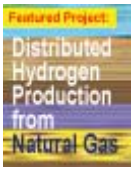
Agency for Science, Technology and Research
SINGAPORE

Selected Science & Engineering Projects by Research Institutes



Distributed Hydrogen Production from Natural Gas

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Research Area: Catalysis

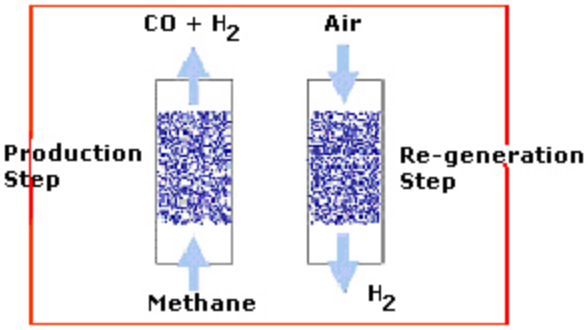
This project is aimed at the development of effective technologies for the hydrogen production from natural gas via catalytic partial oxidation (CPO) at low cost. Hydrogen is potentially an ideal energy carrier for future. A transition from fossil fuels to hydrogen as a major fuel in the next 50 years could increase energy security and reduce environmental pollution. Many countries, including U.S.A., Europe, Canada and Japan, have moved hydrogen economy to the political and technical forefront of their country. For road-vehicle H2 applications, the U.S. Department of Energy (DOE) recommends small-scale direct hydrogen production using natural gas reforming. Small-footprint plants for H2 are expected to be demonstrated in 2011. The main challenge with distributing hydrogen to dispersed locations is the high cost. The fueling park-commercial production of H2 from natural gas is targeted to reduce the H2 cost by 25% by 2015.

Industrially 95% of hydrogen today is produced from natural gas by steam methane reforming (SMR). However SMR is highly endothermic. Its reactor is large due to the use of superheated steam. Catalytic partial oxidation (CPO) of methane is an attractive alternative. It is slightly exothermic and its reactor is small. It is the lowest-cost option recommended for small scale hydrogen production. Additionally the emissions of CO_x to the atmosphere are significantly reduced for CPO as compared to SMR. Therefore CPO is a promising process for distributed hydrogen production.

Conventionally CPO uses pure oxygen to partially oxidize methane to syngas (CO and hydrogen). One strategy to reduce the cost of hydrogen production is using air, rather than pure oxygen as the raw material. Membrane reactors which can combine the CPO reaction and air separation in a single unit operation are one approach of this strategy. However the major problem for this approach is that the membrane must have very high oxygen permeability and it must be chemically and mechanically stable. It is hard to find a material which can meet all the requirements. In this proposal a new concept for distributed hydrogen production is developed, and a novel operation system is designed, in which a novel material reacts with methane, forming synthesis gas in the production step, and the reduced material is regenerated by air in a subsequent step. The cyclic operation can then result in the overall reaction:

$$CH_4 + \text{air} \rightarrow CO + H_2 + N_2.$$

If successful this project will be able to provide new technology for syngas as well distributed hydrogen production. 35-60% lower cost and lower pollutants emission have been estimated. Syngas is starting materials for many high-value chemicals such as ammonia, methanol, formaldehyde, and light hydrocarbon fuels etc. The great reduction in the cost will benefit to all these related chemical processes.


CO + H2
Air
Production Step
Re-generation Step
Methane
H2