

**Resume' for
Bruce F. Monzyk**



**Research Leader
Technology Director, Technology Innovation Team
Chemicals and Advanced Materials Solutions**

Education

Ph.D., Inorganic/BioInorganic Chemistry, Duke University (1980)
Masters, Inorganic Chemistry (with thesis), University of Missouri-Columbia (1976)
Bachelors, Chemistry, University of Missouri-Columbia (1972)

Professional History

Battelle Memorial Institute, 1993-Present
Monsanto Chemical Company, 1980-1993
Areas of Industrial New Process and/or Product Development, especially involving aqueous solution processing of dissolved salts and oxidants

Qualifications

- Development of industrially viable process for large-scale manufacture of low-cost, environmentally compatible, strong oxidant (ferrate(VI) salts)
- Electrochemical manufacturing new or improved processes, e.g., nylon intermediates, hydrogen peroxide, strong oxidants (ferrate(VI), etc.)
- Identification and comparisons of selective, low-cost methods for purifying waters, including environmental, industrial, agricultural, potable, and municipal wastewaters
- Chemical and material process development in separations and in the production and use of strong oxidizers for water purification
- Development of new chemical/material products and devices and manufacturing/fabrication processes for them
- Fundamental science and analytical methodology identification, especially to yield cost effective, environmentally compatible, process development and industrial plant operations
- Forensics: Manufacturing plant process troubleshooting/consulting
- Forensics: Chemical manufacturing process troubleshooting, reactor failure autopsies

- Numerous fundamental laboratory testing performed using perchlorate ion salts relating to the kinetic and thermodynamic equilibrium studies involving toxic metal ions in water solutions
- Hydrometallurgy, e.g., primary and secondary metals extraction including Ga, Ni, Co, RE's, Zn, Fe, ultra-high purity chemicals production (Ga), etc.
- Metal plating, metal surface finishing, surface cleaning, i.e., aerospace, large area cleaning, cleaning operations, cleaning formulations, rust preventatives, etc.
- Waste avoidance processing, pollution prevention (P2), e.g., water treatment and purification, avoidance of chelating agent upsets of water purification/decontamination, and chelated toxic metal treatment/recovery.

Research and Professional Experience

Water Purification Process Development. Dr. Monzyk is experienced in formulating and executing programs designed for the identification, selection, and development of environmentally compatible industrial and waste-water aqueous stream purification, potable (drinking) water production, development of novel but practical and low-cost water purification chemicals and processes, and environmentally benign water decontamination products.

Chemical Process Development. In addition to those mentioned above, he has identified and patented or is patenting new economical waste avoidance industrial processes and materials (e.g., liquid extractants and solid sorbents) for oxygen, hydrogen, ammonia, and carbon dioxide separation and use. He has identified and patented detergent ingredients, formulations, and applications. He has developed, tested, and economically evaluated ammonia gas recovery methods for odor control and for recycling ammonia values within chemical manufacturing plants. Currently, he is leading several programs for the large-scale production and use of the environmentally friendly, one-step water purification reagent ferrate(VI). This technology is anticipated to be applicable at the full range of scales, from home use to large-scale potable water production, including emergency disaster relief and corporate farm waste management.

Pollution Prevention (P2). Dr. Monzyk is experienced in developing new or selecting from conventional separation technologies, identifying chemistry for industrial process stream rejuvenation for recovery/recycle and resulting in waste avoidance/pollution minimization, including waste volume reduction processes for industrial waste treatment plants, waste avoidance, and waste volume reduction. He initiated the hexavalent chrome recovery and reuse P2 process. He has several patents for the nonpolluting surface finishing industrial processes in the areas of nickel and copper plating. Specific projects in P2 include the following:

