344g Pure Hydrogen from Natural Gas

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The conventional hydrogen production techniques, such as steam reforming, auto-thermal reforming and partial oxidation of methane, yield large amount of carbon oxides as by-products. The capture, transportation and sequestration of carbon dioxide are energy intensive processes. The capture and disposal of carbon dioxide from the steam methane reforming (SMR) process is nearly 25 – 30 % of the cost of hydrogen produced. Theoretically, the possible hydrogen yield for steam methane reforming in conjunction with the water gas shift reaction is two times that of thermocatalytic decomposition (H2/CH4=4 and 2 mole/mole, respectively). The high reaction endothermicity in combination with the energy requirements for carbon dioxide sequestration would considerably reduce the net yield of hydrogen produced by SMR process. The decomposition of methane, on the other hand, can be used to obtain carbon oxides-free hydrogen at higher efficiencies. It produces hydrogen and solid carbon and thereby eliminates the necessity for the hydrogen separation. The catalysts that have been explored in the past suffer from quick deactivation, presumably due to carbon deposition on its surface, thus plugging the pores. The reported equilibrium conversion degrees of methane decomposition under atmospheric pressure are about 32, 59, and 81% at 773, 873, and 973 K, respectively. However, these catalysts are deactivated at high temperatures within the minutes. The authors have recently developed a catalyst that has been proven to completely decompose CH4 at 1073 K continuously for over 7 hours. The product gas constitutes pure hydrogen.

The paper presents the results of the investigations on the abovementioned, durable and high reactivity catalyst for ultra high purity hydrogen production by thermocatalytic decomposition of synthetic natural gas. The main advantages of these catalysts identified were: its ability to completely decompose methane (as compared to a maximum of 81 % by other catalysts) and to maintain high reactivity for a long period of time (more than 4 times as long as current catalysts). The data from TGA and TPR experiments will be presented along with the kinetics of methane decomposition. The estimated kinetic parameters from the analysis of this data will also be presented. In addition, the effects of temperature, flow rate and catalysts loading in a fixed bed reactor will be presented.