Tuning adsorption properties of $Ga_xIn_{2-x}O_3$ catalysts for enhancement of methanol synthesis activity from CO_2hydrogenation at high reaction temperature

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ABSTRACT

Light olefins can be produced from CO_2 hydrogenation in a single reactor using a combination of a methanol synthesis catalyst and a methanol-to-olefin (MTO) catalyst. However, commercial methanol synthesis catalysts are active at low temperatures (200–260 °C), while MTO reaction is feasible at higher temperatures (>300 °C). Herein, we report the CO_2 hydrogenation to methanol at high temperatures (320–400 °C) over $Ga_xIn_{2-x}O_3$ catalysts. By tuning the Ga/In ratios, phase, crystallinity, pore structure, morphology, electronic properties as well as adsorptive properties of $Ga_xIn_{2-x}O_3$ catalysts can be modified. At the lowest temperature (320 °C), the pure In_2O_3 shows the highest methanol yield. However, the maximum methanol yield declines significantly with increasing reaction temperatures. Incorporation of Ga into the In_2O_3 crystal lattices at $x = 0.4$ ($Ga_{0.4}In_{1.6}O_3$) maximizes the methanol yield at higher reaction temperatures of 340–360 °C. This enhancement can be attributed to an increased binding energy of adsorptive molecules with the catalyst surface to promote the hydrogenation of CO_2 to methanol. Further increasing Ga content ($x > 0.4$) leads to greatly strengthen the binding for adsorptive molecules, resulting in a lower methanol yield and the formation of methane. The surface chemisorbed oxygen is found to be a key factor determining the CO yield.

KEYWORDS

CO_2 hydrogenation; Methanol; Indium; Gallium

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