Syngas Production via Dry Reforming of Methane in a Gliding Arc Plasma Reactor Packed with NiO/ZSM-5 Catalyst

Pornpawee Saratana 650510077

Advisor: Asst. Prof. Dr. Nongnuch Rueangjitt

FACULTY OF SCIENCE
CHIANG MAI UNIVERSITY

Abstract

In this special project, a plasma-catalysis system was employed for the carbon dioxide reforming of methane (dry reforming of methane) within a Gliding Arc Discharge (GAD) reactor. The study explored the effect of feed gas flow rate (25 mL/min and 100 mL/min) and the effect of NiO loading on ZSM-5 support (5%wt., 7%wt., and 10%wt.) on the production of syngas. The result indicated that the optimal performance was achieved at a feed flow rate of 25 mL/min, with using 10%wt. NiO/ZSM-5 catalyst. The conversion rates for CH_4 and CO_2 were 23.09% and 10.60%, respectively. The selectivities for H_2 and CO were 45.01% and 19.42%, respectively. The syngas yield reached at 16.84%. The specific consumed energy, E_c was 5.16×10^{-18} W·s/molecule of reactant converted, and E_s was 6.82×10^{-18} W·s/molecule of syngas produced.

Introduction



Dry Reforming of Methane

Plasma

$CO_2 + CH_4$ → NiO/ZSM-5 Catalyst (Reactor) → $2H_2 + 2CO$ (Syngas)

Objective

To study the effects of feed gas flow rate and NiO loading on ZSM-5 support on the syngas production from methane dry reforming in a gliding arc plasma reactor

Experimental

Catalyst Preparation



ZSM-5 → Calcination (500°C, 5 hr) →  Nickel solution → Drying (110°C, 12 hr) →  → Calcination (500°C, 5 hr) → **NiO/ZSM-5**



5%wt. NiO
7%wt. NiO
10%wt. NiO

Catalyst Characterization

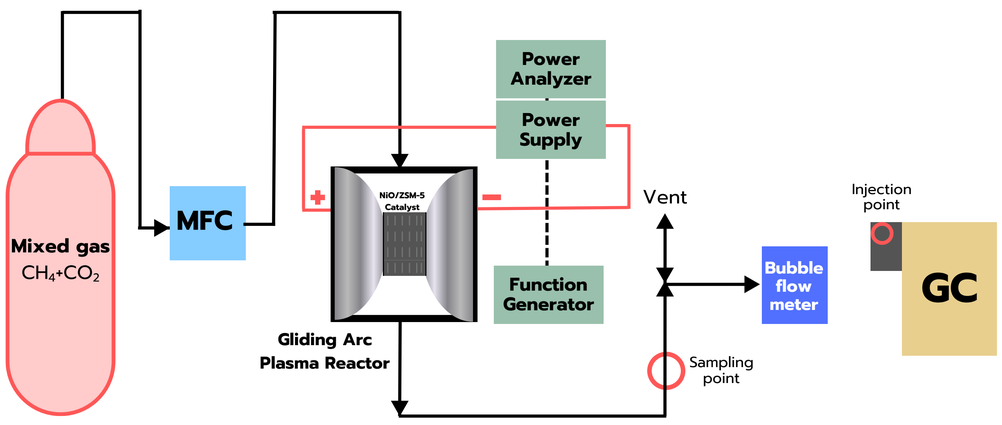


Scanning Electron Microscopy (SEM)



