Activity and characteristics of regeneration of Pt-Sn/Al2O3 catalyst for propane dehydrogenation with conditions

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Abstract: The propane dehydrogenation promotes side reactions to light alkanes and catalyst deactivation due to coke deposition, thereby significantly reducing the activity of the catalyst. Coke deposition is the main cause of deactivation, and there is a growing interest in regeneration of catalysts for activity recovery. It is important to regenerate the material so that the substance supported on the catalyst can be restored to its activity by redispersion.
In this study, we investigated the effect of liquid chlorine compound on the catalytic regeneration. XRD, CO-chemisorption and TEM analyses were performed to confirm the change of the metal particles. It was confirmed that the activity of the catalyst was restored by the HCl treatment in the regeneration process after the catalytic reaction.

Keywords: regeneration, HCl treatment, activity recovery

1. Introduction (11-point boldface)

Propane dehydrogenation is an endothermic reaction based on thermodynamic principles and requires high temperatures of 550-650℃ and low pressures. High temperature process can increase the propylene yield but accelerate the side reaction into the light alkane and deactivation of the catalyst due to coke deposition. Therefore, after the reaction, the catalyst must undergo a regeneration process.

2. Experimental (or Theoretical)

To investigate the effect of hydrochloric acid on the regeneration process of catalyst for propane dehydrogenation reaction, 3Pt-4.5Sn/Al_2O_3 catalyst was prepared. After the incipient wet impregnation method, it was dried (110℃, 12hr) and calcined (600℃, 4hr). The catalytic dehydrogenation reaction was carried out by reducing the catalyst while raising the temperature to 600°C and measuring the reaction activity of the catalyst while flowing propane, hydrogen and nitrogen over the catalyst. After regeneration of the catalyst, the concentration of HCl(5%, 15%, 25%, 35%) was differently treated with HCl after coke burning and then dried (110, 12hr) and calcination (600, 4hr). After the regeneration, the propane dehydrogenation reaction performance was measured once more, and the relative conversion and relative selectivity were obtained in comparison with the first cycle's activity. CO-chemisorption was applied to investigate the Pt dispersion of the catalysts treated with HCl, and the physicochemical properties of the catalysts were analyzed by XRD and TEM.

3. Results and discussion

As a result of the reaction experiment, the selectivity showed similar value. At the concentration of HCl 35%, the relative activity was 1.28, indicating that the activity after regeneration was higher than that of the existing activity. As a result of CO-chemisorption, it can be seen that the regenerated catalysts were redispersed through regeneration rather than the fresh catalyst. The catalysts regenerated by HCl treatment at the concentration of HCl 15% showed the next best value of 6%. It can be seen that the activity recovery is higher as dispersion of Pt is higher and the particle size of Pt is smaller. HR-TEM analysis and FFT analysis and XRD show the type of PtSn alloy can be different with HCl treatment and regeneration procedure.

Figure 1. Relative activity with HCl concentration

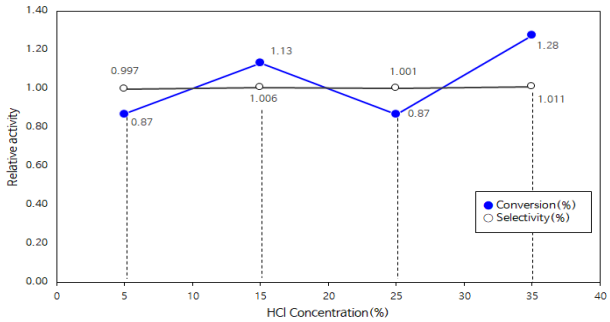
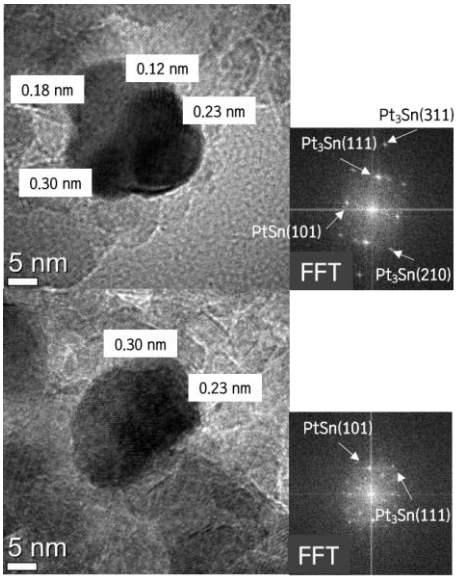


Table 1. CO chemisorption by HCl concentration

Catalyst	Amount of CO adsorbed (cm^3 STP g^{-1}cat)	Metal dispersion (%)
3Pt-4.5Sn/fresh	0.16	4.63
3Pt-4.5Sn/coke burning	0.14	4.03
3Pt-4.5Sn/HCl(5%)	0.09	2.57
3Pt-4.5Sn/HCl(15%)	0.24	6.85
3Pt-4.5Sn/HCl(25%)	0.18	5.08
3Pt-4.5Sn/HCl(35%)	0.24	7.09

Figure 2. TEM by HCl concentration



4. Conclusions

3Pt-4.5Sn/ Al_2O_3 catalyst was prepared and used to investigate the effect of propane dehydrogenation catalyst on regeneration conditions. As a result of measuring the regeneration activity of the catalyst according to the concentration of HCl, it showed the best activity recovery when treated with 35% HCl. Catalysts treated with 35% HCl seem to have a high dispersion and a significant reduction in particle size. It can be confirmed that redispersed than fresh catalyst. Therefore, it was confirmed that the effect of coke burning and HCl treatment affects redispersion of the catalyst by TEM and XRD and CO-chemisorption analysis.

References

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