Reduction and Activation of Ni-based Catalyst on Al_2O_3 Support Under DBD Plasma Condition and CO_2 Methanation Testing

Wipaporn Jai-eye and Visawa Phanomai

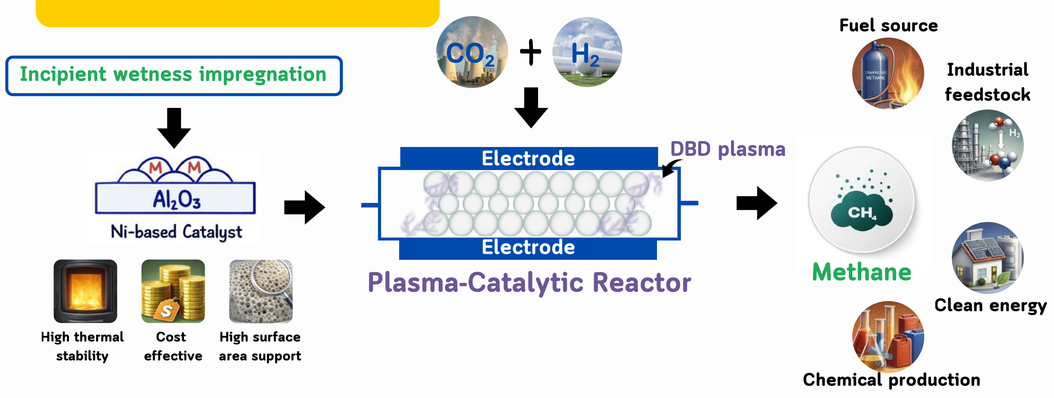
Advisor: Asst.Prof.Dr. Nongnuch Rueangjitt

Department of Industrial Chemistry, Faculty of Science, Chiang Mai University

Abstract

The research project aims to investigate the characteristics and catalytic activity of nickel-based catalyst supported on alumina (Ni/Al_2O_3) for CO_2 methanation. This study focuses on the effects of nickel loading (10%wt. and 20%wt.) and voltage of Dielectric Barrier Discharge (DBD) plasma (61.5, 115 and 125 V). The prepared catalysts (incipient wetness impregnation) were reduced by hydrogen under the conventional heating and plasma treating conditions. The catalyst characterization was determined using SEM-EDS and BET surface area and pore analyzer. The result indicated that the plasma-treated catalysts significantly better performed than the untreated one. This improvement was attributed to the ability of plasma in enhancing nickel particle dispersion and surface activation of the support, which promoted the adsorption and activation of CO_2 and H_2 molecules. The 10NiR125 catalyst achieved the highest conversion rates for CO_2 and H_2 at 11.78% and 6.39%, respectively. In addition, carbon monoxide (CO) was found to be the primary product. The 10NiRP125 catalyst performed the CO yield of 10.30%.

