



**Curriculum Vita**  
**Robert J. Farrauto, Ph.D.**  
**Professor of Professional Practice**  
**Earth and Environmental Engineering**  
**Columbia University in the City of New York**  
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**Personal**

Birth Date: November 22, 1941 /New York City

Gender: Male

Citizenship: United States of America

Status: Married with two children/six grandchildren, two step-daughters

**Education**

Ph.D. Chemistry, 1968, Rensselaer Polytechnic Institute, Troy, New York

Advisor: David Aikens

B.S. Chemistry, 1964, Manhattan College, Bronx, New York

**Current Employment Experience**

**September 2012- present: Professor of Professional Practice, Columbia University, Earth and Environmental Engineering Department, Columbia University in the City of New York, 10027 USA**

Currently supervising four PhD and four master's degree students engaged in catalysis research.

Catalytic air pollution control, hydrogen generation, carbon dioxide capture and catalytic conversion.

I currently teach two graduate (1, 2) and two undergraduate courses (3,4)

- 1) "Catalysis for Emission Control"
- 2) "Industrial Catalysis"
- 3) "Environmental Control Pollution Reduction"
- 4) "Senior Design (Capstone)"

## **Industrial Employment**

### **2008-retired August 2012:**

Research Vice President, BASF Catalysts (formerly Engelhard),

25 Middlesex-Essex Turnpike, Iselin, New Jersey 08830

Managed a team developing catalysts and adsorbents for the Hydrogen Economy

### **1995-2008:**

Research Fellow/Manager of Hydrogen and Fuel Cell Technology, BASF (formerly Engelhard)

Managed a team of scientists and engineers developing catalysts for hydrocarbon fuel processing for the generation of hydrogen and fuel cells. Team commercialized 25 new products for world wide markets.

### **1990-1995:**

Principle Scientist of Manager of Diesel Technology, Engelhard (now BASF)

Principle Investigator of a team of 20 scientists and engineers in the development and commercialization of the first monolith-diesel oxidation catalyst for heavy duty trucks, buses and light duty vehicles for the US, Asian and European market. Total revenues have exceeded \$600 million. Developed new nitric oxide catalysts and hydrocarbon traps for automobile catalytic converters

### **1976-1990:**

Manager of Chemical and Environmental Catalysts, Engelhard (now BASF)

Managed a team of scientists and engineers developing advanced three way catalysts for abating emissions from passenger car vehicles serving the US, Asian and European market. Managed a team in the development of improved chemical catalysts for the production of nitric acid. Supervised a research team developing and commercializing new precious metal catalysts for the hydrogenation of a wide variety of organic functional groups. Was responsible for establishing a materials characterization group serving the entire worldwide company needs for catalyst and materials product.

### **1974-1976**

Research Scientist, Gulf Oil, Harmarville, PA

Catalyst development in upgrading petroleum and coal liquids to useful fuels and chemicals.

## **1968-1974**

Research Scientist at Corning Glass Works, Corning New York  
Catalyst development for base metal emission control catalysts

## **Awards**

- 2016 Distinguished Faculty Teaching Award, Columbia University in the City of New York
- 2008 Ciapetta Lectureship Award sponsored by the North /American Catalysis Society
- 2005 Catalysis and Reaction Engineering Practice Award from the American Institute of Chemical Engineers
- 2001 International Precious Metal Institute (IPMI) Award for Outstanding Contributions in the field of precious metal catalysis
- 1998 Cross Canada Lectureship Award sponsored by the Canadian Catalysis Society
- 1995 Teaching Excellence Award from the New Jersey Institute of Technology

## **Society Memberships**

- Program Chairman for the 19<sup>th</sup> North American Catalysis Society Meeting, Philadelphia, PA 2005
- American Institute of Chemical Engineers (AIChE)
- American Chemical Society (ACS)
- International Precious Metal Institute

