Abstract

This study focuses on the development of Al_2O_3 supported nano-NiO/SiO_2 catalyst for reforming of C_1 and C_2 hydrocarbons. The first part of the work involved preparation of nano-NiO, highly dispersed in silica, by sol-gel method using nickel nitrate hexahydrate [$Ni(NO_3)_2$, $6H_2O$] as precursor and tetraethyl orthosilicate (TEOS) as silica source. The prepared catalysts were characterized by XRD, SEM coupled with EDS, TEM, BET surface area and TPR. The average crystallite size of NiO in NiO/SiO_2 was found to be 10 nm.

Reforming of three hydrocarbons, namely methane, methanol and ethanol was carried out over the developed catalyst in a fixed bed tubular reactor. Optimum nickel loading in the catalyst was first determined for each hydrocarbon reforming. Reforming temperature, feed ratio and space time or space velocity were chosen as process parameters. The optimum operating conditions were established for each reforming system. Under optimum reforming condition, yield of H_2 and products selectivity were obtained together with the conversion of hydrocarbons.

For steam reforming of methane, the optimum operating conditions were established at 700 ^oC with a feed H_2O/CH_4 molar ratio of 3.5 and space-time of 11.31 kg catalyst h/kmol of inlet CH_4. Under this condition, conversion of methane was 95.71 % and yield of H_2 was 3.8 mole of hydrogen per mole of methane reacted. In case of methanol steam reforming, the established optimum conditions are: temperature, 425 ^oC; H_2O/methanol molar ratio, of 1.8:1; WHSV (weight hourly space-velocity), 0.14 kmol methanol per kg catalyst per h. Under this condition, the conversion of methanol is 95 % and yield of H_2 is 3.2 mole of hydrogen per mole of methanol reacted.

After successful methanol steam reforming, ethanol steam reforming (ESR) was carried out over the developed catalyst. Detailed parametric studies including kinetics of ESR were performed. A power-law type kinetic rate equation was developed by non-linear regression analysis of the experimental data and the activation energy of ESR was determined to be 27 kJ/ mole. Finally, dry reforming of ethanol (DRE) was performed successfully over the developed catalyst. The developed catalyst was found to be more active than the commercial nickel based reforming catalyst for all the hydrocarbons studied.

Keywords: Reforming, Nano-nickel, Space-time, Kinetics, Hydrogen yield, Syngas