Bioelectrochemical Systems From Extracellular Electron Transfer To Biotechnological Application Integrated Environmental Technology

This thesis presents studies that examine microbial extracellular electron transfer that an emphasis characterizing how environmental conditions influence electron flux between microbes and a solid-phase electron donor or acceptor. I used bioelectrochemical systems (BESs), fluorescence and electron microscopy, chemical measurements, 16S rRNA analysis, and qRT-PCR to study these relationships among chemical, physical and biological parameters and processes.

Current research fields in science and technology were presented and discussed at the EKC2008, informing about the interests and directions of the scientists and engineers in EU countries and Korea. The Conference has emerged from the idea of bringing together EU and Korea to get to know each other better, especially in fields of science and technology. The focus of the conference is put on the topics: Computational Fluid Dynamics, Mechatronics and Mechanical Engineering, Information and Communications Technology, Life and Natural Sciences, Energy and Environmental Technology.

Artificial or constructed wetlands are an emerging technology particularly for tropical areas with water scarcity. For big cities, the sustainable management of water resources taking into account proper use is always challenging. The book presents case studies illustrating the above. As plants and microorganisms are a fundamental part of the correct functioning of

these systems, their contribution to the degradation of the organic matter and to the removal and transformation of the pollutant compounds present in the wastewaters is also a highlight of this book.

The increasing demand for energy worldwide, currently evaluated at 13 terawatts per year, has triggered a surge in research on alternative energy sources more sustainable and environmentally friendly. Bio-catalyzed electrochemical systems (BESs) are a rapidly growing biotechnology for sustainable production of bioenergy and/or value-added bioproducts using microorganisms as catalysts for bioelectrochemical reactions at the electrode surface. In the last decades, this biotechnology has been intensively studied and developed as a flexible and practical platform for multiple applications such as electricity production, wastewater treatment, pollutants remediation, desalination and production of biogas, biofuels, or other commodities. BESs could have a critical impact on societies in many spheres of activity and become one of the solutions to reform our petroleum-based economy. However, BESs research has so far been limited to lab scale with the notable exceptions of pilot scale microbial fuel cells for brewery and winery wastewater treatment coupled with electricity generation. In general, more knowledge has to be acquired to overcome the issues that are stymieing BESs development and commercialization. For example, it is critical to understand better microbial physiology including the mechanisms responsible for the transfer of electrons between the microbes and the electrodes to start optimizing the systems in a more rational manner. There are many BES processes and for each one of them there is a multitude of biological and electrochemical specifications to investigate and adjust such as the nature of the microbial platform, electrode materials, the reactor design, the substrate, the medium composition, and the operating

conditions. The ultimate goal is to develop highly energy efficient BESs with a positive footprint on the environment while maintaining low cost and generating opportunities to create value. BESs are complex systems developed with elements found in multiple fields of science such as microbiology, molecular biology, bioinformatics, biochemistry, electrochemistry, material science and environmental engineering. Given the high volume of research activities going on in the field of BESs today, this e-book explores the current challenges, the more recent progresses, and the future perspectives of BESs technologies. The BESs discussed here include microbial fuel cells, microbial electrolysis cells, microbial electrosynthesis cells, microbial electroremediation cells, etc.

Microbial electrochemical systems (MESs, also known as bioelectrochemical systems (BESs) are promising technologies for energy and products recovery coupled with wastewater treatment, and have attracted increasing attention. Many studies have been conducted to expand the application of MESs for contaminants degradation and bioremediation, and increase the efficiency of electricity production by optimizing architectural structure of MESs, developing new electrode materials, etc. However, one of the big challenges for researchers to overcome, before MESs can be used commercially, is to improve the performance of the biofilm on electrodes so that ‘electron transfer’ can be enhanced. This would lead to greater production of electricity, energy or other products. Electrochemically active microorganisms (EAMs) are a group of microorganisms which are able to release electrons from inside their cells to an electrode or accept electrons from an electron donor. The way in which EAMs do this is called ‘extracellular electron transfer’ (EET). So far, two EET mechanisms have been identified: direct electron transfer from microorganisms physically attached to an electrode, and