Introduction

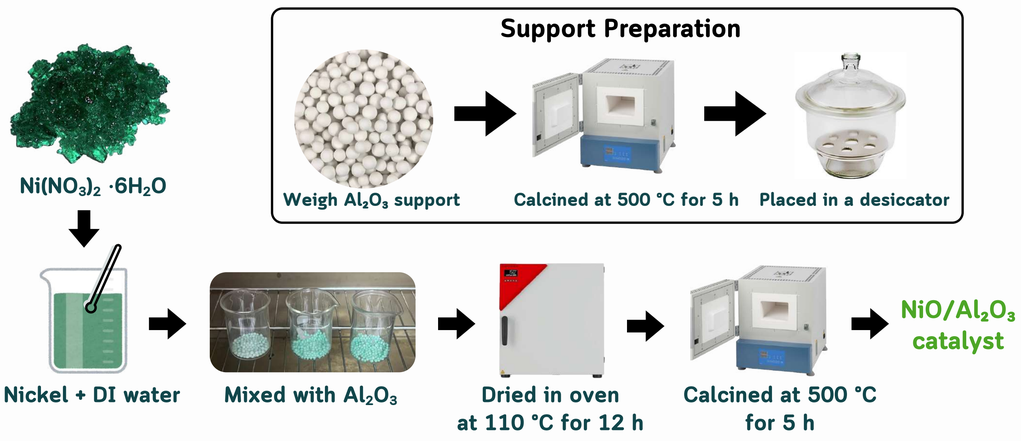


Objective

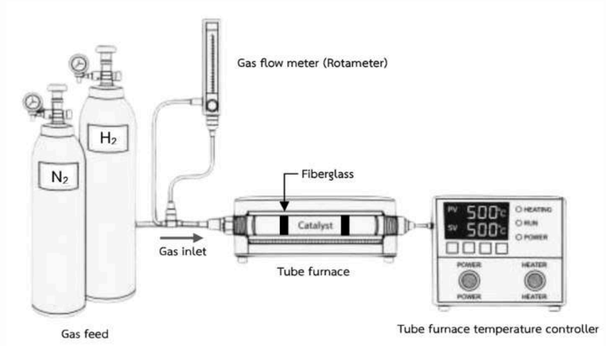
To investigate the characteristics and catalytic activity of nickel-based catalyst supported on alumina (Ni/Al_2O_3) for CO_2 methanation

Experimental

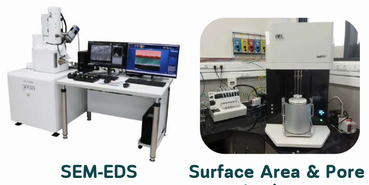
Catalyst Preparation : Incipient wetness impregnation



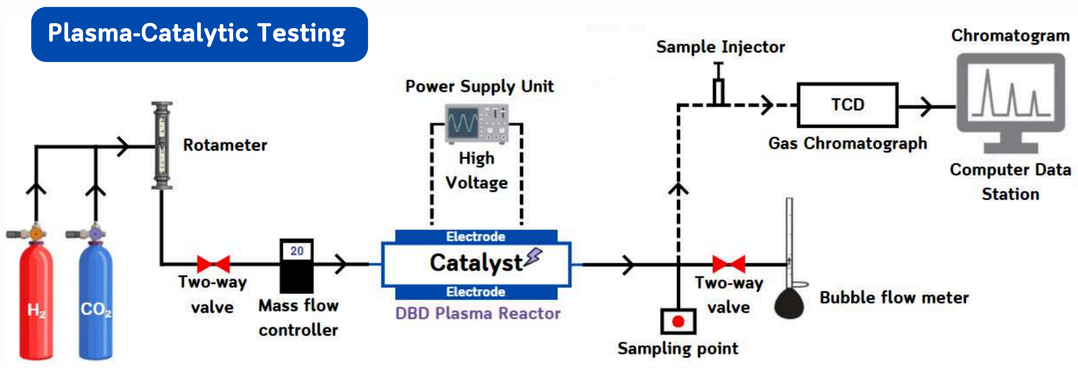
Hydrogen Reduction by Conventional Method



