Nanoscale Zerovalent Iron Particles For Environme

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SUMMERS DOWNS

Surface Modified Nanomaterials for Applications in Catalysis Springer This volume provides comprehensive up-to-date descriptions of the principles and practices of in situ chemical oxidation (ISCO) for groundwater

remediation based on a decade of intensive research, development, and demonstrations, and lessons learned from commercial field applications.
Calcium-Based Coating on the Surface of Nanoscale Zero-Valent Iron (Nzvi) for Improvement of Its Stability and Transport in Environmental Remediation Academic Press
The sorption of aqueous uranium onto nanoscale zero-valent iron particles has been, studied in the present work. The research has determined both the mechanisms and rates of reaction under a range of geochemical and redox conditions applicable to natural waters: Sorption experiments using uranium contaminated groundwater taken from the Lisava Uranium Mine, Banat, SW Romania and synthetic surrogate solutions were tested using a variety of analytical techniques including: inductively coupled plasma mass spectrometry, inductively coupled atomic emission spectrometry, Raman spectroscopy, X-ray diffraction and X-ray photoelectron spectroscopy. The results provide clear evidence that nanoscale zero-valent iron particles are highly effective for the rapid removal of aqueous uranium. Two mechanisms have been determined: (i) Adsorption followed by reductive precipitation. Aqueous hexavalent uranium IS adsorbed and then chemically

reduced by metallic and/or ferrous iron, resulting in the surface mediated precipitation of tetravalent uranium oxide. (ii) Adsorption, complexation and/or incorporation. Aqueous hexavalent uraruum IS removed from solution without chemical reduction via surface mediated adsorption, complexation and/or structural incorporation/entrapment with ferric iron oxides and/or hydroxides. The long-term removal and retention of uranium on different iron-based nanopowders was also studied. For waters containing appreciable concentrations of complexing agents, namely dissolved carbonate, significant uranium re-release was recorded. The mechanism is attributed to the ingress of atmospheric oxygen and other associated gases (including C02) back into the experimental solutions, facilitating the reformation of thermodynamically stable uranyl carbonate complexes. To improve uranium retention the effect of vacuum annealing on the structure and surface chemistry of nanoscale magnetite, zero-valent iron and zero-valent iron-nickel particles was tested. Results highlight the key role that changes in nanoparticle crystallinity, surface oxide stoichiometry and impurity phases (H20, hydroxide, carbon, etc.) have on the material's aqueous corrosion and associated uranium removal efficacy.

Results provide clear evidence that vacuum annealing can be applied to improve the aqueous reactivity of both nanoscale zero-valent iron and nanoscale zero-valent iron-nickel particles. *Life Cycle Assessment of Non-aqueous Phase Trichloroethene Treatment with Nanoscale Zerovalent Iron Particles in a Biphasic Reactor* Royal Society of Chemistry "This thesis investigates the applicability of surface functionalization techniques for nanoscale zerovalent iron (NZVI) particles for improving the degradation of a toxic, common groundwater contaminant, trichloroethene (TCE). Although NZVI has emerged as a promising environmental remediation agent in the past decade and has the potential to transform a number of chlorinated organic pollutants to non-toxic end products, factors such as loss of electrons to reactions with water, formation of passivating oxide layers on NZVI surface and aggregation of NZVI to micron-sized particles pose significant challenges in the application of NZVI for TCE remediation. This research investigated techniques for the modification of NZVI surface with secondary metals (e.g. palladium), inorganic ions (e.g. sulfide), polyelectrolytes and surfactants (e.g. carboxymethylcellulose and rhamnolipid), and solid supports (e.g.

activated carbon) to enhance reactivity through mitigation of the challenges mentioned above. The research was aimed at assessing the increases in reactivity, and also characterizing the fundamental physico-chemical processes that were responsible for the changes in reactivity. It was observed that organic macromolecules such as rhamnolipid (M.W. 600 g mol-1) sorbed on NZVI and prevented the deposition of rate enhancing surface dopants namely, palladium and sulfide, and inhibited TCE degradation. Conversely larger molecules such as carboxymethylcellulose (M.W. 700000 g mol-1) and humic acids bound to NZVI hindered deposition of the surface dopants to a lesser extent. Powdered activated carbon when used as a support for embedding NZVI was observed to significantly enhance the TCE degradation rate, however the method adopted for deposition of NZVI critically affected the rate enhancements because of changes in structural properties of activated carbon. Lastly, a phase transfer approach was developed to degrade the solvent (oil) phase of TCE using a rhamnolipid coated Pd-NZVI. This approach enabled 50% higher degradation of TCE solvent compared to a system where phase transfer was not employed." --