- **Alternatives to Heavy Metal Plating and Associated Processes Chemistry (Electrolytic and Electroless) and Related Applications to Air Force Weapons Systems.** For an Air Force project, he identified, developed, and demonstrated separations technologies for removing impurities from nickel and chromium plating baths. Results minimized waste by extending the lives of plating baths. The target technologies were selective precipitation and ion exchange. These separation technologies were tested in the laboratory and then demonstrated at Air Force Air Logistics Centers. The Anion Liquid Ion Exchange (A-LIX) process from this task won an R&D 100 Award.
- **Alternatives to Inorganic Corrosion Preventative Maintenance Systems Currently Used on Air Force Weapons Systems.** Dr. Monzyk identified and tested hexavalent chrome replacement and minimization technologies and conducted laboratory and field demonstration/testing of a permanganate alternative.
- **Coatings to Replace Hazardous Chromic Conversion Coatings.** He investigated the recycle/reuse of hexavalent chrome from current operations.
- **Contaminant Recovery and Separations for P2 in Aqueous Streams.** Among the many P2 processes identified and developed, Dr. Monzyk developed a continuous liquid-liquid ion exchange process for removing trace cadmium from a complex iron containing synthetic fiber intermediate aqueous stream. This work was done as part of a waste reduction effort at a major synthetic fiber intermediate chemical plant. This process required the removal of 70 ppm cadmium (Cd) to much less than 0.1 ppm in both the effluent and iron (Fe) co-product. Both metals were then recyclable. The process was demonstrated at the bench and pilot (2 gal/min) scales. He identified and piloted a commodity chemical plant process for Fe (700 ppm) and Cd (70 ppm) recovery and separation to discharge levels (<0.1 ppm) for production of reusable and pure concentrates (percent levels of both) (commercial client)
- Additional waste avoidance research scale projects were performed on arsenic recovery from chloride media produced from PCl_3 and PCl_5 reactor bottoms, trace lead removal from a concentrated nickel chloride process stream, mercury and selenium recovery from pyrometallurgical plant flue dusts, phosphorous plant Treater dust processing for contained values, contaminant nickel removal from cobalt, recovery of antimony sizing agent in a synthetic fiber mill, and recovery and recycle of copper catalyst used to produce vanillin from Kraft process Black Liquor.

Applied Fundamental Chemistry. He has in-depth training and use experience in the technology science fundamentals of separation methods; process chemistry; chemical speciation; aqueous chemistry; and the chemistry of micelles, vesicles, colloids, emulsions, and particulate dispersions. Additional fundamental science areas of expertise include applications of inorganic materials fabrication, performance, and corrosion. In aqueous processing, his skill base includes

metal ion chelating agent selection as well as design and prevention of wastewater treatment process upset prevention by chelating agents, pH control, chemical speciation, etc.

Hydrometallurgy. His technology application expertise includes industrial process production schemes for metal-based products that involve metal separation, purification and recovery from primary and secondary (recovery from waste and recycle) sources, especially using solvent extraction (liquid ion exchange). For much of the technology based on liquid-liquid solvent extraction, he developed new highly selective metal extractants undergoing commercialization by a commercial client. Processes were developed for nickel, cobalt, copper, iron, the rare earths, zinc, cadmium, magnesium, and gallium. In this regard, he identified and developed a commercial proprietary lowest cost process for ultra-high purity (8N) electronic grade gallium from gallium arsenide scrap and parallel processes for secondary and primary gallium recovery from phosphorous furnace Treater dust.

Surface Finishing (SURFIN) and Cleaning. His technology application expertise include surface finishing technologies for metal plating, conversion coating, and cleaning. Dr. Monzyk participated in the development and validation of value-added waste avoidance processes for waste stream minimization/avoidance/rejuvenation of metal cleaning, plating, and stripping baths using chemistry changes, liquid and resin ion exchange separations; absorption; selective precipitation, and other selective chemical conversions. Other schemes provided control of metal impurity effects in oil/water emulsion-based corrosion inhibitors. He has participated in major programs to identify and/or validate alternatives to chromates in corrosion protection and chromium plating as well as ways to continue to use current high performance SURFIN technologies in an environmentally sound manner. He has actively carried out R&D programs in the areas of electrolytic and electroless metal plating, metal pretreatments, and metal conversion coatings. For the metal surface finishing industry, Dr. Monzyk has helped develop electroless copper and nickel metal plating baths along with associated liquid-liquid extraction and membrane-based waste avoidance process technology.

