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CO_2 hydrogenation selectivity shift over In–Co binary oxides catalysts

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The hydrogenation of CO_2 into methanol by renewable H_2 has attracted much attention due to its mitigation of overall CO_2 emissions and the simultaneous production of valuable chemical products. In_2O_3 is a promising catalyst for CO_2 to methanol. Introducing metal elements into In_2O_3 (M/In_2O_3) is one of the main strategies to improve its catalytic performance. However, the mechanism and active sites of the M/In_2O_3 catalytic system remain unclear and need to be further elucidated.

In the presentation, the In_x–Co_y binary oxides catalysts will be introduced for CO_2 hydrogenation to methanol. Much-improved performance and obvious product selectivity shift were observed. The optimized catalyst (In_1–Co_4) showed five times methanol yields than pure In_2O_3. And the cobalt-catalyzed CO_2 methanation activity was significantly suppressed, although cobalt was the majority of the metal element. To unravel the reason for this selectivity shift, detailed catalysts performance evaluation, together with several *in-situ* and *ex-situ* characterizations, were employed on cobalt and In–Co for comparative study. The results indicated CO_2 hydrogenation on cobalt and In–Co catalyst both followed the formate pathway, and In–Co reconstructed and generated a surface In_2O_3-enriched core-shell-like structure under a reductive atmosphere. The enriched In_2O_3 at the surface significantly enhanced CO_2 adsorption capacity and well stabilized the intermediates of CO_2 hydrogenation. CO_2 and carbon-containing intermediates adsorbed much stronger on In–Co than cobalt led to a feasible surface C/H ratio, thus allowing the $*CH_3O$ to desorb to produce CH_3OH instead of being over-hydrogenated to CH_4.

Prof. Limin Guo studied materials science and engineering at Shanghai Institute of Ceramics, Chinese Academy of Sciences. Then, as JSPS postdoctoral fellow, he spent two years (2010–2012) in Department of Chemistry, Tohoku University, Japan. From 2012–2016, he worked as postdoctoral researcher in International Institute for Carbon-neutral Energy Research, Kyushu University, Japan. Since 2016, he is full professor in School of Environmental Science and Engineering/China-European Union School for Clean and Renewable Energy, Huazhong University of Science and Technology, WPI visiting professor in International Institute for Carbon-neutral Energy Research, Kyushu University. Up to now, he has published more than 100 research/review papers.

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