Electronic Supplementary Information

Structure and performance of V_2O_5-WO_3/TiO_2-SiO_2 catalyst derived from blast furnace slag (BFS) for DeNOx

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1. Preparation of mesoporous TiO_2-SiO_2 supports

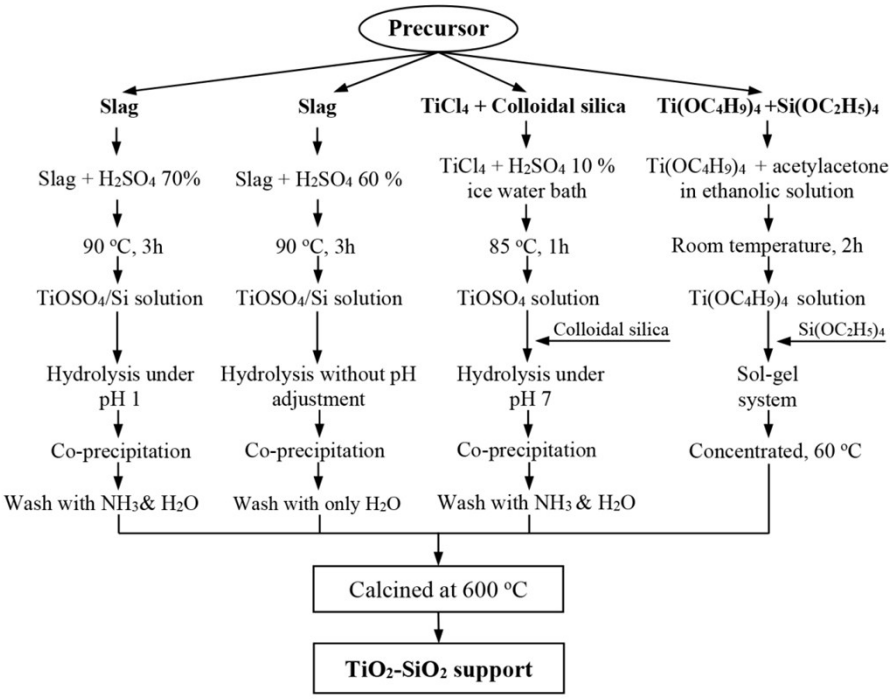

Figure S1. A schematic presentation of different technical routes for preparing TiO_2-SiO_2 supports.

The first support denoted as S-BFS-1 was prepared from blast furnace slag (BFS) by, in succession, digesting the slag in 70 wt.% H_2SO_4 at 90 °C for 3 h, hydrolyzing the resulting solution containing $TiOSO_4$/Si at pH=1 and 110 °C for 5 h, washing the obtained H_2TiO_3 slurry using H_2O, then aqueous NH_3 (10 wt.%) and further H_2O, and finally drying the filter cake to obtain the TiO_2-SiO_2 support. The second BFS-based support with different amounts of Al_2O_3/Fe_2O_3/SO_4^{2-} dopants (S-BFS-2) was obtained via a similar procedure but its slag digestion used 60 wt.% of H_2SO_4, hydrolysis did not have any pH adjustment, and slurry washing to pH=7 used only distilled water.

For catalytic activity comparison, commercial Ti and Si precursors were also used to

synthesize TiO_2-SiO_2 by co-precipitation and sol-gel methods. $TiCl_4$ and colloidal silica were employed to get S-CP-$TiCl_4$ by co-precipitation method. A certain amount of $TiCl_4$ solution was slowly added to a solution of 10 wt.% H_2SO_4 at 0 °C in an ice-water bath with vigorously stirring. The mole ratio of H_2SO_4 to $TiCl_4$ was maintained at 4.0. A grey solution that was formed after about half an hour, was heated to 60 °C to get a clear solution. Then colloidal silica was introduced into the clear solution and kept there for 1 h. Later, aqueous $NH_3.H_2O$ was added drop by drop to the solution until the pH value reached about 7 and the color of the solution changed to white. At last, the white solution was aged for 12 hours and the resulting precipitate was filtered, washed using distilled water and aqueous NH_3, and finally dried at 110 °C. For TiO_2-SiO_2 prepared by sol-gel method from $Ti(OC_4H_9)_4$ and $Si(OC_2H_5)_4$ precursors, the procedure goes as follows: firstly $Ti(OC_4H_9)_4$ was stabilized by adding acetylacetone ($C_5H_8O_2$) and the solution was diluted with ethanolic solution, with some $Si(OC_2H_5)_4$ added at last. After stirring for 2 h at room temperature, the sol was concentrated at 60 °C and subsequently dried at 110 °C to obtain S-SG-Organic. Finally, all prepared samples having the similar SiO_2 content (about 9.3 wt.%) were calcined at 600 °C for 4 h in air to obtain the TiO_2-SiO_2 supports for tests.

