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Ultra-deep Hydrodesulfurization and Aromatics Hydrogenation of Diesel Fuel over a Pd-Pt Catalyst Supported on Yttrium-modified USY

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Bimetallic palladium-platinum catalyst supported on yttrium-modified ultrastable Y (USY) zeolite, Pd-Pt/Y-USY, showed high activity and stability for deep hydrodesulfurization (HDS) and hydrodearomatization (HDA) of diesel fuel. In model reactions, the HDS activity based on rate constant increased as much as 5.3 times and HDA activity increased as much as 1.9 times after yttrium modification. The deeper hydrogenation of 4, 6-dimethyldibenzothiophene (4, 6-DMDBT) allowed the following HDS reactions to be promoted over the Pd-Pt/Y-USY catalyst. The adsorptive interaction between Pd-Pt/Y-USY and basic tetralin was weaker than that between Pd-Pt/USY and tetralin. Under reaction conditions of P = 4.9 MPa, $WHSV$ = 4 h^{-1} and T = 280°C for hydrotreating desulfurized gas oil feedstock, Pd-Pt/Y-USY successfully removed a large part of 4, 6-DMDBT and also almost all refractory alkyl-substituted sulfur compounds, which are supposed to be more difficult to hydrodesulfurize. The hydrotreated product after 216 h on stream contained 28 wtppm sulfur and 8 wt% aromatics. NH_3 adsorption analyses showed that yttrium modification decreased the number of strong acidic sites with little change in the total acidic sites. This modification in acidity could help to minimize the excessive hydrocracking which causes carbonaceous deposits, and to increase the nitrogen tolerance. Scanning transmission electron microscopy (STEM) analyses clearly showed that yttrium modification suppressed the agglomeration of Pd-Pt phases, which might be linked to the high stability of the Pd-Pt/Y-USY catalyst. Therefore, Pd-Pt/Y-USY catalyst is quite

promising as a second stage catalyst for the integrated two-stage reformulation of gas oils.

Keywords: Palladium-platinum catalyst, USY zeolite, Yttrium modification, Hydrodesulfurization, Aromatics saturation, Diesel fuel

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