Catalyst Characterization



Plasma-Catalytic Testing

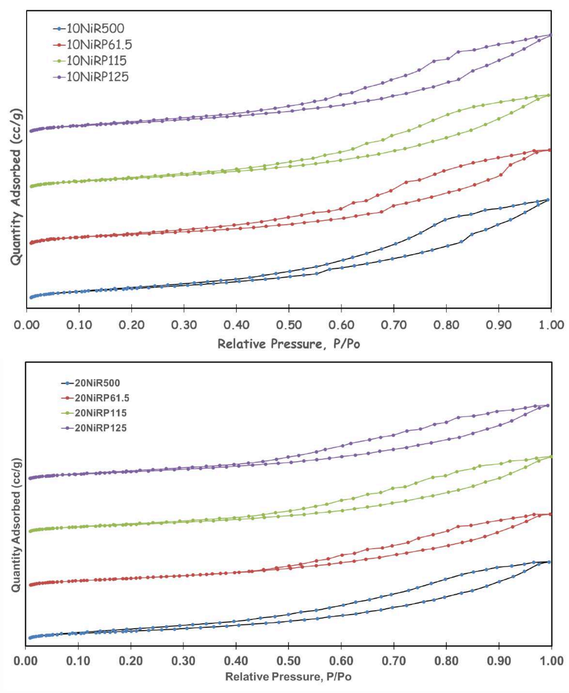


Results & Discussion

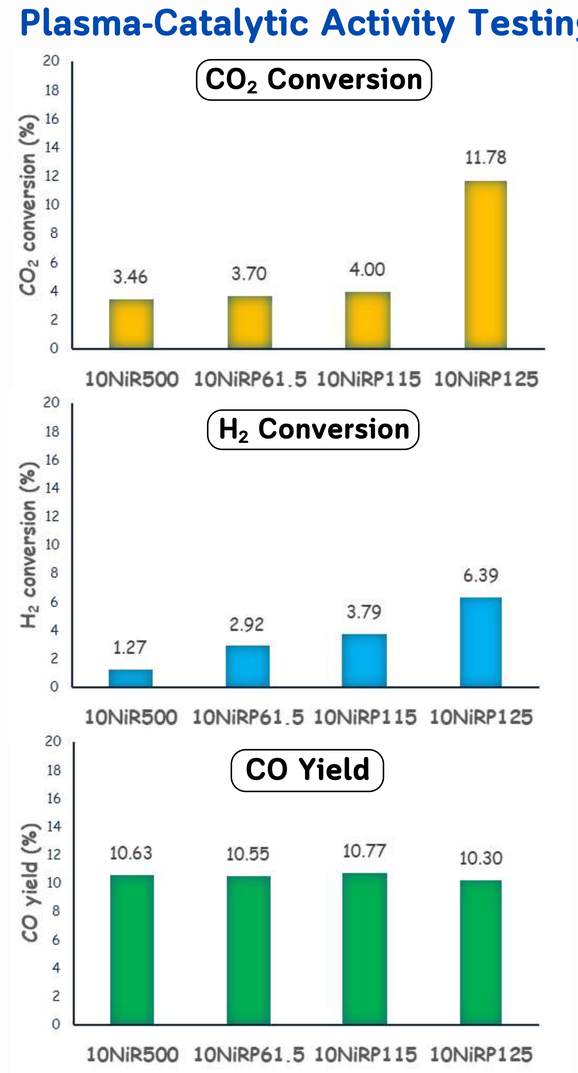
Catalyst Characterization

Surface Area, Pore Volume & Pore Size

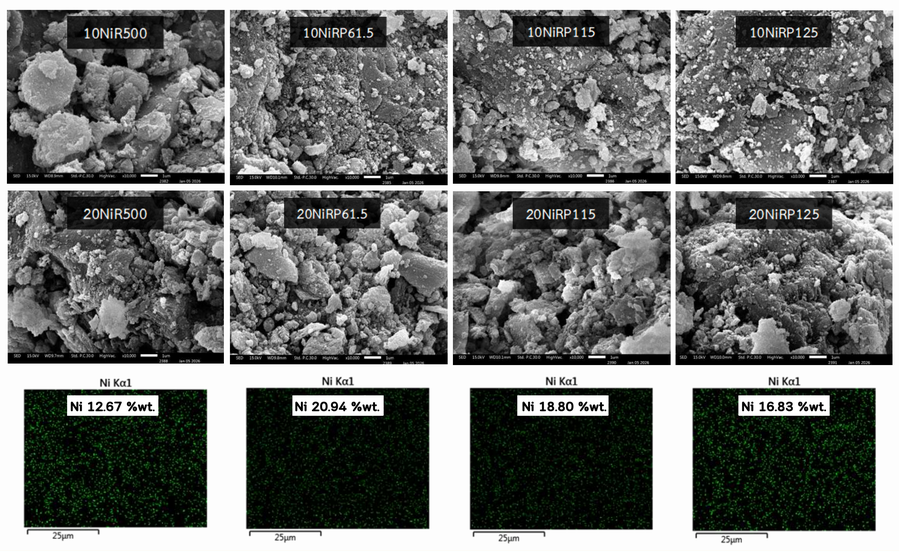
Sample ID	BET surface area (m^2/g)	Pore volume, V_p (cm^3/g)	Average pore diameter (nm)
10NiR500	190.34	0.4510	4.74
10NiRP61.5	171.79	0.4254	4.95
10NiRP115	183.36	0.4215	4.60
10NiRP125	180.65	0.4396	4.87
20NiR500	153.86	0.3665	4.77
20NiRP61.5	152.51	0.3422	4.49
20NiRP115	152.22	0.3608	4.74
20NiRP125	152.43	0.3526	4.63



Plasma-Catalytic Activity Testing



SEM-EDS



Conclusions

- The plasma-treated catalyst performed better than the untreated catalyst.
- The 10NiRP125 catalyst showed the best results, giving the highest CO_2 conversion of 11.78% and H_2 conversion of 6.39%, with CO yield of 10.30%.

Reference

Li, L., Chen, X., Bella, Hu, F., Zhang, X., Ye, R., Gong, L., Zhang, R., Feng, G., and Kawi, S. (2025), Dielectric barrier discharge plasma catalysis for CO_2 conversion: Recent progress and perspectives, Carbon Capture Science and Technology, 16. https://doi.org/10.1016/j.ccst.2025.100485