He specifically contributed to the formation of a new business division by providing technical expertise in the development of new electroless plating processes, including the development of complementary "zero discharge" waste avoidance technology and strategy. Such processes were developed for copper, nickel, magnetic cobalt, and also for palladium catalyst systems. In this area, he contributed technical lead and project management of electroless metal plating bath formulation optimization and waste avoidance process chemistry to the commercial products and metallized fabrics for electromagnetic interference (EMI) shielding and to the magnetic security thread (possessing five degrees of security) in international currency notes. He also developed the technology to rejuvenate spent or contaminated nickel strike and cadmium substitute baths. This technology need requires the removal of impurities under conditions where normal ion exchange does not apply, in one step, and with extremely high selectivity (10-200 impurities separated from 60,000 ppm nickel).

Separations. Dr. Monzyk is expert in the applications and hands-on use of separations process chemistry unit operations, e.g., liquid-liquid extraction (liquid ion exchange), membrane (porous metal/metal oxide, SLM, NF, UF, uF, ED, EdeIX) techniques, and ion exchange, including liquid ion exchange, leaching, flotation, precipitation, crystallization, electrowinning, electropurification, and metal sequestration. He has extensive experience in the area of inorganic separations comparing conventional with novel gas/liquid, liquid/liquid and liquid/solid systems. He has developed and patented a series of high performance and highly selective liquid-liquid extractants based on N-alkyl hydroxamic acids. (SLM = support liquid membrane, NF = nanofiltration or negative ion filtration, UF = ultrafiltration, uF = microfiltration, EdeIX = electro deionization, and ED = electro dialysis).

Gas and Odor Control. Dr Monzyk also has worked out process schemes to control odors of noxious gases such as ammonia (R&D100 Award in 1999), including the selective recovery for reuse of such gases as ammonia, carbon dioxide, and sulfur dioxide to trace levels for reuse in industrial processing. He also designed and is patenting a number of schemes for oxygen gas production and hydrogen gas purification. The ammonia recovery technology involved anaerobic digester effluent waters, high ammonia removal fractions by identifying a Battelle-proprietary sorbent based on unique chemistry.

Thermal Chemical Processing. Dr Monzyk has contributed to the thermal recycling of inorganic solid wastes such as gypsum. In performing these tasks, Dr. Monzyk also provided the fundamental science chemical speciation analyses which serve to describe the chemistry involved to support efforts in defining the fundamental cause(s) of problems to use in selecting and assessing nonpolluting process options.

New Product Identification. He formulated, presented, and then executed projects in the areas of high-performance materials, especially high-performance ceramics, bio-technology, separation processes (ion exchange, selective solvent extraction of metals, ion exchange resins, and liquid membranes), and micronutrient carriers. In particular, he developed a novel process for the production of "nano-sized" 70 angstrom particles using apoferritin as a template for high-performance materials, especially high-performance ceramics.

Dr. Monzyk developed a proprietary lowest-cost process for ultra-high purity electronic grade liquid gallium. Also, he developed processes for secondary and primary gallium recovery and took both processes to the semicommercial scale.

He identified new chelation compounds for decreased peroxide consumption in wood pulp bleaching, for perborate bleach stabilization, and for iron micronutrient carriers. He also developed the molding technology that enabled phosphate fiber to be used as plastics reinforcement. After identifying and developing a scaleable electrochemical process for the manufacture of water-soluble potassium ferrate (VI), he verified its usefulness for water purification and corrosion inhibition. He evaluated novel antimicrobials, processes for obtaining chemicals from biomass, and compounds for selective metal extraction.