indirect electron transfer from microorganisms that are not physically attached to an electrode. 1) Direct electron transfer between microorganisms and electrode can occur in two ways: a) when there is physical contact between outer membrane structures of the microbial cell and the surface of the electrode, b) when electrons are transferred between the microorganism and the electrode through tiny projections (called pili or nanowires) that extend from the outer membrane of the microorganism and attach themselves to the electrode. 2) Indirect transfer of electrons from the microorganisms to an electrode occurs via long-range electron shuttle compounds that may be naturally present (in wastewater, for example), or may be produced by the microorganisms themselves. The electrochemically active biofilm, which degrades contaminants and produces electricity in MESs, consists of diverse community of EAMs and other microorganisms. However, up to date only a few EAMs have been identified, and most studies on EET have focused on the two model species of Shewanella oneidensis and Geobacter sulfurreducens.

Pond treatment technology is used in tens of thousands of applications serving many millions of people across the globe - why? Simply because it is efficient and effective. While pond treatment technology offers relative simplicity in its application, it incorporates a host of complex and diverse mechanisms that work to treat and cleanse polluted waters before their return to our environment. This book offers a comprehensive review of the pond technology field including the newest ideas and latest findings. Topics covered include: The physical, chemical and biological characteristics of the pond environment; A detailed review of pond treatment mechanisms and performance; Comprehensive guidance on pond design, operation and upgrade options; A range of chapters summarising new and emerging pond technologies;

The integration of ponds with wetlands and aquaculture systems and their use as storage reservoirs; Special applications of pond technology in cold climates, for agricultural wastes and for treatment of stormwater. The objective of this book is to get this wealth of knowledge "out there" to the users to ensure the continuous improvement and ongoing success of this crucial technology.

Expert authors provide critical, in-depth reviews of available methods for retrieving selective information out of complex biological systems. Sensors, probes and devices are present and future tools of medicinal diagnostics, environmental monitoring, food analysis and molecular biology. These are based on fluorescence, electrochemistry and mass spectrometry. Coverage of this volume includes sensor development for the detection of small analytes, monitoring of biomolecular interactions, analysis of cellular function, development of diagnostic tools.

Bioelectrochemical SystemsFrom Extracellular Electron Transfer to Biotechnological ApplicationIWA Publishing

Microbial Biodegradation and Bioremediation: Techniques and Case Studies for Environmental Pollution, Second Edition describes the successful application of microbes and their derivatives for bioremediation of potentially toxic and relatively novel compounds in the environment. Our natural biodiversity and environment is in danger due to the release of continuously emerging potential pollutants by anthropogenic activities. Though many attempts have been made to eradicate and remediate these noxious elements, thousands of xenobiotics of relatively new entities emerge every day, thus worsening the situation. Primitive microorganisms are highly adaptable to toxic

environments, and can reduce the load of toxic elements by their successful transformation and remediation. This completely updated new edition presents many new technologies and techniques and includes theoretical context and case studies in every chapter. Microbial Biodegradation and Bioremediation: Techniques and Case Studies for Environmental Pollution, Second Edition serves as a single-source reference and encompasses all categories of pollutants and their applications in a convenient, comprehensive format for researchers in environmental science and engineering, pollution, environmental microbiology, and biotechnology. Describes many novel approaches of microbial bioremediation including genetic engineering, metagenomics, microbial fuel cell technology, biosurfactants and biofilm-based bioremediation Introduces relatively new hazardous elements and their bioremediation practices including oil spills, military waste water, greenhouse gases, polythene wastes, and more Provides the most advanced techniques in the field of bioremediation, including insilico approach, microbes as pollution indicators, use of bioreactors, techniques of pollution monitoring, and more Completely updated and expanded to include topics and techniques such as genetically engineered bacteria, environmental health, nanoremediation, heavy metals, contaminant transport, and in situ and ex situ methods Includes theoretical context and case studies within each chapter

