Ru/La$_x$Ce$_{1-x}$O$_y$ composite as an efficient catalyst for H$_2$ production from ammonia decomposition

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Ru doped on a series of La$_x$Ce$_{1-x}$O$_y$ composites by the deposition–precipitation (DP) method was studied in NH$_3$ decomposition to generate CO$_x$–free H$_2$. N$_2$ physisorption, CO chemisorption, XRD, XPS, XAS, ICP–OES, HAADF–STEM, TPR, and TPD analysis were used to investigate the catalyst properties and to elucidate the beneficial properties for the reaction. Density functional theory (DFT) calculations provided insights into how the La addition promoted the high recombinative N$_2$ desorption capacity leading to the high NH$_3$ decomposition activity of the Ru–based catalysts at low temperatures. Among the tested catalysts, Ru/La$_{0.33}$Ce$_{0.67}$ exhibited superior catalytic activity and excellent stability. This study provides direct proof that the combination of the relatively small Ru size with strong interaction with the composite La$_x$Ce$_{1-x}$O$_y$ by the DP method and the optimized acidity–basicity property for the enhancement of both H$_2$ and N$_2$ desorption is essential to the development of Ru–based catalysts for NH$_3$ decomposition.