Commercial Applications of Inorganic Materials. Dr. Monzyk identified, evaluated, and developed many new proprietary products. Applications identification for inorganic salts, inorganic and organic oxidants, and materials fabrication was a major part of this activity. He participated in the development of consumer and industrial applications for phosphates, such as safe inorganic fibers, buffers, electrolytes (including borate) for industrial electrolytic manufacturing, detergent builders and other chelating products, corrosion inhibitors, peracid bleaches, personal care products, food ingredients, etc. His efforts focused on achieving proprietary, highest value-added products needed to justify the up-front new product development efforts as well as new uses for products already in existence to fill plant capacity or to replace sales lost from phased-out products. Portions of this work involved the identification of economical means to purify inorganic salts to allow their application to a broader range of markets or to provide a new lower-cost process for their production. Dr. Monzyk has the fundamental science basis in buffering systems, metal ion complexation, solution chemistry of ions, aqueous solutions chemical speciation modeling, separations, neutralizations, etc. to allow efficient and cost effective process development and screening of potential applications for inorganic materials. For example, Dr. Monzyk helped identify optimized chemical borate ester structures for commercial production of “KA” oil adipic acid precursor.

Consultant Activities. Dr. Monzyk regularly performs consulting tasks for clients in many areas, e.g., water purification, use and corrosion protection processing, hydrogen peroxide industrial use and food production line sterilization processing, reactor failure analyses for large petrochemical manufacturers, O₂ generation options for ambulatory oxygen suppliers, break line failure for automotive manufacturing, and others. He also participates regularly in Battelle “brain storming sessions” to aid clients and groups across Battelle in problem solving, intellectual property capture, proposal generation, white paper generation, and commercialization activities. In 2002 and 2003, he also served on the Advisory Board for the N-methyl pyrrolidone (NMP) process development and commercialization program at Pacific Northwest National Laboratory (PNNL) and currently is serving on one for fuel cell membrane commercialization. He has served as a professional expert witness.

Dr. Monzyk has over 40 issued and several pending patents in these areas; see the section on Publications. He has generated over 100 client reports in appropriate media, summarizing the research results in useful form for easy retrieval and implementation.

Honors and Awards

- Inventor of the Year Award, Battelle, 2005
- Outstanding Technical Achievement Award (Bio-Mimic Artificial Lung), Battelle, 2004
- Key Contributor to Deicer to Cryotech Deicing Technology, Inc., a Battelle license business, 2004; this technology won an *R&D Magazine* R&D100 Award for 2003

- Advisory Board Member, Commercialization of PEM Fuel Cell Membrane, Battelle, 2003-5
- Advisory Board Member, Commercialization of Biobased Lubrication Oils, Battelle, 2003-5
- Advisory Board Member for the Commercialization of a Bio-Based N-methyl pyrrolidone (NMP) Product, Battelle, 2002-2003
- Battelle's *R&D Magazine* R&D100 Award for "Hexavalent Chrome Recovery/Recycle Process," 2002
- Battelle Outstanding Technical Achievement Award, 2003;
- Key Contributor to Velocys, Inc., a Battelle spinoff business, 2002
- Key Contributor to ThermoEnergy, Inc., a Battelle spinoff ammonia recovery business, 2000
- Battelle's *R&D Magazine* R&D100 Award for Ammonia Recovery Process, 1999
- Candidate for Monsanto Fellow, 1993 (transferred to Battelle instead)
- Promoted to the Science Fellow Program as Associate Fellow, Monsanto Company, 1989
- Achievement Award, New Product Development, Monsanto Company, 1986
- Achievement Award, New Product Development, Monsanto Company, 1982
- Award from Duke University Graduate School, 1977-1978
- American Chemical Society, North Carolina Section, Centennial Scholarship, 1977
- Missouri Academy of Science Student Research Award, 1972.