## **Plenary Lectures and from 2006-Present**

- XX Reaction Engineering December 2012 “New Catalysts and Reactor designs for the Hydrogen Economy”, Luxembourg
- Mitsui Keynote lectureship Award, March 2009: “Automobile Catalysis: Past, Present and Future”. Tokyo, Japan
- Idecat, Porguellos, France “The Road to the Hydrogen Economy,” May 2007
- Natural Gas Conversion Conference, Natal, “The Convergence of Fundamental and Applied Catalysis in Solving Industrial Problems.” May 2007
- Mittasch Conference, BASF Ludwigshafen, Germany, “Advances in Environmental and Petroleum Catalysis by Engelhard” November 2006
- 13<sup>th</sup> Nordic Conference on Catalysis, Goteborg, Sweden “New Catalysts for the Hydrogen Economy” October 2008
- 50<sup>th</sup> Anniversary of the Japanese Catalysis Society “From the Internal Combustion Engine to the engine of the future: The Fuel Cell” November 2008

### **Books authored**

Heck, Ronald and Farrauto, Robert J. “*Catalytic Air Pollution Control: Commercial Technology*” Third edition, Wiley and Sons, New York, NY, NJ 2009. Two precious editions.

Bartholomew, Calvin. and Farrauto, Robert J. “*Fundamentals of Industrial Catalytic Processes*” Second edition, Wiley and Sons, New York, NY, 2006

Farrauto, Robert J., Dorazio, L. and Bartholomew, C., “*Introduction to Catalysis and Industrial Catalytic Processes*” Wiley and Sons, New York, NY, 2016

### **US Patents: Commercialized Technology**

US 5,462,907, “CeO<sub>2</sub> containing diesel oxidation catalyst”, **R.J. Farrauto**, K. Voss and R.M. Heck. Commercial product for Cummins Engine Company and others with approximate revenues 10’s of millions of US dollars. This was the first diesel oxidation catalyst with no precious metal commercialized.

US 5,627,124, “Ceria-alumina catalyst,” **Farrauto, R.** K. Voss and R.M. Heck.  
See US 5,462,907 (above)

US 5,491,120, “Oxidation catalyst with bulk ceria, a second metal oxide, and platinum,” K. Voss, B. Yavuz, **R. Farrauto** and M. Galligan. Commercial product for Volkswagen with approximate revenues 10’s of millions of US dollars.

US 6,274, 107, “Zeolite containing oxidation catalyst and method of use,” B. Yavuz, K. Voss, M. Deeba, J. Adomaitis, **R.J. Farrauto**, See US 5,491,120

US 6, 248, 684, “Zeolite containing oxidation catalysts and method of use,” B. Yavuz, K. Voss, M. Deeba, J. Adomaitis, **R. Farrauto**, Commercial product see US 5,491,120

US 5,108,730, “Room temperature lite off catalyst,” H.C. Lee, **R.J. Farrauto**, and W.R. Hatfield. Commercial product but revenues unknown

US 4,863,893, “Low temperature lite off catalyst,” **R.J. Farrauto**, H.C. Lee and W.R. Hatfield. Commercial product but revenues unknown

US 5,756,053, “System and method for abatement of food cooking,” J. Hoke, M. Larkin, R. J. **Farrauto**, K. Voss, R. Whitely and L.M. Quick. Commercial product for fast food restaurants. Revenues unknown

US 5,580,535, “System and method for abatement of food cooking fumes,” J. Hoke, M. Larkin, **R.J. Farrauto**, K. Voss, R. Whitely, and L.M. Quick. Commercial product but revenues unknown

44. US 6,849,572, "Process for generating hydrogen-rich gas," S. Hwang and **R. Farrauto**. Revenues unknown.

US 6,977,067 (2005), "Selective Removal of olefins from hydrocarbons feed streams," Shin Hwang and **Robert J. Farrauto**. Revenues unknown

US 7,074,375 (2006), "Method of desulfurizing a hydrocarbon gas by selective partial oxidation and adsorption," Lampert, J., Hwang, S., Shore, L. and **Farrauto, R.** Revenues unknown

US 7,569,511 (2009) "Catalyst Composition for Alcohol Steam Reforming," Castelano, C., Keromer, G. Liu, Y and **Farrauto, R.J.** Revenues unknown

US 7, 901,565 "Reforming a Sulfur-containing-hydrocarbon using a sulfur tolerant catalyst," Giroux, T., Waterman, E. and **Farrauto, R.J.** Revenues unknown

US 8,444,402, "Preferential oxidation catalyst with Pt, Cu and Fe," Shore, L. and **Farrauto R.J.** Revenues unknown

