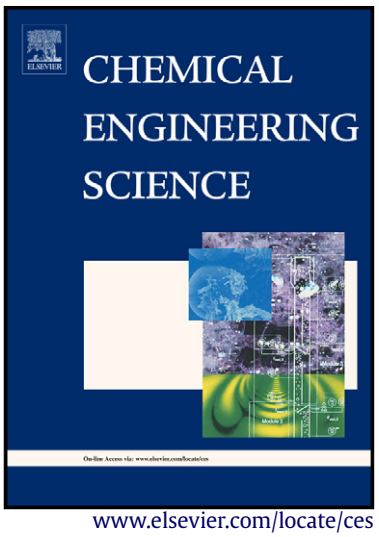

www.elsevier.com/locate/ces

A Catalytic Hollow Fibre Membrane Reactor for Combined Steam Methane Reforming and Water Gas Shift Reaction

Ana Gouveia Gil, Zhentao Wu, David Chadwick, K. Li

PII: S0009-2509(15)00459-5
DOI: http://dx.doi.org/10.1016/j.ces.2015.06.051
Reference: CES12454

To appear in: *Chemical Engineering Science*

Received date: 27 February 2015
Revised date: 26 June 2015
Accepted date: 27 June 2015

Cite this article as: Ana Gouveia Gil, Zhentao Wu, David Chadwick, K. Li, A Catalytic Hollow Fibre Membrane Reactor for Combined Steam Methane Reforming and Water Gas Shift Reaction, *Chemical Engineering Science,* http://dx.doi.org/10.1016/j.ces.2015.06.051

A Catalytic Hollow Fibre Membrane Reactor for Combined Steam Methane Reforming and Water Gas Shift Reaction

Ana Gouveia Gil, Zhentao Wu, David Chadwick*, K. Li*

Department of Chemical Engineering, Imperial College, London SW7 2AZ, United Kingdom

(*) Corresponding author. Tel.: +44 207 5945676; Fax: +44 207 5945629. Email: kang.li@imperial.ac.uk

Abstract

A catalytic hollow fibre membrane reactor (CHFMR) was developed in this study for combined steam methane reforming (SMR) and water gas shift (WGS) reaction. This is achieved by incorporating a Ni/SBA-15 catalyst into a plurality of micro-channels with open entrance from inner surface of Al_2O_3 hollow fibres, followed by coating of a 3.3 μm Pd membrane on the outer surface of the hollow fibre using an electroless plating method. In addition to systematic characterizations of each reactor component, i.e. Ni/SBA-15 catalyst, micro-structured ceramic hollow fibre and Pd separating layer, the effect of how the reactor was assembled or fabricated on the catalytic performance was evaluated. Electroless plating of the Pd membrane impaired the catalytic performance of the deposited Ni/SBA-15 catalyst. Also, the over-removal of hydrogen from the reaction zone was considered as the main reason for the deactivation of the Ni-based catalyst. Instead of mitigating such deactivation using "compensating" hydrogen, starting the reaction at higher temperatures was found more efficient in improving the reactor performance, due to a better match between hydrogen production (from the reaction) and hydrogen removal (from the Pd membrane). An effective methane conversion of approximately 53 %, a CO_2 selectivity of 94 % and a H_2 recovery of 43% can be achieved at 560 °C. In order for a more significant "shift" phenomenon, alternative methodology of fabricating the reactor and more coke resistant catalysts are recommended.

Keywords: Catalytic hollow fibre membrane reactor, Steam methane reforming, Water-gas shift, H_2 production, Ni/SBA-15 catalyst, Pd membrane