The generality of surface vanadium oxide phases in mixed oxide catalysts

5 January 2011, by Chris Keturakis

In the spirit of the physicist’s pursuit of a ‘theory of everything,’ Israel E. Wachs, the G. Whitney Snyder Professor of Chemical Engineering at Lehigh University, has published a paper entitled "The generality of surface vanadium oxide phases in mixed oxide catalysts."

Different types of metal oxide materials employed as oxidation catalysts. (Chris Keturakis/Lehigh University)

It is common knowledge throughout the heterogeneous catalysis community that reactions take place at the surface of metal oxide catalysts, rather than in the bulk (inside) of the catalyst. Thus, the goal of fundamental catalysis research focuses on developing structure-activity relationships based on the surface metal oxide phases present, ultimately allowing for the rational design of improved heterogeneous catalysts from the ground up.

This paper discusses research on vanadium oxide-containing catalysts performed in the past 30 years using a variety of techniques: IR and Raman vibrational spectroscopies, CH₃OH-temperature programmed surface reaction (TPSR) spectroscopy and steady-state oxidation reactions. The paper shows that surface VOₓ phases, two-dimensional vanadium oxide overlayers, are a general phenomenon in vanadium-containing mixed oxide catalytic materials and that they also control the catalytic properties.

Mixed oxide catalysts consist of many different metal oxide arrangements, as depicted in the figure. Bulk oxides consist of either pure oxides (e.g., V₂O₅) or mixed oxides that can exist as either stoichiometric compounds (e.g., FeVO₄) or as solid solutions (e.g., VₓTi₁₋ₓO₂). Supported metal oxides involve the impregnation of metal oxides onto high surface area supports (e.g., pure oxides, mixed oxides, zeolites, or molecular sieves). Polyoxometalate (POM) clusters are nanometer sized mixed oxide clusters consisting of a central XO₄ unit (PO₄, SiO₄, etc.) that are surrounded by 12 or 18 O=MO₅ units (M = V, Mo, W, Cr, etc.).

Supported Metal Oxides

On pure oxide supports, isolated O=VO₃ species are almost exclusively present at low surface coverages (1/2...

This document is subject to copyright. Apart from any fair dealing for the purpose of private study or research, no part may be reproduced without the written permission. The content is provided for information purposes only.