21st Century Nanoscience Springer

Separations of Water Pollutants with Nanotechnology, the latest volume in the Separation Science and Technology series, offers new solutions for remediating water pollution utilizing nanomaterials with separation methods. Current water purification methods are unsuitable, inconvenient or expensive, so there is a need for new and better processes and techniques. Nanomaterials can purify water by removing pollutants such as heavy metals, pathogens, organic compounds, inorganic compounds, pharmaceuticals, and chemicals of emerging concern. These can effectively replace membrane-based methods if the right expertise is developed—this book helps separation scientists do just that. Existing water treatment problems can be solved by applying a nanotechnology-based processes: antimicrobial nanotechnology, zero-valent iron nanoparticles, nanoadsorbents, nano-enhanced membranes, nanometal oxides, and nano photocatalysts. The current literature places emphasis on materials chemistry rather than the separation methods used for water purification. This new volume presents a collection of chapters that deal with remediation based on separation chemistry. Written by leaders in their respective fields

from around the world and edited by Satinder Ahuja, a leading expert on water quality improvement Covers the environmental impact of anthropogenic nanoparticles and plant derived bionanomaterials, which are not contained in other books related to nanomaterials for water purification Illustrates key information visually wherever possible throughout the book, e.g. process diagrams in the nanomaterial synthesis and nanomembrane fabrication chapters, electron microscope images, and more *Functional Hybrid Nanomaterials for Environmental Remediation* William Andrew

This 21st Century Nanoscience Handbook will be the most comprehensive, up-to-date large reference work for the field of nanoscience. Handbook of Nanophysics by the same editor published in the fall of 2010 and was embraced as the first comprehensive reference to consider both fundamental and applied aspects of nanophysics. This follow-up project has been conceived as a necessary expansion and full update that considers the significant advances made in the field since 2010. It goes well beyond the physics as warranted by recent developments in the field. This eighth volume in a ten-volume set covers nanopharmaceuticals,

nanomedicine, and food nanoscience. Key Features: Provides the most comprehensive, up-to-date large reference work for the field. Chapters written by international experts in the field. Emphasises presentation and real results and applications. This handbook distinguishes itself from other works by its breadth of coverage, readability and timely topics. The intended readership is very broad, from students and instructors to engineers, physicists, chemists, biologists, biomedical researchers, industry professionals, governmental scientists, and others whose work is impacted by nanotechnology. It will be an indispensable resource in academic, government, and industry libraries worldwide. The fields impacted by nanophysics extend from materials science and engineering to biotechnology, biomedical engineering, medicine, electrical engineering, pharmaceutical science, computer technology, aerospace engineering, mechanical engineering, food science, and beyond.

Separations of Water Pollutants with Nanotechnology CRC Press

Emerging Natural and Tailored Nanomaterials for Radioactive Waste Treatment and Environmental Remediation: Principles and Methodologies, Volume 29 provides an

overview of the most important radionuclide sources in the environment, their interaction with environmental media, and appropriate remediation techniques. The book focuses on the assessment of radionuclide sorption behavior in contaminated sites and the synthesis of new materials for radionuclides remediation through sorption concepts. Chapters investigate the main interaction mechanisms between toxic/radioactive metal ions with natural and manmade materials, natural clay minerals and oxides, and novel nanomaterials, such as ordered mesoporous silicas, carbon nanotubes, graphene, and metal-organic framework-based materials. Techniques and models discussed include kinetics analysis, thermodynamic analysis, surface complexation models, spectroscopic techniques, and theoretical calculations. Provides a systemic discussion on the interactions between toxic and radioactive metal ions and natural and manmade materials Helps to select the best approach to remove toxic/radioactive metal ions from a surface Edited by a scientific authority in toxic/radioactive metal ion interactions