#### **54 US Patents (from 1972-Present);**

1. US 3,743,525 "Hydraulic cements from glass powders", R.J. Farrauto and W.L. Haynes.
2. US 3,720,527 "Fast setting hydraulic cements from glass powders," R.J. Farrauto and W.L. Haynes.
3. US 3,870,658 "Copper chromite / alumina catalyst having high temperature stability," R.J. Farrauto, K. Hoekstra, and R.D. Shoup.
4. US 4,416,916, "Thin film solar energy collector," K. Aykan, R.J. Farrauto, R. Lanam and C. Jefferson.
5. US 4,321,300, "Solar energy collector," R.J. Farrauto, C.F. Jefferson and R.D. Lanam.
6. European Patent 0161743, "Nitric oxide abatement catalyst," R.M. Heck, C.D. Keith and R.J. Farrauto.
7. US 4,863,893, "Low temperature lite off catalyst," R.J. Farrauto, H.C. Lee and W.R. Hatfield. Commercial product but revenues unknown

8. US 5,108,730, "Room temperature lite off catalyst," H.C. Lee, R.J. Farrauto, and W.R. Hatfield. Commercial see 7.
9. US 4,893,465, "Process conditions for operation of the ignition catalyst for natural gas combustion," R.J. Farrauto, T. Kennelly, M.C. Hobson and E. Waterman.
10. US 5,214,912, "Process conditions for operation of ignition catalyst for natural gas combustion," R.J. Farrauto, T. Kennelly, E. Waterman and M.C. Hobson.
11. US 5,126,300, "Praseodymium-Palladium binary oxide catalyst, methods of combustion and regeneration," T. Chou, t. Kennelly and R.J. Farrauto.
12. US 5,102,639, "Praseodymium-Palladium binary oxide catalyst compositions containing the same and methods of use," T. Chou, T. Kennelly and R.J. Farrauto.
13. US 5,196,617, "Direct catalytic hydro-dechlorination of toxic organics in wastewater," S. Kovenklioglu, E. Balko, J. Hoke, R.J. Farrauto and G. Gramiccioni.
14. US 5,216,875, "Catalysts for combustion of natural gas," T. Kennelly and R.J. Farrauto.
15. US 5,378,142, "Combustion process using catalysts containing binary oxides," T. Kennelly, R.J. Farrauto, T. Chou, and J. Hochmuth.
16. US 5,474,441, "Catalyst configuration for catalytic combustion," R.J. Farrauto, J. Feeley, D. Simone, Y.K. Lui and T. Kennelly.
17. US 5,462,907, "CeO<sub>2</sub> containing diesel oxidation catalyst," R.J. Farrauto, K. Voss and R.M. Heck. Commercial product for Cummins Engine Company with approximate revenues 10's of millions of US dollars
18. US 5,491,120, "Oxidation catalyst with bulk ceria, a second metal oxide, and platinum," K. Voss, B. Yavuz, R.J. Farrauto and M. Galligan. Commercial product for Volkswagen with approximate revenues 10's of millions of US dollars
19. US 5,552,360, "Substrate configuration for catalytic combustion systems," R.J. Farrauto.
20. US 5,580,535, "System and method for abatement of food cooking fumes," J. Hoke, M. Larkin, R.J. Farrauto, K. Voss, R. Whitely, and L.M. Quick. Commercial product but revenues unknown
21. US 5,627,124, "Ceria-alumina catalyst," R.J. Farrauto, K. Voss and R.M. Heck. See 17.
22. US 5,750,458, "Combustion catalysts containing binary oxides," T. Chou, T. Kennelly and R.J. Farrauto.