Professional Affiliations and Activities

- Member, American Water Works Association (AWWA)
- Member, American Electroplaters and Surface Finishing (AESF)
- Judge at American Chemical Society (ACS)-Sponsored Metropolitan Columbus Public Schools Science Fair, 2000

- Advisory Board, University of Missouri Chemistry Department, 1985-1993
- Member, The Metallurgical Society of the American Institute of Metallurgical, Material, and Mining Engineers (TMS-AIME) (not renewed in 2003 to join AWWA)
- Member, American Chemical Society, Inorganic Chemistry and Industrial and Engineering Chemistry Divisions (not renewed in 2003 to join AWWA)
- Recruiter for Monsanto, 1982-8/1993
- Coordinator for Monsanto/University Missouri-Columbia collaborative research project on determination of complex stability constants for Monsanto Dequest products
- Secretary, Sigma XI, Monsanto Chapter, 1988-1989
- Founding member of The Planetary Society
- Volunteer, Science Booth, St. Louis Vail Prophet Fair (1985-1991)
- St. Louis Award Chairman, ACS, St. Louis Section, 1984
- Minuteman, ACS, 1980-8/1993.

Publications

Patents (Issued U.S. Patents only unless only intended for foreign issuance. Does not include Applied For or Pending Patent, or numerous ongoing internal company patent Invention Reports).

1. Monzyk, B.; Dasse, K.; Burkle, E.C., "Photolytic Cell for Providing Physiological Gas Exchange", U.S. Patent No. 7,718,144 (May 18, 2010).
2. Monzyk, B. and John H. Brophy., Microchannel Apparatus Capable of Separating Phases and Methods of Using Same", "U.S. Patent No. 7,604,781; (10/20/2009)
3. Monzyk, B., et. al. "Multiphasic Microchannel Reactions", U.S. Pat.7,118,920 (Nov, 10, 2006).
4. Monzyk, B. et. al. "Impact of SO_x and NO_x in Flue Gas on CO₂ Separation, Compression, and Pipeline Transmission", Chap. 17 of "Carbon Dioxide Capture for Storage in Deep Geologic Formations, Vol. 2. (D.C. Thomas and S.M. Benson, Eds.), 2005 (Elsevier, Ltd. Publ.), p 955.
5. Monzyk, B., Nick Conkle, et al., "Method for the Purification, Recovery, and Sporulation of Coccidial Cysts and Oocysts," U.S. Patent No. 6,984,378 (2006).