There are a large number of books available on fuel cells; however, the majority are on specific types of fuel cells such as solid oxide fuel cells, proton exchange membrane

fuel cells, or on specific technical aspects of fuel cells, e.g., the system or stack engineering. Thus, there is a need for a book focused on materials requirements in fuel cells. Key Materials in Low-Temperature Fuel Cells is a concise source of the most important and key materials and catalysts in low-temperature fuel cells. A related book will cover key materials in high-temperature fuel cells. The two books form part of the "Materials for Sustainable Energy & Development" series. Key Materials in Low-Temperature Fuel Cells brings together world leaders and experts in this field and provides a lucid description of the materials assessment of fuel cell technologies. With an emphasis on the technical development and applications of key materials in low-temperature fuel cells, this text covers fundamental principles, advancement, challenges, and important current research themes. Topics covered include: proton exchange membrane fuel cells, direct methanol and ethanol fuel cells, microfluidic fuel cells, biofuel cells, alkaline membrane fuel cells, functionalized carbon nanotubes as catalyst supports, nanostructured Pt catalysts, non-PGM catalysts, membranes, and materials modeling. This book is an essential reference source for researchers, engineers and technicians in academia, research institutes and industry working in the fields of fuel cells, energy materials, electrochemistry and materials science and engineering.

This book represents a novel attempt to describe microbial fuel cells (MFCs) as a renewable energy source derived from organic wastes. Bioelectricity is usually

produced through MFCs in oxygen-deficient environments, where a series of microorganisms convert the complex wastes into electrons via liquefaction through a cascade of enzymes in a bioelectrochemical process. The book provides a detailed description of MFC technologies and their applications, along with the theories underlying the electron transfer mechanisms, the biochemistry and the microbiology involved, and the material characteristics of the anode, cathode and separator. It is intended for a broad audience, mainly undergraduates, postgraduates, energy researchers, scientists working in industry and at research organizations, energy specialists, policymakers, and anyone else interested in the latest developments concerning MFCs.

Disasters and Minewater: Good Practice and Prevention draws together all of the major minewater catastrophes that have occurred over the last half century. It examines incidents to find useful and positive information of great value that could prevent future disasters. Practical experience provides many lessons in respect of the causes of minewater incidents where lack of adhesion to good practice is principally to blame. Disasters and Minewater: Good Practice and Prevention is of particular interest to students of mining, civil engineering and environmental engineering. It is an invaluable resource for mining engineers, geotechnical engineers environmental engineers and disaster relief professionals and consultants.

This book encompasses the most updated and recent account of research and

implementation of Microbial Electrochemical Technologies (METs) from pioneers and experienced researchers in the field who have been working on the interface between electrochemistry and microbiology/biotechnology for many years. It provides a holistic view of the METs, detailing the functional mechanisms, operational configurations, influencing factors governing the reaction process and integration strategies. The book not only provides historical perspectives of the technology and its evolution over the years but also the most recent examples of up-scaling and near future commercialization, making it a must-read for researchers, students, industry practitioners and science enthusiasts. Key Features: Introduces novel technologies that can impact the future infrastructure at the water-energy nexus. Outlines methodologies development and application of microbial electrochemical technologies and details out the illustrations of microbial and electrochemical concepts. Reviews applications across a wide variety of scales, from power generation in the laboratory to approaches. Discusses techniques such as molecular biology and mathematical modeling; the future development of this promising technology; and the role of the system components for the implementation of bioelectrochemical technologies for practical utility. Explores key challenges for implementing these systems and compares them to similar renewable energy technologies, including their efficiency, scalability, system lifetimes, and reliability.

Implantable sensor systems offer great potential for enhanced medical care and

improved quality of life, consequently leading to major investment in this exciting field. Implantable sensor systems for medical applications provides a wide-ranging overview of the core technologies, key challenges and main issues related to the development and use of these devices in a diverse range of medical applications. Part one reviews the fundamentals of implantable systems, including materials and material-tissue interfaces, packaging and coatings, microassembly, electrode array design and fabrication, and the use of biofuel cells as sustainable power sources. Part two goes on to consider the challenges associated with implantable systems. Biocompatibility, sterilization considerations and the development of active implantable medical devices in a regulated environment are discussed, along with issues regarding data protection and patient privacy in medical sensor networks. Applications of implantable systems are then discussed in part three, beginning with Microelectromechanical systems (MEMS) for in-vivo applications before further exploration of tripolar interfaces for neural recording, sensors for motor neuroprostheses, implantable wireless body area networks and retina implants. With its distinguished editors and international team of expert contributors, Implantable sensor systems for medical applications is a comprehensive guide for all those involved in the design, development and application of these life-changing technologies. Provides a wide-ranging overview of the core technologies, key challenges and main issues related to the development and use of implantable sensor systems in a range of medical applications Reviews the