23. US 5,756,053, "System and method for abatement of food cooking," J. Hoke, M. Larkin, R.J. Farrauto, K. Voss, R. Whitely and L.M. Quick. Commercial product for fast food restaurants. See 20.
24. US 5,776,423, "Trimetallic zeolite catalyst for NO abatement," J. Feeley, R.J. Farrauto, M. Deeba and J. Lampert.
25. US 5,792,436, "Method for using a regenerable catalyst trap," J. Feeley, R.J. Farrauto, M. Deeba and J. Lampert.
26. US 5,804,155, "Basic zeolites / HC traps," M. Deeba and R.J. Farrauto.
27. US 5,863,851, "Combustion catalysts containing binary oxides and processes using the same," T. Kennelly, T. Chou, and R.J. Farrauto.
28. US 5,874,057, "Lean NO<sub>x</sub> catalyst/trap method," M. Deeba, J. Feeley and R.J. Farrauto.
29. US 5,968,861, "Trimetallic zeolite catalyst and method of NO<sub>x</sub> abatement using the same," J. Feeley, M. Deeba and R.J. Farrauto.
30. US 6,074,973, "Catalyzed hydrocarbon trap material and method," J. Lampert, M. Deeba and R.J. Farrauto.
31. US 6,080,377, "Method of abating NO<sub>x</sub> and a catalytic material," M. Deeba, J. Feeley and R.J. Farrauto
32. US 6,150,291, "Method of abating NO<sub>x</sub> and preparation of catalytic materials," J. Feely, M. Deeba and R. Farrauto
33. US 6,153,160, "Catalytic oxidation method", K. Voss, B. Yavuz, R. Farrauto, M. Galligan. Commercial product for Volkswagen. See 18.
34. US 6,248,684, "Zeolite containing oxidation catalysts and method of use," B. Yavuz, K. Voss, M. Deeba, J. Adomaitis, R. Farrauto Commercial product see 33.
35. US 6,255,249, "Oxidation catalyst and method of use," K. Voss, B. Yavuz, R. Farrauto and M. Galligan. See 33
35. US 6,274,107, "Zeolite containing oxidation catalyst and method of use", B. Yavuz, K. Voss, M. Deeba, J. Adomaitis, R. Farrauto, See 33.

36. US 6,319,484, "Composition for abatement of VOC and apparatus and methods of the same," L. Shore, R. J. Farrauto, M. Deeba, J. Lampert and R. Heck
37. US 6,428,761, "Process for reduction of gaseous sulfur compounds," Larry Shore and R. J. Farrauto
38. US 6,436,363, "Process for generating a hydrogen rich gas," Shinn Hwang and Robert J. Farrauto
39. US 6,559,094, "Method for preparation of catalytic materials for selective oxidation and catalyst members thereof," Olga Korotkikh, Robert J. Farrauto and Andrew McFarland.
40. US 6,471,924, "Method and Apparatus for NO<sub>x</sub> abatement in lean gaseous streams," J. Feeley, R. Farrauto and M. Deeba
41. US 6,541,419, "Process for reduction of gaseous sulfur compounds," Larry Shore and R. J. Farrauto
42. US 6,562,315, "Suppression of methanation in a WGS catalyst," Korotkikh, O., Ruettinger, W. and Farrauto, R. J.
43. US 6,790,432, "Suppression of methanation activity of Platinum group metal water gas shift catalyst," Ruettinger, W. and Farrauto, R. J.
44. US 6,849,572, "Process for generating hydrogen-rich gas," S. Hwang and R. Farrauto
45. US 6,903,050, "Method of preparation of non-pyrophoric copper alumina catalysts," O. Ilinich W. Ruettinger and R. J. Farrauto
46. US 6,913,739, "Platinum group metal promoted copper oxidation catalyst and methods for carbon monoxide remediation," L. Shore, W. Ruettinger, and R. Farrauto
47. US 6,977,067 (2005), "Selective Removal of olefins from hydrocarbons feed streams," Shin Hwang and Robert J. Farrauto
48. US 7,074,375 (2006), "Method of desulfurizing a hydrocarbon gas by selective partial oxidation and adsorption" Lampert, J., Hwang, S., Shore, L. and Farrauto, R.
49. US 7,357,911 "Process conditions for Pt-Re bimetallic for water gas shift catalysts," Ruettinger, W. and Farrauto, R. J.
50. US 7,569,511 (2009) "Catalyst Composition for Alcohol Steam Reforming," Castelano, C., Keromer, G. Liu, Y and Farrauto, R.J.



