Dry reforming of methane for syngas production over Ru catalysts supported on mixed CeO_2 - M_2O_3 oxides (M: La, Pr, Nd, Eu, Gd, Tb, Dy, Er)

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The European Union has pledged to reach carbon neutrality by 2050 harnessing renewable energy sources that have enormous potential as fossil fuel alternatives. Among many, like solar, wind or tidal, biogas is a promising factor in decarbonizing our energy systems. Biogas is composed mainly by CH_4, CO_2, two relatively inert gases that could be utilized to either produce hydrogen or synthetic fuels [1,2]. The Dry Reforming of Methane (DRM) reaction to produce syngas (H_2 and CO) has been gaining increasing popularity over the years in the scientific community compared to the Steam Reforming of Methane (SRM) reaction or the Partial Oxidation of Methane (POM) reaction. This is attributed to the advantages that DRM offers in comparison with the two alternative reforming reactions, namely the valorization of the two most important greenhouse gases (CH_4, CO_2), the production of syngas with a H_2/CO ratio close to unity which renders it ideal for Fischer-Tropsch reactions to produce synthetic fuels, as well as the ability to directly use biogas deriving from anaerobic digestion of biomass from landfills or sewage refining facilities, which is composed of 50-70 % CH_4 and 25-50 % CO_2 [3,4]. Of great importance, when it comes to the yield of the DRM reaction using supported metallic catalysts, is the nature of the support and the promoters employed. The promotion of Cerium oxide (CeO_2) with rare earth elements (e.g. Pr) improves the ability of CeO_2 to store oxygen [5] but also the lability of the lattice oxygen, thereby diminishing the carbon formed on the surface of the catalyst and facilitating the activation of CO_2. Toward this direction a series of 1 wt.% Ru catalysts supported on mixed oxides $Ce_{0.8}M_{0.2}O_x$ (M: La, Pr, Nd, Eu, Gd, Dy and Er) were synthesized by the wet impregnation method in order to be studied as it concerns their DRM activity. The supports were synthesized via the co-precipitation method [6] with a molecular ratio of Ce:M equal to 80:20. The as synthesized catalysts were characterized with respect to their specific surface area and phase composition employing the BET method and X-ray diffraction technique, respectively. The reducibility of the catalysts was investigated with the TPR-H_2 technique. The catalytic performance tests were performed in the temperature range 550-800 ^oC with a volumetric feed ratio of CH_4: CO_2 equal to 50:50. Ru catalysts supported on $Ce_{0.8}Dy_{0.2}O_x$ and $Ce_{0.8}Gd_{0.2}O_x$ mixed oxide carriers have shown the best results.

References

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