Influence of Lanthanum Addition on Catalytic Properties of PtSnK/Al₂O₃ Catalyst for Isobutane Dehydrogenation

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Figure S1 shows NH$_3$-TPD profiles of the different catalysts.

*Figure S1. NH$_3$-TPD profiles of the different catalysts: (1) Al$_2$O$_3$; (2) Sn/Al$_2$O$_3$; (3) K/Al$_2$O$_3$; (4) PtSnK/Al$_2$O$_3$; (5) PtSnKLa(0.9 wt%)/Al$_2$O$_3$; (6) PtSnKLa(1.5 wt%)/Al$_2$O$_3$*
Figure S2 shows stability test of PtSnKLa(0.9 wt%)/Al₂O₃ catalyst in the isobutane dehydrogenation at 590°C.

Figure S2. Stability test of PtSnKLa(0.9 wt%)/Al₂O₃ catalyst in the isobutane dehydrogenation at 590°C. (1) isobutane conversion; (2) isobutene selectivity.
Figure S3 shows TPO profiles of the different catalysts: (1) PtSnK/Al$_2$O$_3$; (2) PtSnKLa(0.3 wt%)/Al$_2$O$_3$; (3) PtSnKLa(0.6 wt%)/Al$_2$O$_3$; (4) PtSnKLa(0.9 wt%)/Al$_2$O$_3$; (5) PtSnKLa(1.2 wt%)/Al$_2$O$_3$; (6) PtSnKLa(1.5 wt%)/Al$_2$O$_3$.

Figure S3 exhibits the TPO profiles of the coked catalysts. According to the profiles, two successive peaks representing two different carbon deposits are displayed. Generally speaking, the first peak at about 480 °C represents the coke deposited on the surface of the metal, whereas the other peak at high temperature represents the one deposited on the surface of Al$_2$O$_3$ support.$^1$

The profile shows that a majority of the carbon deposits for PtSnK/Al$_2$O$_3$ catalyst covers the active metal and only a small proportion covers the surface of the support. When lanthanum is added to the PtSnK/Al$_2$O$_3$ catalyst, both the peaks area of the carbon deposits decreases evidently, which is favorable for the reactant gas to contact the active sites to improve the catalytic activity. On the basis of Afonso et al.,$^2$ the coke formation on the catalyst refers to several processes: (1) successive dehydrogenation/cyclization of alkyl chains; (2) n-alkane oligomerization; (3) Diels-Alder type reactions. Olefins are primary precursors of the mechanism of coke formation and the inherent acidity of the carrier can promote the undesirable reactions such as cracking/isomerization, therefore increase the carbon deposits. Following the mechanism, it is suggested that the change of Pt active sites and catalyst acidity can
affect the coke formation evidently.

However, with the continuous addition of La (1.2wt% and 1.5wt%), the peaks move towards the higher temperature. Excessive addition of La increases the acid intensities (based on the analysis of NH$_3$-TPD), which is disadvantageous to the desorption of olefins from the catalyst surface, leading to the polymerization of the products.$^3$