51. US 8,221,693, "Use of radial flow air injection for preferential oxidation for fuel cells applications," Larry Shore and Robert J. Farrauto.
52. US 7, 901,565, "Reforming a Sulfur-containing-hydrocarbon using a sulfur tolerant catalyst," Giroux, T., Waterman, E. and Farrauto, R.J
53. US 8,444,402, "Preferential oxidation catalyst with Pt, Cu and Fe," Shore, L. and Farrauto R.J.
54. US 8,926,942, "Method and system for generating hydrogen and separation from CO<sub>2</sub>," Castaldi, M. Yegulalp, T and Farrauto, R. J

**Recent Journal Publications: Google Scholar Citation index (August 2017) H =42**

1. Emi Leung, Akiko Shimizu, Katayun Barmak, Robert Farrauto  
"CO oxidation with CuO promoted by Nb<sub>2</sub>O<sub>5</sub>" Catalyst Communications (2017), 97, 42-46
2. Zheng, Q and Farrauto, Robert J. "In situ regeneration of Rhodium in three way catalysts by aqueous ethanol injection for sustained methane emissions abatement" Catalysis Communications 95 (2017) 63-66
3. Wang, S., Shrunk, E., Mahajan, H. and Farrauto, Robert J. "The Role of Ruthenium in CO<sub>2</sub> Capture and Catalytic Conversion to Fuel by Dual Function Materials (DFM)" Catalysts 7 (2017) 88-101
4. Xiang, Wendi, Han, Xioachen, Alstordotter, Jennifer, and Farrauto, Robert J. "Catalysts promoted with niobium oxide for air pollution abatement" Catalysts (2017) 7, 144
5. Leung, Emi, Lin, Qiyuan, Farrauto, R. and Barmak, K "Enhanced oxygen storage and redox properties by niobium-doped oxygen storage materials for three-way automobile exhaust catalytic converters" Catalysis Today in press.
6. Zheng, Qinghe, Farrauto, Robert and Anh Nguyen "Adsorption and Methanation of Flue Gas with Dual Functional Materials: A Parametric Study, Industrial and Engineering Research 55 (issue 24) 6768-6776 (2016)

7. Duyar, Melis, Ramachandran, Arvind, Wang, Christine, Farrauto, Robert J. "Kinetics of CO<sub>2</sub> methanation over Ru/Al<sub>2</sub>O<sub>3</sub> and implications for renewable energy storage applications" *Journal of CO<sub>2</sub> Utilization* 12 (2015) 27-33.
8. Zheng, Qinghe, Farrauto, Robert, Deeba, Michel, Valsamakis, Ioannis, "Part 1: A comparative thermal aging study on the regenerability of Rh/Al<sub>2</sub>O<sub>3</sub> and Rh/Ce<sub>x</sub>O<sub>y</sub> as model catalysts for automotive three way catalysts" *Catalysts* (2015) 5, 1770-1796
9. Zheng, Qinghe, Farrauto, Robert, Deeba, Michel, Part II: Oxidative thermal aging of Pd/Al<sub>2</sub>O<sub>3</sub> and Pd/Ce<sub>x</sub>O<sub>y</sub> in automotive three way catalysts: The effects of fuel shutoff and attempted regeneration" *Catalysts* (2015) 5, 1797-1814
10. Duyar, Melis, S., Trevino, Martha Arellano, and Farrauto, Robert J. "Dual function materials for CO<sub>2</sub> capture and conversion using renewable H<sub>2</sub>" *Applied Catalysis B; Environmental* 168 (2015) 370-376
11. Zheng, Qinghe, Janke, Christiane and Farrauto, Robert J. "Steam reforming of sulfur-containing dodecane on a Rh-Pt catalyst: influence of process parameters on catalyst stability and coke structure" *Applied Catalysis B: Environmental* 160-161 (2014) 525-533
12. Farrauto, R.J. "New Catalysts and Reactor Designs for the Hydrogen Economy" *Chemical Engineering Journal* 238 (2014) 172-177
13. Duyar, M., Farrauto, R. J., Castaldi, M. and Yegalulp, T. "Enhanced Hydrogen Generation in the Water Gas Shift Reaction" *Industrial and Engineering Chemical Research*, 53, (#3) 1064-1072, 2014
14. Janke, C., Duyar, M, Hoskins, M. and Farrauto, R.J. "Catalytic and adsorption studies for the Hydrogenation of CO<sub>2</sub> to Methane, *Applied Catalysis B: Environmental*" 26 June (2014) 184-191
15. Farrauto, R. J. "Low temperature oxidation of methane" *Science* 337 (2012) 659-660
16. Zhang, Q and Farrauto, R. "Methanol steam reforming catalyst for portable power applications" *Applied Catalysis A. General* (2011) 395, 64-70
17. Gruene, P, Belsova, A., Yegalulp, T. Farrauto, R. And Castaldi, M "Dispersed calcium oxide as a reversible and efficient CO<sub>2</sub>-sorbent for intermediate temperatures. *IE and C Research* 50 (2011) 4042-4049
18. Eichelbaum, M., Farrauto, R. J. and Castaldi, M. "The impact of urea on the performance of metal exchanged zeolites for selective catalytic reduction of NO<sub>x</sub> (Part I): Pyrolysis and hydrolysis of urea over zeolite catalysts" *Applied Catalysis* 97 (2010) Issue 1 and 2, 90-97