6. Monzyk, B. et al., "Photolytic Artificial Lung," U.S. Pat 6,866,755 (March 15, 2005).
7. Blonigan, S. J., A.G. Fassbender, R. D. Litt, B. F. Monzyk, and Rachelle Neff "Apparatus and Method for Ammonia Removal from Waste Streams," U.S. Patent 6,838,069 (January 4, 2005).
8. Monzyk, B. et al., "Apparatus for Hydrogen Separation/Purification Utilizing Rapidly Cycled Thermal Swing Sorption," U.S. Patent. No. 6,824,592 (November 30, 2004).
9. Monzyk, B. et al., "Process for Separating a Fluid Component from a Fluid Mixture using Microchannel Process Technology," U.S. Patent 6,652,627 (November 25, (2003).
10. Monzyk, B. et al., "Apparatus and Methods for Separation/Purification Utilizing Rapidly Cycled Thermal Swing Sorption," U.S. Patent No. 6,814,781 (January 21, 2004).
11. Monzyk, B. et al., Electrochemical Ferrate(VI) Production Device and Processes," U.S. Patent Submitted (January 2004).
12. Monzyk, B., B. Sass, J. H. Saunders, R. H. Barnes, N.Gupta, P. R. Webb, and J. A. Stets, "Method of Separating Carbon Dioxide from a Gas Mixture Using a Fluid Dynamic Instability," U.S. Patent 6,582,498 (June 24 2003).
13. Blonigan, S. J., A.G. Fassbender, R. D. Litt, B. F. Monzyk, and Rachelle Neff, "Method for Ammonia Removal from Waste Streams," U.S.Pat 6,558,643 (5/6 /2003).
14. Monzyk, B. et al., "Radioactive Implantable Devices and Methods and Apparatuses for Their Production and Use" (Heart Stent Implants), U.S. Patent Application Publication 2003/0065242 A 1 (April 3, 2003). (Claims Allowed).
15. Monzyk, B. and E. C. Burckle, "Artificial Pulmonary Capillary," WO 03/011359 A2 International Publication Date (February 13, 2003).
16. Monzyk, B. et al., "Apparatus and Methods for Separation/Purification Utilizing Rapidly Cycled Thermal Swing Sorption," U.S. Patent. No. 6,508,862 (January 21, 2003).
17. Monzyk, B. et al., "Methods for Hydrogen Separation/Purification Utilizing Rapidly Cycled Thermal Swing Sorption," U.S. Patent. No. 6,503,298 (January 7, 2003).
18. Conkle, Nick, Sara Kuczek, Bill Samuels, and B. Monzyk, "Biobased Deicing/Anti-Icing Fluids," U.S. Patent 10/374,662 (2003).
19. Monzyk, B. and E. C. Burckle, "Photolytic Oxygenator with Carbon Dioxide and/or Hydrogen Separation and Fixation," Provisional U.S. Serial No. 60/404,978 Filed (August 21, 2002).
20. Monzyk, B., Kurt Dasse, and E. C. Burckle, "Photolytic Cell for Providing Physiological Gas Exchange" (Useful for an Artificial Lung), PCT Serial No. PCT/US02/24319 Filed (August 1, 2002).
21. Monzyk, B. and E. C. Burckle, "Artificial Pulmonary Capillary," PCT Serial No. PCT/US02/24587 Filed (August 1, 2002).
22. Monzyk, B. and E. C. Burckle, "Photolytic Oxygenator with Carbon Dioxide Fixation and Separation," PCT Serial No. PCT/US02/24277 Filed (August 1, 2002).
23. Monzyk, B., "Metal Extractant Solution Comprising N-Ethyl Hydroxamic Acid Chelants and Kerosene Solvent," U.S. Patent No. 5,487,842 (1994).
24. Monzyk, B. F., "Ferritin Analogs," U.S. Patent 5,358,722 (1994). (Method of Preparation of Nanoparticles)
25. Monzyk, B., "N-Ethyl Hydroxamic Acid Chelates," U.S. Patent No.5,328,626 (1994).