N_2 Adsorption-Desorption Isotherm/BET Analyzer

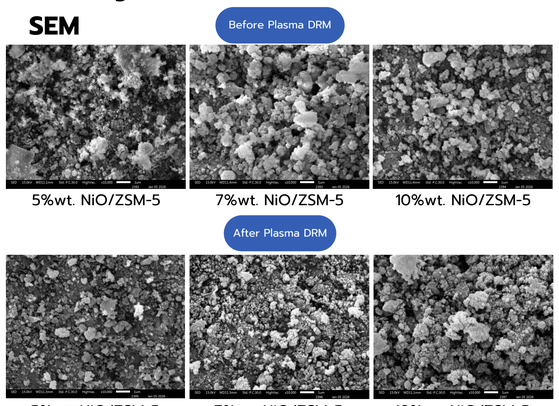
Plasma-Catalysis System



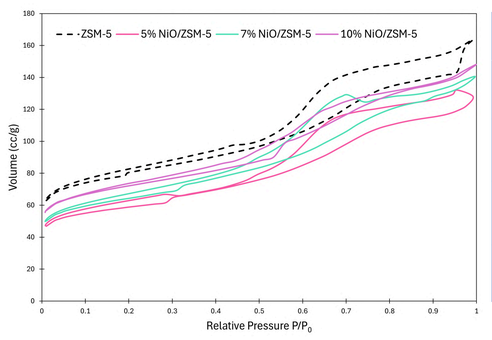
Results & Discussion

• Catalyst Characterization

SEM



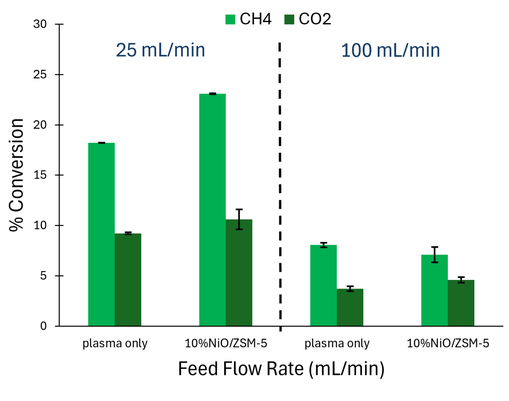
N_2 Adsorption-Desorption Isotherm/BET Surface Area

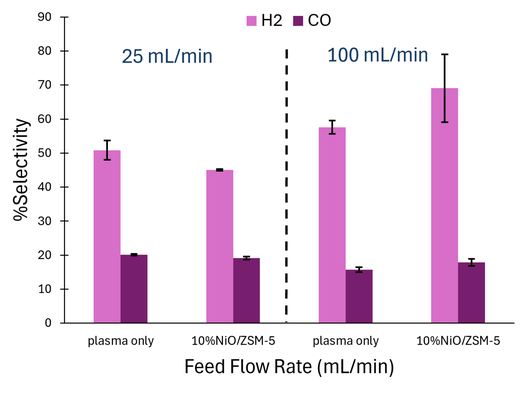


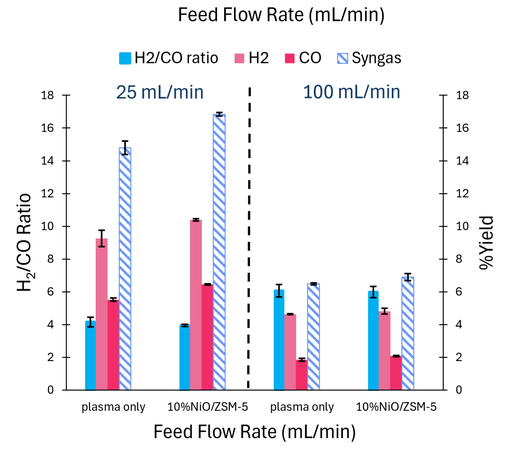
Sample	Specific Surface Area (m^2/g)
ZSM-5	291.04
5%wt. NiO/ZSM-5	215.94
7%wt. NiO/ZSM-5	234.60
10%wt. NiO/ZSM-5	262.99

