
Chiara Nannuzzi¹

Janssens V.W.T.², Berlier G.¹

¹University of Turin, Via Pietro Giuria, 7, 10125, Turin, Italy

²Umicore ApS, Kogle Allè 1, 2970, Hørsholm, Denmark

chiara.nannuzzi@unito.it

Dispersion studies of VO_x/WO_x/TiO₂ catalysts: the importance of combining Raman and IR spectroscopies

The emission of nitrogen oxides (NO_x) produced by fuel combustion poses a significant threat to both air quality and public health [1,2]. To address this problem, the current technology used to comply with the imposed restrictions is based on the selective catalytic reduction of NO_x, with NH₃ (NH₃-SCR) [3], where the NO_x and NH₃ react in the presence of O₂, to produce N₂ and H₂O [3–5]. The commonly used catalysts for NH₃-SCR in stationary plants and heavy-duty diesel vehicles are based on vanadium oxide supported on anatase TiO₂ with tungsten (W) used as promoter (VO_x/WO_x/TiO₂) [5].

This work utilizes Raman and infrared (IR) spectroscopy to study the dispersion of VO_x and WO_x species on the TiO₂ surface, a critical factor for catalyst performance.

Raman spectroscopy is commonly employed to evaluate the dispersion of VO_x and WO_x species on the TiO₂ surface and the corresponding monolayers through the identification of V₂O₅ and WO₃ crystalline phases, but distinguishing between V-O-V and V-O-W signals in mixed VO_x/WO_x/TiO₂ systems is challenging.

The use of resonance-enhanced Raman signals, alongside complementary IR data, provides valuable insights into surface species distribution.

Our results indicate crystalline phases of V₂O₅ and WO₃ at surface densities of 6.4 V and 5.3 W atoms/nm², respectively, as measured by Raman, while IR-based titration of Ti⁴⁺ surface sites on TiO₂ with CO molecules, yielded slightly different values of 5.7 V and 5.2 W atoms/nm². Interestingly, WO₃ appears before full surface coverage of TiO₂, suggesting early agglomeration, while V₂O₅ emerges after complete surface saturation. These findings highlight the necessity of combining both Raman and IR techniques to fully characterize the dispersion of oxides on catalyst surfaces, providing a more accurate understanding of monolayer formation and catalytic behavior.

References

- [1] C.D.Koolen, G. Rothenberg, *ChemSusChem*, 12 (2019) 164-172.
- [2] D.R. Rondinel-Oviedo, N. Keena, R.I. Citron, H.B. Perets, O. Aharonson, J.E. Jonson, J. Borken-Kleefeld, D. Simpson, A. Nyiri, M. Posch, C. Heyes, *Environ. Res. Lett.* 12 (2017) 094017.
- [3] K. Skalska, J.S. Miller, S. Ledakowicz, *Sci. Total Environ.* 408 (2010) 3976–3989.
- [4] P. Forzatti, *Appl. Catal. A Gen.* 222 (2001) 221–236.
- [5] U. Asghar, S. Rafiq, A. Anwar, T. Iqbal, A. Ahmed, F. Jamil, M.S. Khurram, M.M. Akbar, A. Farooq, N.S. Shah, Y.K. Park, *J. Environ. Chem. Eng.* 9 (2021) 106064.