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Abstract
The recent increase in the availability of hydrocarbons, especially methane, from shale gas exploration has led to renewed interest in converting or upgrading methane to higher value chemicals. Steam reforming is still the most developed and widely practiced industrial process for converting methane to hydrogen/syngas and its derivatives. It has no oxygen requirement and the most favorable H2/CO ratio for methanol and ammonia production of all available technologies. However, opportunities still remain to lower the energy requirement of steam reforming, including development of more efficient catalyst systems in terms of higher activity and effectiveness factors. Recently, Alloy Surfaces Co. Inc. developed an intrinsically bound thin-layered skeletal catalyst adhered on a metal substrate. These structures having relatively uniform coating thickness allow the physical manipulation into a highly active complex monolith structure that greatly enhances the catalyst effectiveness and inte...

Document type : Communication à un colloque (Conference Paper)

Référence bibliographique
Lugo, Michael ; Tiliakos, Nickolas ; De Wilde, Juray ; Gill, Rajinder ; W. Davis, Andrew ; et. al. Enhanced hydrogen production from methane steam reforming using a new thin layered structural coating on a metal substrate. AIChE 2015 Annual Meeting (Salt Lake City, UT, USA, du 08/11/2015 au 13/11/2015).
Enhanced hydrogen production from methane steam reforming using a new thin layered structural coating on a metal substrate

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The recent increase in the availability of hydrocarbons, especially methane, from shale gas exploration has led to renewed interest in converting or upgrading methane to higher value chemicals. Steam reforming is still the most developed and widely practiced industrial process for converting methane to hydrogen/syngas and its derivatives. It has no oxygen requirement and the most favorable H2/CO ratio for methanol and ammonia production of all available technologies. However, opportunities still remain to lower the energy requirement of steam reforming, including development of more efficient catalyst systems in terms of higher activity and effectiveness factors. Recently, Alloy Surfaces Co. Inc. developed an intrinsically bound thin-layered skeletal catalyst adhered on a metal substrate. These structures having relatively uniform coating thickness allow the physical manipulation into a highly active complex monolith structure that greatly enhances the catalyst effectiveness and interfacial heat and mass transport without applying an intermediate washcoat. A collaboration among City University of New York, City College, Alloy Surfaces, Co. Inc., Innoveering, and Université catholique de Louvain has been established to develop novel catalyst systems to more efficiently convert methane. Recently the team studied and analyzed this catalyst developed for hydrogen generation via steam methane reforming. Results have demonstrated that this catalyst is intrinsically more active than the conventional Ni catalyst and shows an increased selectivity toward CO2 and H2 and higher WGS rates.

Methane-to-steam ratios ranging from 2.0 to 6.0 were tested over a temperature range between 400°C to 900°C at pressures of 1.0, 1.5, 3.0 bar with GHSV from 50,000 to 350,000 h⁻¹. Mass balances were closed to within 2% and methane conversions were maintained below 20% of the potential equilibrium conversions possible at the particular test conditions. Results demonstrate the catalyst is capable of producing H2/CO ratios up to 425 from a reactant steam to carbon ratio of 3 at 515°C with no measurable change in activity over the time tested. The WGS reaction is about an order of magnitude faster than on the conventional nickel catalyst with nearly a factor of 2 enhancement of the CH₄ + 2 H₂O = CO₂ + 4 H₂ reaction. This presentation will show the results obtained over a wide range of conditions. A kinetic model with rate parameters derived from the experiments was used to quantify the enhance selectivity toward hydrogen and carbon dioxide under typical commercial operating conditions. Finally some details will be given on how the enhanced performance is achieved.