Groundwater Geochemistry

Springer

Fundamentals of Environmental Site Assessment and

Remediation examines all aspects of environmental site assessment and remediation and outlines the interdisciplinary skills needed to work in the field. It provides a comprehensive overview for students, environmental professionals, and real estate developers, and includes the latest environmental regulations, environmental site assessment and remediation practices, and industry standards. It examines pollution sources and the related impacts on drinking water supplies, the associated health risks, and how to protect water resources. The monitoring of surface water, groundwater, and soil is explained, as well as vapor intrusion. It will include several practical case studies throughout. Features Includes the latest and best practices for environmental site assessment and remediation procedures. Presents a multidisciplinary approach, including environmental forensics, nanotechnology, microbiology (DNA technology) and isotopes, etc. Examines various pollutants and their related impacts on drinking water supplies, the associated health risks, and how to protect water resources. Presents the best practices for the monitoring of surface water, groundwater, and soil. Covers the latest environmental

regulations and industry standards. **Phytotoxicity of Nanoparticles** CRC Press Aquananotechnology: Applications of Nanomaterials for Water Purification focuses on the impacts of, and opportunities for, the application of nanotechnology to enhance water quality and the societal concerns surrounding the widespread use of nanotechnology in the water arena. Sections cover the use of nano-sensors for the detection of water pollutants, the control of waterborne pathogens, and the use of nano-biochar coal fly composites for phytoremdtions wastewater pollutants. In addition, the book explores the uses of nanoadsorbents for heavy metals, dyes, Arsenic, pesticides, and water/wastewater remediation and decontamination of water from xenobiotics, bionanocomposites, metal oxides, silver, zinc nanoparticles, and carbon-based nanomaterials for wastewater treatment. In addition, the book covers the use of zerovalent iron nanomaterials and nanostructured mesoporous silica for water purification, along with nano-hydrogels to increase water efficiency and conservation. Finally, the socioeconomic impacts and risks of aquananotechnology in ecosystems are discussed. This book provides a detailed description of the ecological applications of nanomaterials in

aquatic environments, offering a cogent analysis of both major applications and challenges. Shows how a range of nanomaterial types are being used for ecological applications in aquatic environments Explores the effects different types of nanomaterials have on a variety of ecosystems Assesses the major challenges of using nanotechnology to improve water quality on a mass scale **Iron Oxides** Open Dissertation Press Magnetic nanocatalysts are an important tool for greener catalytic processes due to the ease of their removal from a reaction medium. This book explores different magnetic nanocatalysts, their use in industrial applications, and their recyclability. Topics covered include wastewater treatment, drug delivery, and industrial catalysis. Nanochemistry Springer Science & Business Media Novel nanoscale materials are now an essential part of meeting the current and future needs for clean water, and are at the heart of the development of novel technologies to desalinate water. The unique properties of nanomaterials and their convergence with current treatment technologies present great opportunities to revolutionize water and wastewater treatment. Nanoscale Materials for Water Purification brings together sustainable solutions using novel

nanomaterials to alleviate the physical effects of water scarcity. This book covers a wide range of nanomaterials, including noble metal nanoparticles, magnetic nanoparticles, dendrimers, bioactive nanoparticles, polysaccharidebased nanoparticles, nanocatalysts, and redox nanoparticles for water purification. Significant properties and characterization methods of nanomaterials such as surface morphology, mechanical properties, and adsorption capacities are also investigated Explains how the unique properties of a range of nanomaterials makes them important water purification agents Shows how the use of nanotechnology can help create cheaper, more reliable, less energy-intensive, more environmentally friendly water purification techniques Includes case studies to show how nanotechnology has successfully been integrated into water purification system design

Emerging Nanomaterials for Recovery of Toxic and Radioactive Metal Ions from Environmental Media Springer

