In Situ FTIR Study of Vanadia Catalyst Activity

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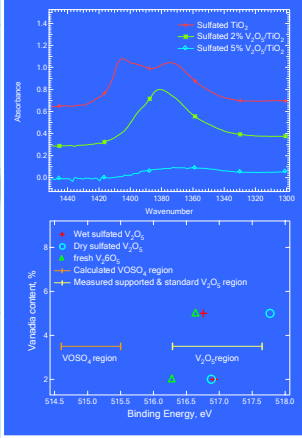
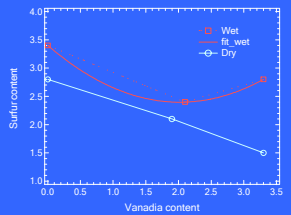
Objectives

- Understand formation mechanism of sulfate species on both the support, TiO_2, and the catalyst, V_2O_5/TiO_2.
- Understand how sulfate species affect adsorption and reaction on vanadium oxide species on the catalyst surface.
- Determine the effects of moisture, vanadia content, and time on sulfation.

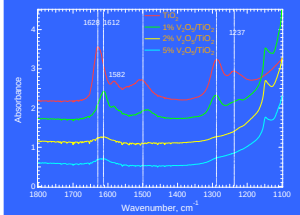
Sulfation site identification

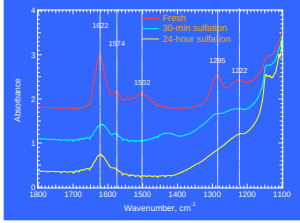


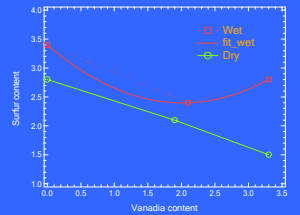


- IR sulfate peak intensities decrease with increasing vanadia contents
- XPS analysis confirms FTIR results
- Vanadia remains at oxidation state 5 before and after sulfation
- Vanadia does not sulfate during sulfation

Surface site identification



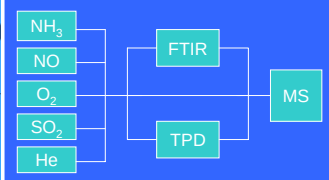


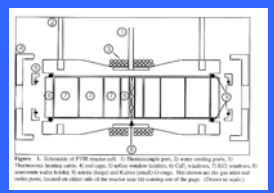


- $NO + O_2$ adsorption intensities decrease with increasing
  - •vanadia content
  - •sulfate content
- Sulfate content and IR peak intensities decrease with increasing
  - •Vanadia content
- NO, Vanadia, and Sulfate compete for same surface site –OH group

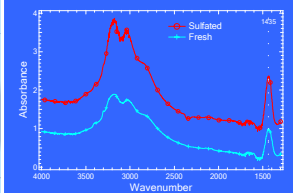
Experimental design

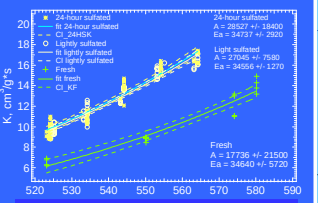
- Sulfation conditions: 380 °C, 1 atm, 3000 ppm SO_2, 5% O_2, helium (balance) , dry or moist gas
- Sulfation sample: TiO_2, 2% V_2O_5/TiO_2, 5% V_2O_5/TiO_2
- NO reduction acitivty test conditions: 250-290 °C, 1 atm, 700ppm NH_3 and NO, 5% O_2, helium (balance), 200,000GHSV, no limitation of film and pore diffusion
- NO reduction test sample: fresh and contaminated 1% V_2O_5/TiO_2 with or without sulfation

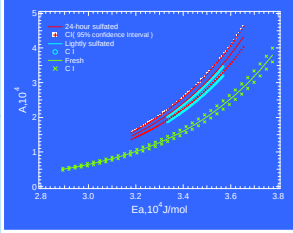


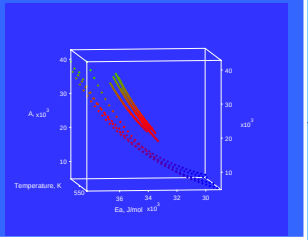


Sulfate impact on vanadia catalyst behavior









Conclusion

Surface sulfate forms on titania sites, not vanadia sites

- Sulfation intensifies NH_3 adsorption
- Sulfation enhances NO reduction by increasing the number of Brønsted acid sites without affecting reaction mechanism
- NO, V, and S compete for the same surface sites –OH group

Future Work

- Combine FTIR study with temperature-programmed desorption and MS to analyze quantities of species adsorbed/desorbed.
- Investigate contaminates (Ca, K, and Na) effects on V_2O_5/TiO_2 properties: sulfation, NH_3 adsorption, activity, etc.

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