19. Eichelbaum, M., Farrauto, R. J. and Castaldi, M. "The impact of urea on the performance of metal exchanged zeolites for selective catalytic reduction of NO<sub>x</sub> (Part I): Catalytic, FTIR and NMR studies" Applied Catalysis 97 (2010) Issue 1 and 2, 98-107

**Complete List of Journal Publications (from 1973 to Present):  
Citation Index Google Scholar = 42**

1. R.J. Farrauto and W.L. Haynes, "Cements from glass powders", Amer. Cer. Soc. (Bull) **52** (3), 276 (1973).
2. W. Morgan and R.J. Farrauto, "Active sites on a copper chromite catalyst", J. Catal. **31**, 140 (1973).
3. W. Hertl and R.J. Farrauto, "Mechanism of carbon monoxide and hydrocarbon oxidation on a copper chromite catalyst", J. Catal. **29**, 352 (1973).
4. R.J. Farrauto and B. Wedding, "Poisoning by SO<sub>x</sub> of some base metal oxide auto exhaust catalysts", J. Catal. **33**, 249 (1973).
5. B. Wedding and R.J. Farrauto, "Rapid evaluation of automotive exhaust oxidation catalysts with a differential scanning calorimeter", Ind. Eng. Chem. **13**, 45 (1974).
6. R.J. Farrauto, "Determination and application of catalytic surface area measurements", AIChE J. **70**, 9 (1974).
7. R.J. Farrauto, "Measuring catalytic surface area", Chem. Eng. Progr. **71**(1), 37 (1975).
8. R.D. Shoup, K. Hoekstra and R.J. Farrauto, "Thermal stability of a copper chromite auto-exhaust catalyst", Amer. Cer. Soc. (Bull) **54**(6), 576 (1975).
9. R.J. Farrauto, "Adsorption studies on a nickel alumina methanation catalyst", J. Catal. **41**, 482 (1976).
10. C. Bartholomew and R.J. Farrauto, "Chemistry of nickel-alumina catalysts", J. Catal. **45**, 41 (1976).
11. J. Patzer, R.J. Farrauto, and A. Montagna, "Characterization of coal liquefaction catalysts using 1-methyl naphthalene as a model compound", Ind. Eng. Chem. Proc. Des. Dev. **18**, 625 (1979).
12. R. St. Amand, J. Williams and R.J. Farrauto, "Application of metallorganic deposition for solar energy collectors", American Optical Society (AOS) Proc., 2<sup>nd</sup> Ann. Conf. Sept. (1979).
13. R.D. Lanam and R.J. Farrauto, "Solar absorber coatings", Solar Energy Research (SERI) Proc., 2<sup>nd</sup> Ann. Conf. 1981.