26. Monzyk, B., "Methods and Apparatus for Treating Electroless Plating Baths," U.S. Patent No. 5,328,616 (1994).
27. Martyak, N. M., B. F. Monzyk, and Henry H. Chien, "Electroless Nickel Plating Solution," U.S. Patent No. 5,306,334 (1994).
28. Martyak, N. M., B. F. Monzyk, and Henry H. Chien, "Sulfate-Free Electroless Copper Plating Baths," U.S. Patent No. 5,306,336 (1994).
29. Monzyk, B., et al., "Electroless Nickel Plating Solution," U.S. Patent 5,306,334 (1994).
30. Monzyk, B. F., "Ferritin Analogs," U.S. Patent 5,304,382 (1994). (Method of Preparation of Nanoparticles)
31. Martyak, N.M., B. F. Monzyk, and Henry H. Chien, "Apparatus and Methods for Treating Electroless Plating Baths," U.S. Patent No. 5,277,817 (1994).
32. Monzyk, B. et al., "Electroless Nickel Plating Baths," U.S. Patent 5,258,061 (1993).
33. Monzyk, B., "N-Ethyl Alkanohydroxamic Acid Composition for Metal Recovery by Solvent Extraction," U.S. Patent No. 5,174,917 (1992).
34. Monzyk, Bruce F., "Device for Measuring Subsurface Temperatures of Liquid Bodies, Useful for Determining Optimum Fishing Locations," U.S. Patent No. 5,072,540 (1992)..
35. Monzyk, Bruce, F., "Device for Measuring Subsurface Temperatures of Liquid Bodies, Useful for Determining Optimum Fishing Locations", U.S. Patent No. 5,065,539 (1991).
36. Monzyk, Bruce F., "Gallium Purification," U.S. Patent No. 5,030,427 (1991).
37. Monzyk, Bruce F., "Ultra Fine Ferritin Analog Particles and Their Use in the Manufacture of High-Performance Ceramics," World Patent No. 91/02704 (1991).
38. Coleman, J.P., C.R. Graham, and B.F. Monzyk, "Gallium Complexes: Solvent Extraction of Gallium," U.S. Patent No. 4,943,646 (1990).
39. May, B. H., F. G. Zutterman, H. H. Nijs, J.P. Coleman, and B. F. Monzyk, Hydroxamate Bleaching Stabilizers Especially for Laundering," European Patent 384,911 (1990).
40. May, B.H., F. G. Zutterman, H. H. Nijs, J.P. Coleman, and B. F. Monzyk, "Stabilized Compositions Containing Peroxygen Compounds for Bleaching Textiles and Pulp," European Patent No. 384,911 (1990).
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42. Coleman, J.P., C. R. Graham, and B. F. Monzyk, "Gallium Complexes and Solvent Extraction of Gallium," U.S. Patent No. 4,943,646 (1990).
43. Monzyk, Bruce F., "Device for Measuring Subsurface Temperatures of Liquid Bodies, Useful for Determining Optimum Fishing Locations," U.S. Patent No. 4,883,365 (1990).
44. Coleman, J.P., C. R. Graham, and B. F. Monzyk, "Succinyl Dihydroxamic Acids," U.S. Patent No. 4,939,299 (1990).
45. Monzyk, Bruce F. and Arthur R. Henn, "Solvent Extraction of Cobalt Using Hydroxamic Acids," U.S. Patent No. 4,882,132 (1989).
46. Coleman, James P. and Bruce F. Monzyk, "Oxidative Dissolution of Gallium Arsenide and Separation of Gallium from Arsenic," U.S. Patent No. 4,759,917 (1988).
47. Coleman, J.P., C.R. Graham, and B.F. Monzyk "Gallium Complexes and Solvent Extraction by Chelating Extractants," U.S. Patent No. 4,741,887 (1988).