2. HR-TEM and SEM-EDS images for V_2O_5-WO_3/TiO_2-SiO_2 catalysts

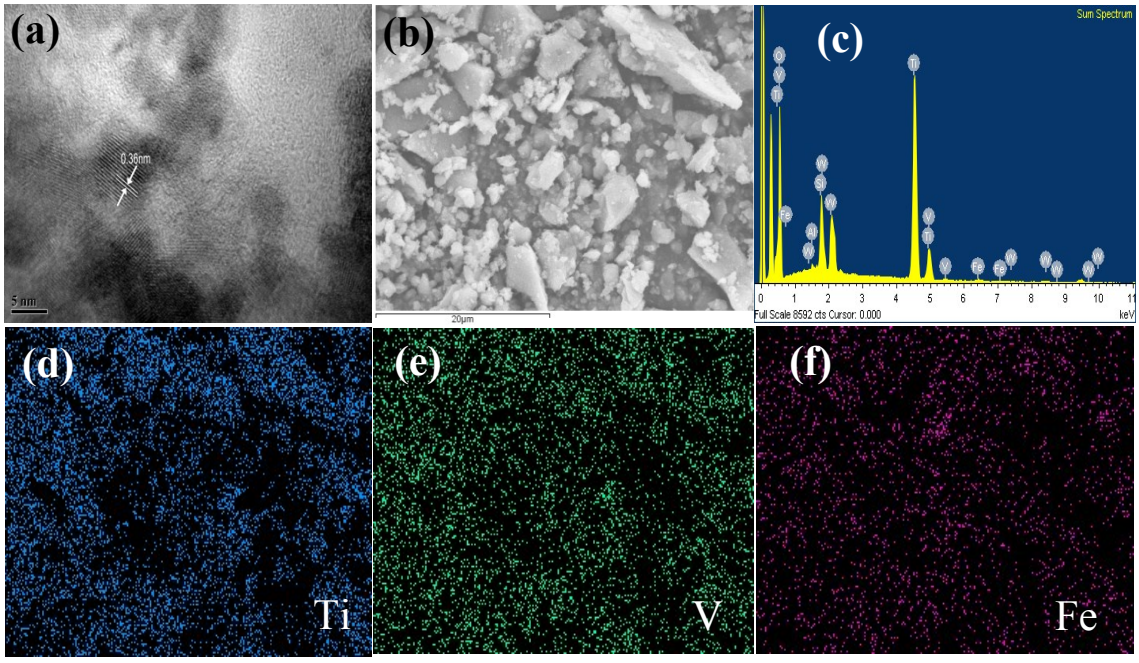

Figure S2. (a) HR-TEM image, (b) SEM image, (c) EDS spectra, and (d-f) EDS mapping of Ti, V and Fe elements for BFS-1 catalyst.