14. R.J. Farrauto and M.H. Hobson, "Catalyst characterization", Encyclopedia of Physical Science and Technology, Academic Press, **2**, 563 (1987).
15. R.J. Farrauto, M.H. Hobson and N. Brungard, "Relationship between catalyst characterization and performance", Catalysis of Organic Reactions, Marcel Dekker, **33**, 177 (1988).
16. R.J. Farrauto, R. McClung and A.B. Stotler, "Precious metals in the petrochemical industry", Proc. 12<sup>th</sup> Intern. Prec. Metals Inst., 1988, pp.13.
17. J.C. Bonacci, R.J. Farrauto, and R.M. Heck, "Catalytic incineration of hazardous wastes", Library for Environ. Sci., Gulf Publishing **1**(4), 130 (1988).
18. C.H. Lee and R.J. Farrauto, "Catalyst deactivation due to transient behavior in nitric acid production", Ind. Eng. Chem. Res. **28**, 1 (1989).
19. R.J. Farrauto and H.C. Lee, "Ammonia oxidation catalyst with enhanced activity", Ind. Eng. Chem. Res. **29**(7), 1125 (1990).
20. D.O. Simone, T. Kennelly, N. Brungard, and R.J. Farrauto, "Reversible poisoning of palladium catalysts for combustion of methane", Appl. Catal. **70**, 87, (1987).
21. R.J. Farrauto, t. Kennelly, E. Waterman and M.H. Hobson, "The catalytic chemistry of supported palladium for combustion of methane", Appl. Catal. **81**(2), 227 (1992).
22. J. Chen, R.M. Heck and R.J. Farrauto, "Deactivation, regeneration and poison resistant commercial catalysts", Catal. Today **11**, 517-545 (1992).
23. R.J. Farrauto and J.J. Mooney, "Reducing truck diesel emissions", Automotive Eng. **100** (2) 19 (1992).
24. R.J. Farrauto and J.J. Mooney, "Effects of sulfur on catalytic diesel oxidation Performance", SAE. 920557, Feb. (1992).
25. R.M. Heck, R.J. Farrauto and H.C. Lee, "Ozone abatement in commercial aircraft", Catal. Today, **13**, 43-58 (1992).
26. S. Kovenklioglu, Z. Coa, D. Shah, R.J. Farrauto and E. Balko, "Direct hydro-dechlorination of toxic organics in waste water", AIChE J. **38**(7), 1003 (1992).
27. T. Yu, H. Shaw and R.J. Farrauto, "Catalytic oxidation of trichloroethylene over PdO catalyst on gamma-alumina", Am. Chem. Soc. Symp. Ser. 495, Catalytic Control of Air Pollution, chap. 11, (1992).

28. Y.Wang, H. Shaw and R.J. Farrauto, "Catalytic oxidation of trace concentrations of trichloroethylene over 1.5% Pt on gamma-alumina", Am. Chem. Soc. Symp. Ser. 495, Catalytic Control of Air Pollution, chap 10 (1992).
29. R.J. Farrauto and R.M. Heck, "Precious metals in industry", Encyclopedia of Chemical Processing and Design, 1992.
30. R.J. Farrauto, R.M. Heck and B.K. Speronello, "Catalysts and the environment", Chem. Eng. News, Sept. 7, 1992, p. 34.
31. R.J. Farrauto, K.E. Voss and R.M. Heck, "A base metal oxide catalyst for reduction of diesel particulates", SAE 932720, Oct. 1992.
32. K.E. Voss, B. Yavuz, C. Hirt, and R.J. Farrauto, "Performance characteristics of a novel diesel oxidation catalyst, SAE. 940239, Feb. 1994.
33. K.E. Voss, J. Lampert, R.J. Farrauto, G. Rice, and A. Punke, "Catalytic oxidation of diesel particulates with base metal oxides", Catalysts for Air Pollution control 3 (CAPOC3), April, 1994.
34. R.J. Farrauto and R.M. Heck, "Precious metals use in environmental catalysis", Intern. Precious. Metals Inst., June 1993.
35. R.M. Heck and R.J. Farrauto, "Catalytic Air Pollution control: Commercial Technology," Wiley and Sons, (1<sup>st</sup> edition, New York, 1994).
36. R.J. Farrauto, M. Larkin, J. Fu and J. Feeley, "Catalytic combustion for ultra-low emissions," Mat. Res. Soc. Symp. Proc. **344**, 101 (1994).
37. V. Bell, J., Feeley, M. Deeba and R.J. Farrauto, "In-situ high temperature studies of NO<sub>x</sub> reduction with propylene over Cu/ZSM-5 catalysts", Catal. Lett. **29**, 15 (1994).
38. M. Deeba, R.J. Farrauto and Y.K. Lui, "Stabilization of Pt on SiO<sub>2</sub> promoted with lanthanum oxide and zirconium oxide", Appl. Catal. A, Gen.: **124**, 339 (1995).
39. J. Feeley, M.Deeba, R.J. Farrauto, G. Beri, and A. Haynes, "Lean NO<sub>x</sub> reduction with hydrocarbons over Ga/S-ZrO<sub>x</sub> and S-GaZr/Zeolite catalyst", Appl. Catal. B, Environ., **6**, 79 (1995).
40. R.J. Farrauto, J. Lampert, M. Hobson, and E. Waterman, "Thermal decomposition and reformation of Pd catalysts, support effects", Appl. Catal. B, Environ., **6**, 263 (1995).
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