48. Monzyk, B.F. and A. R. Henn, "(N-Alkyl Alkanohydroxamato) Cobalt (II/III) Complexes: Useful for Metal Separations," U.S. Patent No. 4,567,284 (1986). {NOTE: Need to still add 30 more patent references (see BFM files)}.
49. Bruce F. Monzyk, F. Michel Von Fahnstock, James K. Rose, H. Nick Conkle, Ming Wang, Satya P. Chauhan, Ruey K. Bruce, Tenisha Highsmith, "Water Purification," U.S Patent No. 10,494,270 (2019).
50. Yawu T. Chi, Scott G. Moffatt, Mikhail Khramov, Ranjeeth Reddy Kalluri, Bruce F. Monzyk, Soundar Ramchandran, Marty Alan Lain, Maruthi Sreekanth Pavini, "Catalyst Compositions and Process for Direct Production of Hydrogen Cyanide in an Acrylonitrile Reactor feed Stream," U.S Patent No. 20,190,009,252 (2019).
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53. Bruce F. Monzyk, Derek R. Heiss, "Processes for Forming Metal Oxide Films on Substrates Using Amino Acids," U.S Patent No. 20,160,201,197 (2016).
54. Bruce F. Monzyk, Tenisha Highsmith, Paul J. Usinowicz, Niharika Chauhan, Ann Lane, Rick Peterson, Slawomir Winecki, "Process Water Treatment Using Liquid-Liquid Extraction Technology," U.S Patent No. 20,150,298,992 (2015).
55. Bruce F. Monzyk, "Apparatus and Methods of Providing Diatomic Oxygen(O) Using Ferrate(VI)- Containing Compositions," U.S Patent No. 8,944,048 (2015)
56. Bruce F. Monzyk, F. Micheal Von Fahnstock, James K. Rose, H. Nick Conkle, Ming Wang, Satya P. Chauhan, Ruey K. Bruce, Tenisha Highsmith, "Water Purification," U.S Patent No. 20,140,217,024 (2014).
57. Bruce F. Monzyk, Jerad A. Ford, John T. Stropki, Davd N. Clark, Vinay V. Gadkari, Katherine P. Mitchell, "Corrosion Resistant Primer Coating," U.S Patent No. 87,22,147 (2014).
58. Bruce F. Monzyk, Micheal J. Murphy, Chad Cucksey, F. Micheal Von Fahnstock, Andrew J. Savage, David N. Clark, "Ferrate(VI)-Containing Compositions and Methods of Using Ferrate(VI)," U.S Patent No. 8,663,607 (2014).
59. Bruce F. Monzyk, Paul J. Usinowicz, Derik R. Heiss, Vinay V. Gadkari, John T. Stropki, "Formulations and Methods to Remove Hexavalent Chrome Contamination," U.S Patent No. 20,140,023,555 (2014).
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61. Bruce F. Monzyk, Chad M. Cucksey, Timothy S. Rennick, Bran J. Sikorski, Martha W. McCauley, "CO2 Sorbent Composition With O2 Co-Generation," U.S Patent No. 20,130,167,840 (2013).

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63. Bruce F. Monzyk, Robert D. Giammar, Ada Cowan, "Fibers Containing Ferrates and Methods," U.S Patent No. 20,130,034,594 (2013).
64. Bruce F. Monzyk, Micheal J. Murphy, Chad Cucksey, F. Micheal Von Fahnestock, Andrew J. Savage, David N. Clark, "Ferrate(VI)-Containing Compositions and Methods of Using Ferrate(VI)," U.S Patent No. 20,110,268,672 (2011).
65. Bruce F. Monzyk, Russell R. Greene, Chad M. Cucksey, John A. McArthur, F. Micheal Von Fahnestock, Steven C. Lorence, Micheal J. Murphy, Brian J. Blackstone, Thomas A. Malloy, IV, "Decontaminant," U.S Patent No. 8,034,253 (2011).
66. Bruce F. Monzyk, Jerad A. Ford, John T. Stropki, David N. Clark, Vinay V. Gadkari, Katherine P. Mitchell, "Corrosion Resistant Primer Coating," U.S Patent No. 20,110,200,754 (2011).
67. Bruce F. Monzyk, Kurt Dasse, "Photolytic Artificial Lung," U.S Patent No. 7,914,479 (2011).
68. Bruce F. Monzyk, Battelle Memorial Institute, "Oxygen Generation for Battlefield Applications," U.S Patent No. 2,142,684 (2012).
69. Bruce F. Monzyk, Battelle Memorial Institute, "Carbon Dioxide Removal from Whole Blood By Photolytic Activation," U.S patent No. 7,909,788 (2011).
70. Bruce F. Monzyk, Battelle Memorial Institute, "Photolytic Generation of Hydrogen Peroxide," U.S Patent No. 20,090,074,611 (2009).
71. Bruce F. Monzyk, Battelle Memorial Institute, "Power Device and oxygen Generator," U.S Patent No. 20,090,061,267 (2009).
72. Bruce F. Monzyk, Battelle Memorial Institute, "Breathing Air Maintenance and Recycle," U.S Patent No. 20,090,220,388 (2009).
73. Bruce F. Monzyk, Kurt Dasse, "Photolytic Artificial Lung," U.S Patent No. 2,002,330,932 (2003).

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