Tandem photothermal steam reforming of methane using gap reactor

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Solar steam reforming of methane (SRM, $CH_4 + H_2O \rightleftarrows CO + 3H_2$, $\Delta H° = 206$ kJ mol^{-1}) is an attractive approach to convert solar energy to the chemical energy of hydrogen or synthesis gas.[1] SRM is highly endothermic, requiring high temperatures above 873 K to achieve a high conversion level. In this study, photothermal SRM was investigated using a tandem reaction system of the Ni/CeO_2 catalysts for SRM and Pt/CeO_2 catalysts for water-gas shift. In this reaction system, direct irradiation to the SRM catalyst formed a temperature gradient, which was utilized to promote downstream WGS reaction.

Moreover, a reactor composed of a quartz tube and quartz filler welded inside the tube, in which the catalysts were filled in the gap between the quartz tube and the filler (named a gap reactor), was investigated for suppression of the reverse reaction in SRM. As shown in Fig. 1, the gap reactor achieved a higher methane conversion of 83.5% (the surface temperature of the reactor: 1078 K) compared to the conventional tubular reactor with an inner diameter of 4 mm. Furthermore, the CO_2 selectivity improved significantly from 47.8 to 77.8% using an insulation unit, which covered the WGS region to increase the temperature. Throughout the investigation, we successfully improved the CH_4 conversion by suppressing the reverse reaction and enhanced CO_2 selectivity by promoting the water gas shift reaction at the low-temperature zone.

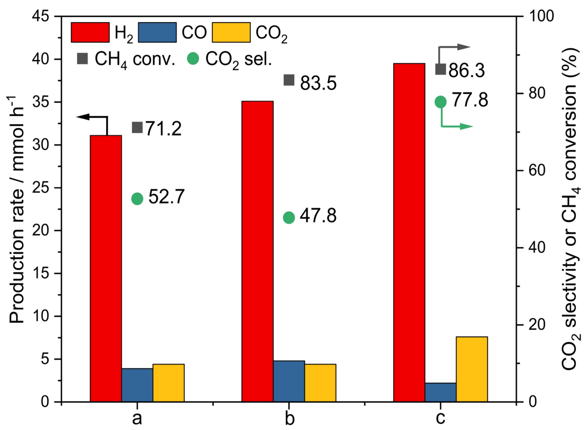

Fig. 1 Effect of the reactor shape and insulation on the catalyst performance for the SRM reaction. (a): tubular reactor without insulation, (b): gap reactor without insulation, and (c): gap reactor with insulation.

1) Román-Leshkov et al., *Catal. Sci. Technol.*, **2015**, *5*, 1991.