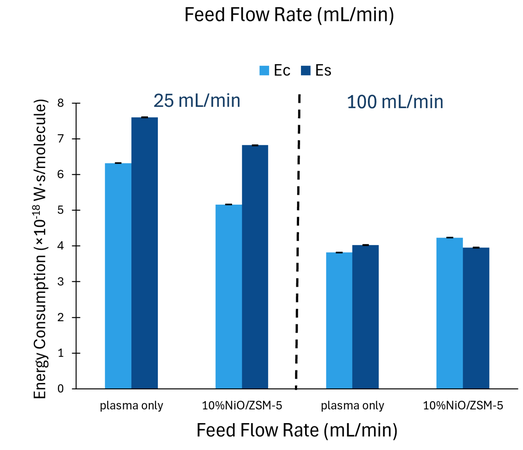
• Plasma Catalysis: DRM

Effect of Feed Flow Rate

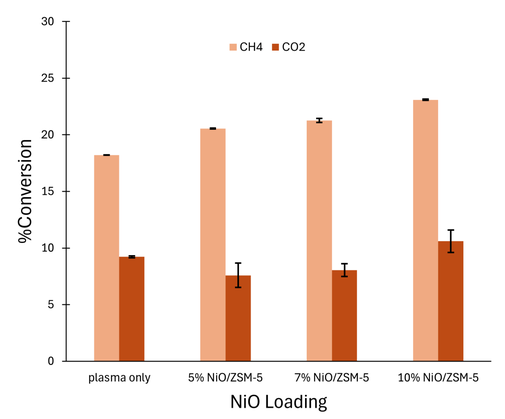


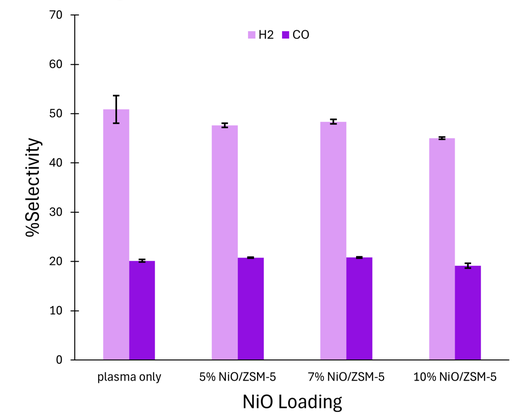


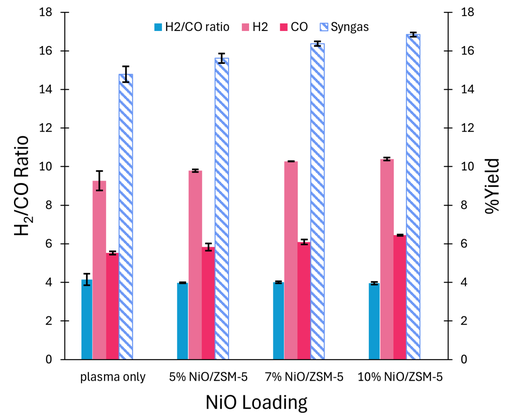


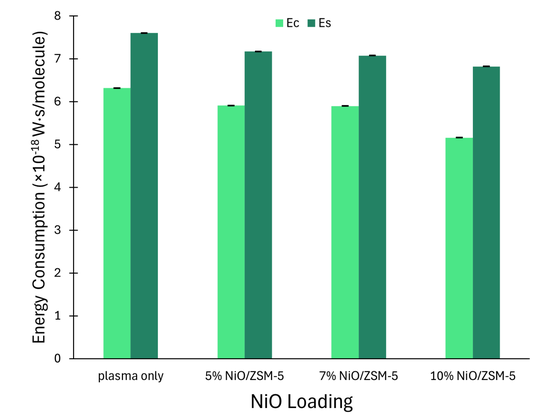


Effect of NiO Loading









Conclusions

- Syngas production via the dry reforming of methane (DRM) in a gliding arc plasma reactor demonstrated that the plasma-catalysis integrated system exhibited superior performance, compared to the sole plasma system.
- The condition at a feed flow rate of 25 mL/min and 10%wt. NiO/ZSM-5 catalyst achieved the highest performance efficiency for syngas production.

Reference

Rueangjitt N, Sreethawong T, Chavadej S, Sekiguchi H, (2011), "Non-Oxidative Reforming of Methane in a Mini-Gliding Arc Discharge Reactor: Effects of Feed Methane Concentration, Feed Flow Rate, Electrode Gap Distance, Residence Time, and Catalyst Distance," Plasma Chemistry and Plasma Processing, 31(4), pp. 517–534.