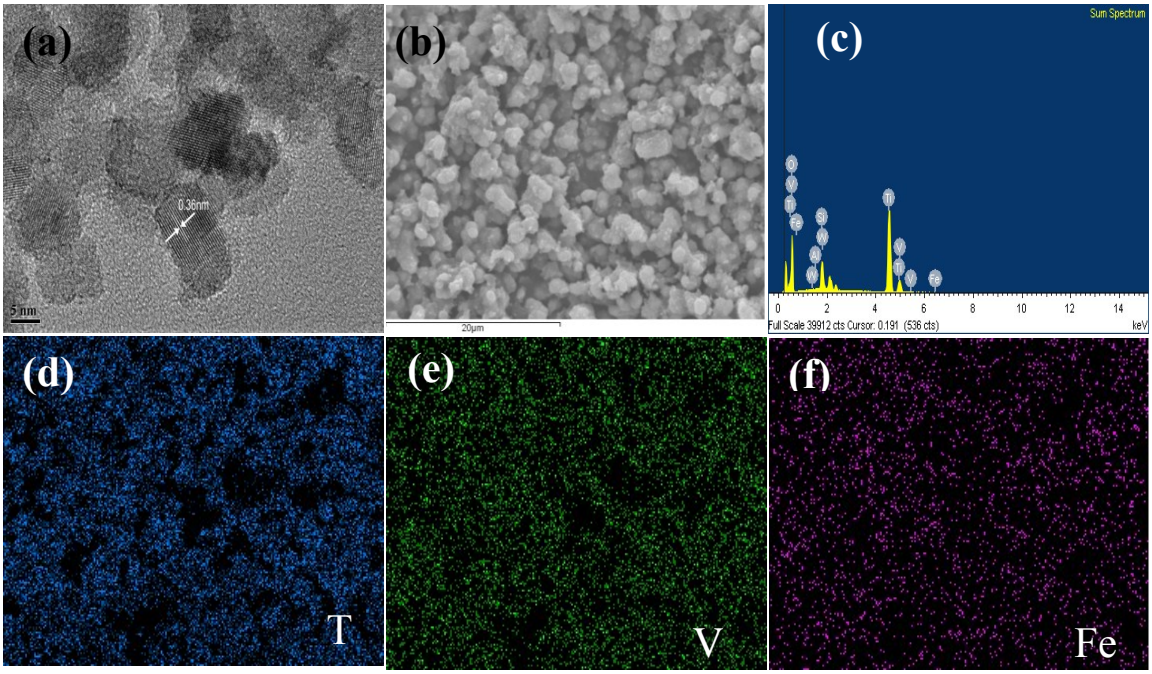

Figure S3. (a) HR-TEM image, (b) SEM image, (c) EDS spectra, and (d-f) EDS mapping of Ti, V and Fe elements for BFS-2 catalyst.

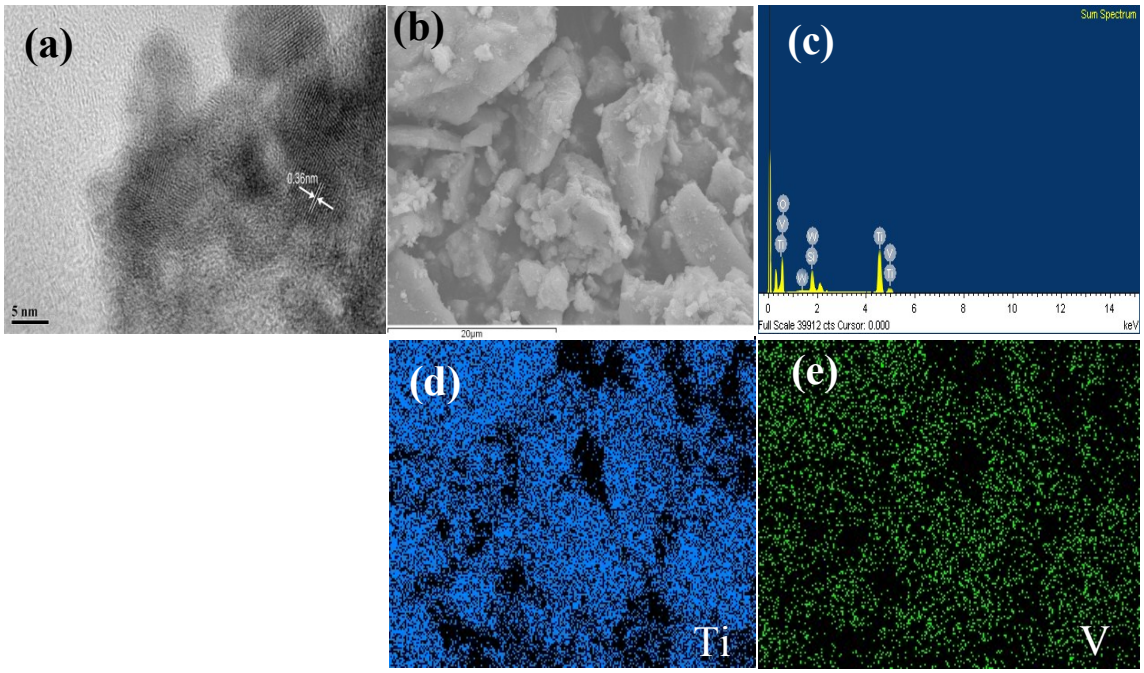

Figure S4. (a) HR-TEM image, (b) SEM image, (c) EDS spectra, and (d,e) EDS mapping of Ti and V elements for CP-$TiCl_4$ catalyst.

