministry of Higher Education, Malaysia for awarding the FRGS research grant vote RDU190197 (FRGS/1/2018/TK02/UMP/02/12) and Universiti Malaysia Pahang (RDU1803118 and PGRS200361) for financial support.

REFERENCES

Abbas M, Sikander U, Mehran MT, Kim SH. 2021. Exceptional stability of hydrotalcite derived spinel Mg(Ni)Al2O4 catalyst for dry reforming of methane. Catalysis Today. doi:10.1016/j.cattod.2021.08.029

Al-Fatesh AS, Ibrahim AA, Fakeeha AH, Singh SK, Labhsetwar NK, Shaikh H, Qasim SO. 2019. CO2 reforming of CH4: effect of Gd as promoter for Ni supported over MCM-41 as catalyst. Renew Energy. 140:658–667. doi:10.1016/j.renene.2019.03.082

Al-Musa A, Al-Saleh M, Ioakeimidis ZC, Ouzounidou M, Yentekakis IV, Konsolakis M, Marnellos GE. 2014. Hydrogen production by iso-octane steam reforming over Cu catalysts supported on rare earth oxides (REOs). Int J Hydrogen Energy. 39(3):1350–1363. doi:10.1016/j.ijhydene.2013.11.013

Anil C, Modak JM, Madras G. 2020. Syngas production via CO2 reforming of methane over noble metal (Ru, Pt, and Pd) doped LaAlO3 perovskite catalyst. Mol Catal. 484(November 2019):110805. doi:10.1016/j.mcat.2020. 110805.

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