Supplementary material

A novel BEA-type zeolite core-shell multiple catalyst for hydrogen-rich gas production from ethanol steam reforming

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Fig. 1S(A) and (B) present CH$_4$- and CO-TPD profiles, respectively, obtained over the 2.5Fe2.5Cu-SB@NB, 5Cu-SB@NB, 5Fe-SB@NB and SB@NB catalysts. Studying the adsorption of CH$_4$ and CO molecules is very important in ESR system because it can determine if the SMR and WGS reactions of CH$_4$ and CO, respectively, as intermediates occur.$^1$ As the CH$_4$-TPD shown in Fig. 1S(A), all catalysts consist mainly of two peaks, one is located in the 100-200 °C range, and the other at approximately 370 °C. One peak at 300 °C in the 2.5Fe2.5Cu-SB@NB and 5Cu-SB@NB catalysts was observed, which might be due to CH$_4$ adsorption on the surface of metallic Cu. On the other hand, a broad peak at high temperatures above 430 °C was observed in 2.5Fe2.5Cu-SB@NB and 5Fe-SB@NB. This peak might be induced by the amount of CH$_4$ adsorbed on metallic Fe or Fe oxide. In addition, CH$_4$ adsorption increased significantly in the 2.5Fe2.5Cu-SB@NB catalyst because of the synergy effect of Cu and Fe components. In Fig. 1S(B), the profile shapes of CO adsorption in all samples were similar to those of CH$_4$-TPD, but the adsorption areas were different and the adsorbed CO molecules increased slightly at lower temperatures in all samples. Generally, CO desorption is accompanied by a significant production of CO$_2$, but there is also a peak of CO at low temperatures (100-180 °C), probably due to the physically-adsorbed CO molecules. In particular, in the case of 2.5Fe2.5Cu-SB@NB had being divided in three peaks (160, 410 and 505 °C), while for the 5Cu-SB@NB, 5Fe-SB@NB and SB@NB catalysts, these peaks were recorded at 156, 317 and 410 °C, and 150, 320 and 405 °C, and °C, respectively. Significantly, two peaks in the 5Cu-SB@NB, 5Fe-SB@NB and 2.5Fe2.5Cu-SB@NB catalysts were separated at the range of 250-480 °C. This result implied that CO molecules were more easily adsorbed on the surfaces of the Cu and Fe catalysts than on the mono-metallic Ni catalyst. Moreover, the 2.5Fe2.5Cu-SB@NB catalyst could be confirmed the areas of the peak being larger if compared with other catalysts. Normally, the adsorption of reactants could increase the catalytic activity. Therefore, the SMR and WGS reactions are more efficient over 2.5Fe2.5Cu-SB@NB catalyst, attributing to the strong adsorption of CH$_4$ and CO molecules.

References