fundamentals of implantable systems, including materials and material-tissue interfaces, packaging and coatings, and microassembly Considers the challenges associated with implantable systems, including biocompatibility and sterilization
Introduces basic principles and mechanisms, covers new developments, and provides a different view of the main facets of bioelectrosynthesis
Bioelectrosynthesis represents a promising approach for storing renewable energy or producing target chemicals in an energy-sustainable and low-cost way. This timely and important book systemically introduces the hot issues surrounding bioelectrosynthesis, including potential value-added products via bioelectrochemical system, reactor development of bioelectrosynthesis, and microbial biology on biofilm communities and metabolism pathways. It presents readers with unique viewpoints on basic principles and mechanisms along with new developments on reactor and microbial ecology. Beginning with a principle and products overview of bioelectrosynthesis, Bioelectrosynthesis: Principles and Technologies for Value-Added Products goes on to offer in-depth sections on: biogas production and upgrading technology via bioelectrolysis; organic synthesis on cathodes; chemical products and nitrogen recovery; external electron transfer and electrode material promotion; and the microbiology of bioelectrosynthesis. Topics covered include: hydrogen production from waste

stream with microbial electrolysis cell; microbial electrolysis cell; inorganic compound synthesis in bioelectrochemical system; microbial growth, ecological, and metabolic characteristics in bioelectrosynthesis systems; microbial metabolism kinetics and interactions in bioelectrosynthesis system; and more. * Comprehensively covers all of the key issues of biolelectrosynthesis * Features contributions from top experts in the field * Examines the conversion of organic wastes to methane via electromethanogenesis; methane production at biocathodes; extracellular electron transport of electroactive biofilm; and more Bioelectrosynthesis: Principles and Technologies for Value-Added Products will appeal to chemists, electrochemists, environmental chemists, water chemists, microbiologists, biochemists, and graduate students involved in the field.

This book serves as a manual of research techniques for electrochemically active biofilm research. Using examples from real biofilm research to illustrate the techniques used for electrochemically active biofilms, this book is of most use to researchers and educators studying microbial fuel cell and bioelectrochemical systems. The book emphasizes the theoretical principles of bioelectrochemistry, experimental procedures and tools useful in quantifying electron transfer processes in biofilms, and mathematical modeling of electron transfer in biofilms. It is divided into three sections: Biofilms: Microbiology and

microbioelectrochemistry - Focuses on the microbiologic aspect of electrochemically active biofilms and details the key points of biofilm preparation and electrochemical measurement Electrochemical techniques to study electron transfer processes - Focuses on electrochemical characterization and data interpretation, highlighting key factors in the experimental procedures that affect reproducibility Applications - Focuses on applications of electrochemically active biofilms and development of custom tools to study electrochemically active biofilms. Chapters detail how to build the reactors for applications and measure parameters

This contributed volume sheds new light on waste management and the production of biofuels. The authors share insights into microbial applications to meet the challenges of environmental pollution and the ever- growing need for renewable energy. They also explain how healthy and balanced ecosystems can be created and maintained using strategies ranging from oil biodegration and detoxification of azo dyes to biofouling. In addition, the book illustrates how the metabolic abilities of microorganisms can be used in microbial fuel-cell technologies or for the production of biohydrogen. It inspires young researchers and experienced scientists in the field of microbiology to explore the application of green biotechnology for bioremediation and the production of energy, which

will be one of the central topics for future generations.
This volume discusses both the latest experimental research in bioelectrosynthesis and current applications. Beginning with an introduction into the “electrification of biotechnology” as well as the underlying fundamentals, the volume then discusses a wide range of topics based on the interfacing of biotechnological and electrochemical reaction steps. It includes contributions on the different aspects of bioelectrochemical applications for synthesis purposes, i.e. the production of fine and platform chemicals based on enzymatically or microbially catalyzed reactions driven by electric energy. The volume finishes with a summary and outlook chapter which gives an overview of the current status of the field and future perspectives. Edited by experts in the field, and authored by a wide range of international researchers, this volume assesses how research from today’s lab bench can be developed into industrial applications, and is of interest to researchers in academia and industry.
This book reviews the latest advances in the bioelectrochemical degradation of recalcitrant environmental contaminants. The first part introduces readers to the basic principles and methodologies of bioelectrochemical systems, electron-respiring microorganisms, the electron transfer mechanism and functional electrode materials. In turn, the second part addresses the bioelectrochemical

remediation/treatment of various environmental pollutants (including highly toxic refractory organics, heavy metals, and nitrates) in wastewater, sediment and wetlands. Reactor configuration optimization, hybrid technology amplification and enhanced removal principles and techniques are also discussed. The book offers a valuable resource for all researchers and professionals working in environmental science and engineering, bioelectrochemistry, environmental microbiology and biotechnology.