Abatement of Environmental Pollutants: Trends and Strategies addresses new technologies and provides strategies for environmental scientists, microbiologists and biotechnologists to help solve problems associated with the

treatment of industrial wastewater. The book helps readers solve pollution challenges using microorganisms in bioremediation technologies, including discussions on global technologies that have been adopted for the treatment of industrial wastewater and sections on the lack of proper management. Moreover, limited space, more stringent waste disposal regulations and public consciousness have made the present techniques expensive and impractical. Therefore, there is an urgent need to develop sustainable management technologies for industries and municipalities. To remove the damaging effect of organic pollutants on the environment, various new technologies for their degradation have been recently discovered. Covers bioremediation of petrochemical pollutants, such as Benzene, Toluene, Xylene, Ethyl Benzene, and phenolic compound Includes discussions on genetic engineering microbes and their potential in pollution abatement Contains information on plant growth promoting bacteria and their role in environment management

21st Century Nanoscience – A Handbook John Wiley & Sons

This is the first complete edited volume devoted to providing comprehensive and state-of-the art

descriptions of science principles and pilot- and field-scaled engineering applications of nanoscale zerovalent iron particles (NZVI) for soil and groundwater remediation. Although several books on environmental nanotechnology contain chapters of NZVI for environmental remediation (Wiesner and Bottero (2007); Geiger and Carvalho-Knighton (2009); Diallo et al. (2009); Ram et al. (2011)), none of them include a comprehensive treatment of the fundamental and applied aspects of NZVI applications. Most devote a chapter or two discussing a contemporary aspect of NZVI. In addition, environmental nanotechnology has a broad audience including environmental engineers and scientists, geochemists, material scientists, physicists, chemists, biologists, ecologists and toxicologists. None of the current books contain enough background material for such multidisciplinary readers, making it difficult for a graduate student or even an experienced researcher or environmental remediation practitioner new to nanotechnology to catch up with the massive, undigested literature. This prohibits the reader from gaining a complete understanding of NZVI science and

technology. In this volume, the sixteen chapters are based on more than two decades of laboratory research and development and field-scaled demonstrations of NZVI implementation. The authors of each chapter are leading researchers and/or practitioners in NZVI technology. This book aims to be an important resource for all levels of audiences, i.e. graduate students, experienced environmental and nanotechnology researchers, and practitioners evaluating environmental remediation, as it is designed to involve everything from basic to advanced concepts.
Aquananotechnology
Springer Nature
Nanoparticles can be synthesised via a number of methods, including chemical vapor deposition, ball milling, laser ablation, thermal decomposition and chemical reduction. Chemical reduction is usually preferred, due to its ease and cost-effectiveness. There are several types of compound used as reducing agents in nanoparticle synthesis, and one recent development is the use of biological entities as environmentally friendly reductants. This book will highlight the role of reducing agents in the chemical synthesis of nanoparticle systems, presenting the main categories of reducing agents, which vary on reactivity, selectivity, availability and toxicity. It will provide

a comprehensive presentation of both modern and more conventional types of reagents. Emphasis will be given on the presentation not only of the functionality, but also of all the different advantages and limitations of each kind of reducing agent. With contributions from global experts, this title will be appropriate for graduate students and researchers in nanochemistry, colloidal synthesis, inorganic chemistry, organometallic chemistry, chemical engineering, physical chemistry, materials science, biology and physics.

Nanoscale Materials in Water Purification

Springer

This dissertation, "Calcium-based Coating on the Surface of Nanoscale Zero-valent Iron (nZVI) for Improvement of Its Stability and Transport in Environmental Remediation" by Caijie, Wei, □□□, was obtained from The University of Hong Kong (Pokfulam, Hong Kong) and is being sold pursuant to Creative Commons: Attribution 3.0 Hong Kong License. The content of this dissertation has not been altered in any way. We have altered the formatting in order to facilitate the ease of printing and reading of the dissertation. All rights not granted by the above license are retained by the author. Abstract: Zero valent iron (ZVI) has demonstrated its reactivity and effectiveness for in-situ groundwater and soil remediation. The

