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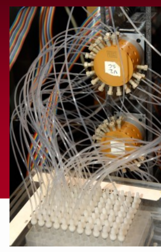

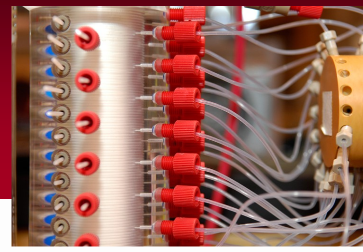

The Gene and Linda Voiland School of

Chemical Engineering and Bioengineering

2015 Seminar Series

Monday, January 26, 2015

12:00 p.m. Wegner G1

Charles H.F. Peden

Institute for Integrated Catalysis

Pacific Northwest National Laboratory

Working at Pacific Northwest National Laboratory (PNNL) since 1992, and promoted to Laboratory Fellow in 2000, Dr. Charles H. F. (Chuck) Peden has an international reputation for his research studies of the surface and interfacial chemistry of inorganic solids in general, and the heterogeneous catalytic chemistry of metals and oxides (reaction mechanisms, materials) in particular. His current research programs address numerous aspects of the physical and chemical properties of oxide surfaces. These include fundamental experimental studies of the geometric and electronic structure of oxide surfaces, as well as more applied studies that are developing oxides as catalytic materials. A particular focus in this latter area is on developing the scientific underpinning of several new catalytic technologies that are viable candidates for exhaust emission control from diesel-fueled vehicles. Dr. Peden is also currently a principal investigator and program leader of a new multi-institution research effort, funded by the Basic Energy Sciences Division of the U.S. Department of Energy, aimed at developing a fundamental understanding of oxide-supported transition metal oxide catalysts.

Dr. Peden is best known as a leader in the development of the mechanisms of automobile exhaust catalytic reactions. For this work, he has used a number of ultra-high vacuum surface science techniques to, for example, identify and explain several very unusual mechanistic features of the heterogeneous chemistry occurring in a catalytic converter including: a) the dramatically different CO oxidation reaction mechanism on ruthenium metal relative to other late transition metals; b) the structure sensitive selectivity of the NO reduction reaction on rhodium metal; c) deactivation of rhodium metal at high oxygen partial pressures; and d) the significantly different CO oxidation reaction mechanism over oxidized rhodium metal.

Some Current and Future Challenges for Catalytic Vehicle Emission Control

The abatement of environmentally harmful compounds (e.g., hydrocarbons (HC), oxides of nitrogen (NOx) and sulfur (SOx), and CO), emitted from mobile or stationary power sources, has been a remarkable success story for the catalysis R&D community [1]. In particular, for mobile (vehicle exhaust emission control) applications, the “three-way” catalyst that is the active component of the “catalytic converter”, a standard component on automobiles in the US and Europe for over 30 years, has contributed to a remarkable drop in emissions of CO, HC and NOx from gasoline-powered vehicles. We now take for granted the dramatic improvements that the introduction of the catalytic converter technology has made in air quality and, correspondingly, human health. However, this technology is not suitable for application on so-called “lean-burn” engines that operate at high air/fuel ratios, including diesel-powered vehicle engines. Although these engine technologies are inherently more fuel efficient than “stoichiometric” gasoline engines, their wide-spread application for vehicles has been limited by the inability of the three-way catalyst to reduce NOx emissions at these high air/fuel ratios. As such, in the last 10-15 years a significant R&D focus has been on this problem of “lean-NOx” emission control. Again, significant achievements have been realized with the very recent commercialization of two new nano-materials-based catalytic emission control applications for diesel-powered vehicles: the NOx storage/reduction (NSR) catalysts and the selective catalytic reduction (SCR) with ammonia using metal-exchanged zeolites. Because these are such newly introduced technologies, many challenges remain to improve performance, enhance stability, and lower costs. Indeed, many of the practical concerns with these new “lean-NOx” catalyst technologies stem from a relatively poor fundamental understanding of catalyst structure/activity and reaction mechanisms. More profoundly, highly novel operating modes for internal combustion engines (ICEs) are being researched in order to meet the very stringent new demands for fuel efficiency (e.g., US “CAFE” standards for average miles/gallon are scheduled to increase dramatically over the next 10-15 years). These new ICE engine operation modes, while highly fuel-efficient, result in much lower exhaust temperatures than current engines; temperatures so low that it is hard to imagine how the current catalytic emission control technologies will be able to function [2]. Thus, both ‘evolutionary’ and ‘revolutionary’ technology development challenges can be foreseen for the catalyst R&D community. This presentation will highlight both the challenges for currently practiced technologies, and some of the significant new catalytic materials and process challenges that will need to be addressed in the near future.

References

[1] R.M. Heck and R.J. Farrauto, “Catalytic Air Pollution Control: Commercial Technology.” Van Nostrand Reinhold (New York) 1995.

[2] M. Zammit, C.L. DiMaggio, C.H. Kim, C.K. Lambert, G.G. Muntean, C.H.F. Peden, J.E. Parks, and K. Howden, “Future Automotive Aftertreatment Solutions: The 150°C Challenge Workshop Report.” U.S. Drive Report (Southfield, MI) 2013, PNNL-22815.