High Temperature WGS Reaction in a Zeolite Membrane Reactor: Effects of Catalyst Packing Configuration

Antonios Arvanitis, Xinhui Sun, Devaiah Damma,Peter Smirniotis, Junhang Dong

Department of Biomedical, Chemical and Environmental Engineering

University of Cincinnati, Cincinnati, OH 45221, USA

ABSTRACT

It has been recently demonstrated in our lab that, the reversible water gas shift reaction (WGS) $CO + H_2O \leftrightarrow CO_2 + H_2$ ($\Delta H^{\ominus}_{298.15K} = -41.2kJ/$mol) is able to achieve nearly complete CO conversion (>99.9%) with almost complete H_2 recovery utilizing in a catalyst packed zeolite tube membrane reactor (MR) when operating at high temperature and high pressure. However, because the zeolite membrane has an imperfect H_2/CO permeation selectivity, the arrangement of catalyst loading along the tube membrane length has significant influences on the CO conversion. The CO must be largely converted at the beginning of the membrane reactor so that CO partial pressure becomes sufficiently low to prevent successive CO leak to the permeate side. Also, the CO concentration, after the first section of the MR, becomes very low and its further conversation requires near complete removal of H_2 from the reaction side. Since H_2 is also largely removed from the initial section of the tube MR (i.e. near the entrance of the feed), the H_2 partial pressure difference between the feed (reaction side) and permeate is very small that needs large membrane area for separation but small amount of catalyst for the remaining CO conversion. Thus, for the same amount of catalyst (which may also limited by reactor volume), the packing arrangement or catalyst distribution play an important role in determining the MR performance. Both experimental investigations and model calculations will be discussed for this subject.