potential of the high reducing activity of nanoscale ZVI (nZVI) for environmental decontamination has attracted more attentions in recent years, as nZVI may be injected with water to the pollution sites for in-situ remediation. However, rapid oxidation and instant agglomeration of nZVI make it difficult for large-scale engineering application. Effort has been made to improve the stability and mobility of nZVI for effective in-situ remediation. In the present study, a novel Ca-based surface coating method has been developed for protection of nZVI and enhancement of its transport in environmental applications. A simple thermal deposition method was employed to coat a Ca-based layer on the surface of micro- or nano- ZVI particles in water or methanol environment. According to microscopic observations, Ca(OH)2 nano-layer was formed on the ZVI surface. A clear core-shell structure was observed for the coated nZVI/Ca(OH)2 particles based on the TEM observations. The Ca(OH)2 coating layer had a thickness about one fifth of the nZVI diameter and the Ca to Fe ratio was below 0.2. With the Ca(OH)2 shell, nZVI particles can be effectively protected against corrosion according to the standard natural spray corrosion tests. Thus, the Ca(OH)2 coating layer is able to greatly improve the stability of

nZVI during storage, transportation and application. In addition, based on the result of the dissolution tests, the Ca(OH)2 shell could be readily dissolved in water with a low Ca content or a low ionic strength. After dissolution of the Ca(OH)2 shell, the reactivity of nZVI was found to be at the similar level as bare nZVI, which could remove Cr(VI) from water by more than 90% in about 20 min. The pseudo-first order rate constants for Cr(VI) reduction by bare nZVI and nZVI/ Ca(OH)2 after shell dissolution were 0.064 and 0.072 min-1, respectively. Moreover, the Ca(OH)2 coating shell would not only function as a protection layer but also improve the mobility of nZVI particles in in-situ applications. The aggregation and sedimentation of nZVI/Ca(OH)2 particles became considerably slower compared to bare nZVI without the coating. Clean-bed water filtration tests were conducted with sand and glass columns to evaluate the mobility and transport of nZVI in porous media. The results show that bare nZVI in the particle suspension deposited mostly at the top of the filters with little penetration. In comparison, the nZVI/Ca(OH)2 particles were able to penetrate through the filter media during the filtration process, and the dark iron particles could fill up the entire filter columns. The

penetration rate increased from nearly 0 m/hr for bare nZVI to 0.43 m/hr for nZVI/Ca(OH)2 through the filter media. The Ca-based coating materials are known as of low cost and environmentally friendly. Thus, the new coating method developed in this study provides a cost-effective means for both the protection of nZVI and improvement of its transport and delivery in porous media for environmental decontamination. DOI: 10.5353/th_b5194795 Subjects: In situ remediation Nanostructured materials - Environmental aspects *The Environmental Geochemistry of Mineral Deposits* Elsevier

The world's fresh water supplies are dwindling rapidly-even wastewater is now considered an asset. By 2025, most of the world's population will be facing serious water stresses and shortages. Aquananotechnology: Global Prospects breaks new ground with its informative and innovative introduction of the application of nanotechnology to the remediatio

Effect of Groundwater Biogeochemistry on Zero Valent Iron Nanoparticles CRC Press

Dense non-aqueous phase liquids (DNAPLs) form underground contamination zones that are vast and heterogeneous in their spatial distribution, making them both

difficult and costly to remediate. The use of nanoscale zero valent iron (NZVI) as an in-situ agent is a good method for reducing contaminants to less toxic forms, but it is limited by cost, scalability, and hazardous synthetic routes. A new inexpensive and environmentally benign synthetic technique of making carbon-adsorbed NZVI from the reduction of iron oxide (magnetite) with carbon black was developed. Powder X-ray diffraction and scanning electron microscopy confirmed that charged polyelectrolytes were necessary to promote sufficiently intimate mixing of the reactants for production of NZVI. Transmission electron microscopy revealed iron particles on the order of 50 to 150 nm diameter. Delivery of nanoparticles to subterranean contamination zones was modeled by the transport of carbonyl iron powder suspended in anionic polymer solutions through sand columns. Iron particles modified with different anionic polymers were found to target dichlorobenzene-coated sand grains with different degrees of effectiveness. Trends in targeting correlated well with the surface energies of the polymer-modified iron surfaces, which were measured by the contact angle method. The experimental results indicate that NZVI can be produced in a new inexpensive, green manner and that the contaminant

