Available online at www.sciencedirect.com

SciVerse ScienceDirect

Procedia Engineering 44 (2012) 513 – 514

Procedia Engineering

www.elsevier.com/locate/procedia

Euromembrane Conference 2012

[OD06]

Metal oxide silica membranes for gas separation

C. Yacou, S. Smart, J. da Costa*

The University of Queensland, Australia

One of the major criticisms that stemmed from the International Conference of Inorganic Membranes held in Washington DC (USA) in July 2010 is that the number of inorganic membrane technologies for gas separation adopted by the industry has been very limited. In other words, inorganic membrane technology for gas separation has been relegated to the realms of laboratory R&D for the last 30 years despite the fact that there is a great potential of this technology to be employed in cleaner energy production, particularly in hydrogen separation. Hence, there is a real need to show proof of concept for scale up and long term testing of these systems.

In this work, we took this challenge head on. First, we developed thermally stable metal oxide silica matrices with tailored pore sizes to separate hydrogen from other gas molecules. Metal oxide silica structures depart from conventional amorphous silica structures, by forming a stable hybrid crystalline and amorphous molecular sieving structures [1-5]. Then the best metal oxide silica sol-gel process was chosen for the preparation of membrane tubes. Second, we build a multi-tube membrane module and assembled 8 membrane tubes totalling 545 cm^2 of membrane area in 4 parallel lines as schematically depicted in Figure 1.

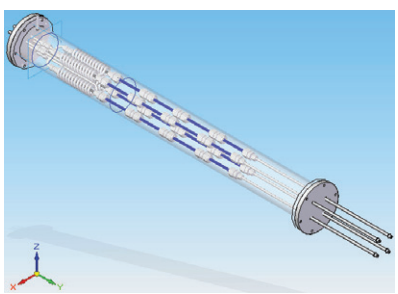

Figure 1 – Membrane reactor design showing to left coils for heat management. Inside the coils are metal tubes which function as pre-reaction chambers [6].

The performance of the multi-tube membrane module was tested up to 500°C. We achieved extremely high selectivities of H_2/CO_2 and He/N_2 close to 1000, unheard of for large porous inorganic membrane systems based on the permeance results in Figure 2a. We also tested the performance of the membranes for gas mixtures which is also rarely reported in the literature. We further show major interesting findings of the effect of gas mixtures on H_2 gas flow rates and gas purity. Contrary to the temperature dependency effect observed for single gas permeation, we show that gas mixtures have a more profound effect on gas permeation rates. These major findings were only possible by the employment of larger membrane surface area as opposed to small scale inorganic membrane work published in the literature.

doi:10.1016/j.proeng.2012.08.470

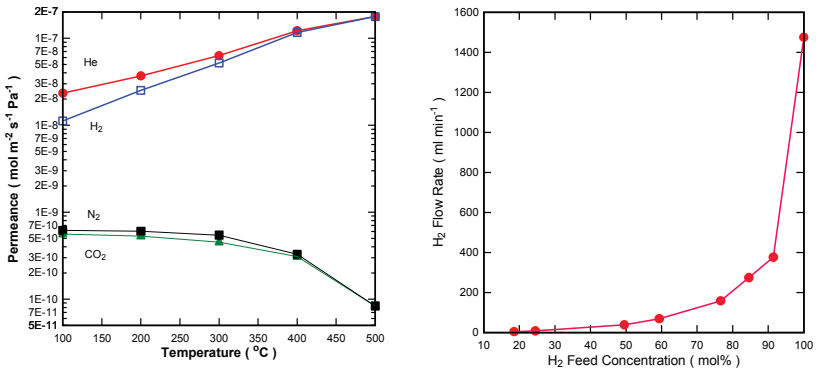

Fig. 2 (a - left) permanence of gases versus temperature [7] and (b - right) H_2 flow rate as a function of H_2 feed concentration in a binary (H_2/Ar) gas mixture.

Additionally, we tested the multi-tube membrane module performance for 2000 hours under varied thermal cycling conditions, including shut down and start up cycles. This was to ensure the robustness of the membranes developed in this work. We believe that the excellent outcomes of a long term testing of a scaled up multi-tube membrane module will deliver positive benefits for those researching in the area of membrane technology for hydrogen or other types of gas separation, or for those seeking deployment of inorganic membrane technology for advanced clean energy systems.

Acknowledgements

The authors acknowledge financial support from the Centre for Low Emission Technology, the Queensland Government via the NIRAP funding scheme, and the Australian Research Council (DP110101185).

References

[1] M. Kanezashi, T. Fujita, M. Asaeda, Sep. Sci. Tech, 40 (2005) 225–238.

[2] M. Kanezashi, M. Asaeda, J. Memb. Sci., 271 (2006) 86.

[3] R. Igi, T. Yoshioka, Y. H. Ikuhara, Y. Iwamoto, T Tsuru, J. Am. Ceram. Soc. 91 (2008) 2975.

[4] D. Uhlmann, S. Liu, B. P. Ladewig, J. C. Diniz da Costa, J. Memb. Sci. 326 (2009) 316.

[5] S. Battersby, T. Tasaki, S. Smart, B. Ladewig, S. Liu, M. C. Duke, V. Rudolph, J. C. Diniz da Costa, J. Memb. Sci. 329 (2009) 91.

[6] S. Smart, C. X. C. Lin, L. Ding, K. Thambimuthu, J. C. Diniz da Costa, Energy & Env. Sci. 3 (2010) 268.

[7] C. Yacou, S. Smart, J. C. Diniz da Costa, Energy & Env. Sci. 5 (2012) 5820.

Keywords: gas separation