A HYBRID ADSORBENT-MEMBRANE REACTOR (HAMR) SYSTEM FOR HYDROGEN PRODUCTION

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Introduction

An experimental study on the performance of a novel reactor system, termed the hybrid adsorbent-membrane reactor (HAMR) is described here. In the HAMR the reaction and membrane separation steps are coupled with adsorption. It was shown previously by our group that for esterification reactions this results in significantly improved performance. The focus in this presentation is on the use of the HAMR for hydrogen production. Experimental investigations are described of the HAMR for the water gas shift (WGS) reaction using hydrotalcite-type CO₂ adsorbents and nanoporous H₂-selective carbon molecular sieve membranes (CMS). The reactor characteristics have been investigated for a range of temperature and pressure conditions relevant to the WGS application, and are compared with the predictions of the mathematical model previously developed.

Hydrotalcite Adsorbent

- High Selectivity
- Memory Effect
- Stable Capacity
- Mechanically Stable During Cyclic Exposure Under High Pressure and Temperature Conditions.

General Formula: MgₓAlₓ(OH)₂(CO₃)ₓ/2.nH₂O

Water-Gas Shift Reaction Kinetics

CO + H₂O ⇄ CO₂ + H₂ \[ ΔH = -41.1 \text{ kJ/mol} \]

Commercial LTS-Cu/Zn Catalyst
Pressure = 308.2 kPa
Temperature = 250°C
Feed: CO : H₂ : H₂O (1 : 4 : 1.1)

Power Law Rate Expression

\[ r = k \cdot P_{CO}^{1+} \cdot P_{H₂O}^{1+} \cdot (1-β) \]

\[ k = k_0 \cdot \exp(-19285.6/(6.2673)) \]

Experimental Set-Up

Hydrogen Production Using Hybrid Adsorbent-Membrane Reactor

Hydrogen Production Using Hybrid Adsorbent-Membrane Reactor (HAMR) System for Hydrogen Production

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CMS Membrane

- Micro-porous CMS Membrane
- Permeate Selective Towards Hydrogen
- Internal Diameter = 0.35 cm, External Diameter = 0.57 cm

Conclusions

- A Novel Concept Called HAMR is Experimentally Investigated for Hydrogen Production via WGS Reaction.
- Experimental studies found good agreement with the model predictions.
- HAMR provides good promise for reducing the hostile operating conditions of conventional reformers, and for meeting PEM fuel cell product purity requirements.