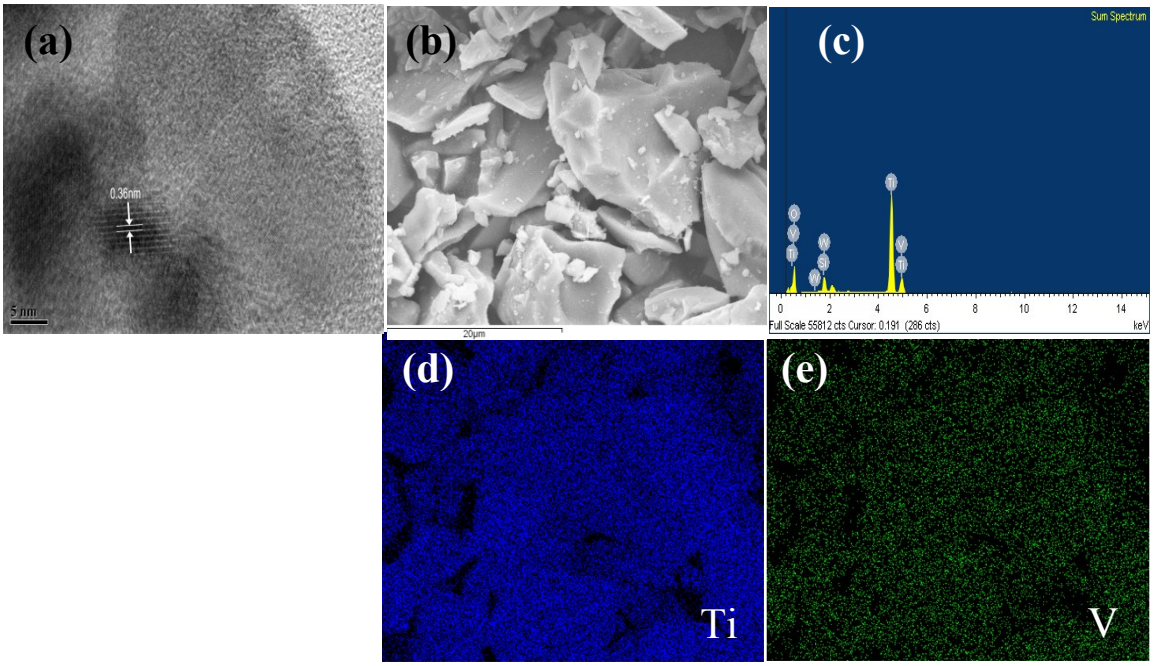

Figure S5. (a) HR-TEM image, (b) SEM image, (c) EDS spectra, and (d,e) EDS mapping of Ti, V elements for SG-Organic catalyst.

Figures S2-S5 presented HR-TEM images (a), SEM images (b), EDS spectra (c), and EDS mapping of Ti, V, Fe elements (d-f) for BFS-1, BFS-2, CP-$TiCl_4$ and SG-Organic catalysts, respectively. The HR-TEM images shown in Figure S2-S5 (a) demonstrated the presence of anatase TiO_2 in all the prepared catalysts by a d-spacing of 0.360 nm that corresponds to the (101) lattice fringes of anatase TiO_2 (d = 0.352 nm, JCPDS No. 21-1272). The SEM images (S2.-S5 (b)) and their corresponding EDS spectra (S2-S5 (c)) further confirmed that these catalysts were composed of Ti, Si, V, W, O, Al, Fe elements. Furthermore, Figures S2-S5(c-e) suggested the incorporation of main active V into TiO_2 lattice and its high dispersion on the catalyst surface. For the slag-based catalysts, EDS mapping in Figures S2-S3 (f) indicated that the Fe element evenly dispersed on the scanning area, meaning the excellent distribution of Fe on the surface of slag-based catalysts. Also, one can conclude from the EDS mapping and spectra that ferric elements were not aggregated, which correlates with the lack of Fe_2O_3 peak in the XRD pattern of supports (see Figure 2).