targeting properties of micron-sized iron particles can be effectively tailored using simple polymeric adsorbents. *Nanoscale Zerovalent Iron Particles for Environmental Restoration* Elsevier "Handling the high amount of waste generated by human activities is a current major challenge. Hazardous waste treatment activities focus on reducing damage caused to the environment and exposure to toxic substances by controlling the amount of untreated waste released into the environment. Although the goal of these activities is favorable in and of itself, they may have unintended consequences because treating the waste requires supplementary materials and energy and may produce toxic by-products. For instance, hazardous waste incineration processes showed to significantly damage the surrounding environment. However, thus far, it is one of the most common methods to treat chlorinated solvents waste, including trichloroethylene (TCE). In recent years, the use of nanoscale zerovalent iron particles (NZVI) for TCE degradation has received attention because of their ability to transform TCE into non-toxic products through chemical reduction reactions. However, degradation of TCE by NZVI in the aqueous phase is limited by NZVI

selectivity to produce hydrogen with water and the growth of an oxide shell on the particles. To address this challenge, a NZVI-based treatment technology, in a novel biphasic reactor, has been developed for non-aqueous phase TCE treatment. The objective of the study is to assess the environmental performance of this technique in a life-cycle perspective, and to identify the configuration with the lowest environmental footprint. The impacts of the NZVI-based process, operating at ambient temperatures, are also compared to catalytic oxidation, an emerging technique for TCE treatment at higher temperatures. The Impact 2002+ model is chosen to evaluate the impacts on a wide range of environmental impact categories, on both global and local levels. The major observation from this study is that the total impacts of TCE degradation with NZVI can be reduced by controlling the amount of solvent used for the NZVI synthesis, choosing an appropriate doping method for the particles and recycling the reaction media. However, additional process optimizations must be achieved to significantly decrease the impacts of TCE waste treatment technique with NZVI. Further studies should also be conducted in order to ensure the validity of the results regarding nanoparticles production and end-of-

life treatment impacts as, due to the novelty of the technology, current data rely on assumptions based on lab scale processes." -- **Nanotechnology for Environmental Remediation** Walter de Gruyter GmbH & Co KG

This text details the plant-assisted remediation method, “phytoremediation”, which involves the interaction of plant roots and associated rhizospheric microorganisms for the remediation of soil contaminated with high levels of metals, pesticides, solvents, radionuclides, explosives, crude oil, organic compounds and various other contaminants. Many chapters highlight and compare the efficiency and economic advantages of phytoremediation to currently practiced soil and water treatment practices. Volume 5 of Phytoremediation: Management of Environmental Contaminants provides the capstone of the series. Taken together, the five volumes provide a broad–based global synopsis of the current applications of phytoremediation using plants and the microbial communities associated with their roots to decontaminate terrestrial and aquatic ecosystems.

Nanoscale Zerovalent Iron Particles for Environmental Restoration Elsevier

Functional and structural nanomaterials are emerging materials that display interesting physical and chemical

properties because of their size and surface area to volume ratio. Applications for these materials include uses in removing pollutants from the environment. Looking at the current state-of-the-art as well as future trends in the use of nanomaterials for tackling environmental issues this book covers everything from the synthesis and characterisation of these materials to their use in the removal of specific contaminants. Functional Hybrid Nanomaterials for Environmental Remediation is a useful resource both for nanomaterial scientists interested in the real world application of hybrid nanomaterials and for environmental chemists and environmental engineers interested in novel materials for environmental remediation. Nanotechnology for Sustainable Development Royal Society of Chemistry ABSTRACT: This research focused on the use of nanoscale zero-valent iron (NZVI) to remediate trinitrotoluene (TNT). Zero-valent iron has demonstrated effective degradation of TNT, however, these particles themselves have significant problems in treating sorbed phase TNT in the aerobic environment. This research was comprised of four areas: degradation studies of neat nano-iron with aqueous TNT, degradation studies of nanoiron emulsion with aqueous TNT,

characterization of TNT in Vieques, Puerto Rico sediment, and Solid Phase Microextraction (SPME) technique interface with HPLC. Both neat and emulsion NZVI studies showed TNT degradation. More degradation was seen in studies using fresher iron. The results from our characterization study in Vieques, PR showed no presence of TNT within our detection limits of 0.0625ppm. Also, SPME is a new extraction solvent saving technique being explored because of its reproducible extractions in water. This work also gives a brief history of SPME and possible uses with TNT.