The European project MINOTAURUS explored innovative bio-processes to eliminate emerging and classic organic pollutants. These bio-processes are all based on the concept of immobilization of biocatalysts (microorganisms and enzymes) and encompass bioaugmentation, enzyme technology, rhizoremediation with halophytes, and a bioelectrochemical remediation process. The immobilization-based technologies are applied as engineered ex situ treatment systems as well as natural systems in situ for the bioremediation of groundwater, wastewater and soil. The selection and application of tailored physico-chemical, molecularbiological and ecotoxicological monitoring tools combined with a rational understanding of engineering, enzymology and microbial physiology is a pertinent approach to open the black-box of the selected technologies. Reliable process monitoring constitutes the basis for

developing and refining biodegradation kinetics models, which in turn improve the predictability of performances to be achieved with technologies. Immobilised Biocatalysts for Bioremediation of Groundwater and Wastewater delivers insight into the concepts and performance of a series of remediation approaches. A key strength of this book is to deliver results from lab-scale through to piloting at different European reference sites. It further suggests frameworks for structuring and making evidence-based decisions for the most appropriate bioremediation measures.

Faced with the upcoming serious deficiency of energy, food and water, along with inevitable environmental pollution, much related research has been on the upsurge because Microbial Fuel Cells (MFCs) seem to be one of the solutions to these concerns in the future. The aim of this book is to describe and consider some concepts regarding MFC application designs for interested colleagues. Five topics regarding the technology of flow control, biocatalysts, biofilms, removal of chemical oxygen demand and biochemical fields are addressed in the book. Considering the low power density and short life span of MFCs, there has been a dramatic increase in funding and research that has led to a greater understanding of the fundamental science behind MFC study. This is driving significant improvements in both the reliability and efficiency of MFCs and hence

their future use.

This volume presents the fundamentals and advances in state-of-the-art catalytic nanoscale interventions to improve the efficiency of bioelectrochemical systems. These systems are used in a number of applications in the water-energy nexus. Contributed chapters describe and build on useful strategies to use and reference when dealing with an important environmental issue: the final disposal of heavy metal catalysts. Summarizing basic and translational research, these chapters are valuable for researchers in energy, nanotechnology, and catalysis.

This book presents the state of the art technologies and solutions to tackle the critical challenges faced by the building and development of the WSN and ecological monitoring system but also potential impact on society at social, medical and technological level. This book is dedicated to Sensing systems for Sensors, Wireless Sensor Networks and Ecological Monitoring. The book aims at Master and PhD degree students, researchers, practitioners, especially WSN engineers involved with ecological monitoring. The book will provide an opportunity of a dedicated and a deep approach in order to improve their knowledge in this specific field.

This brief introduces the structural and functional characterization of this important group of proteins. The content of each chapter is aimed at the non-specialist so that key concepts, methodologies and applications can be presented in a "snapshot" style volume. Multiheme cytochromes are ever more important now that it is possible to

obtain genome sequences of microorganisms which have major biotechnological and environmental implications. There is a tremendous profusion of multiheme cytochromes which have great potential as targets for bioremediation and bioenergy applications. This brief gives a glimpse of an intriguing and fast-moving field.

An introduction to the fundamental concepts and rules in bioelectrochemistry and explores latest advancements in the field Bioelectrochemical Interface Engineering offers a guide to this burgeoning interdisciplinary field. The authors—noted experts on the topic—present a detailed explanation of the field's basic concepts, provide a fundamental understanding of the principle of electrocatalysis, electrochemical activity of the electroactive microorganisms, and mechanisms of electron transfer at electrode-electrolyte interfaces. They also explore the design and development of bioelectrochemical systems. The authors review recent advances in the field including: the development of new bioelectrochemical configurations, new electrode materials, electrode functionalization strategies, and extremophilic electroactive microorganisms. These current developments hold the promise of powering the systems in remote locations such as deep sea and extra-terrestrial space as well as powering implantable energy devices and controlled drug delivery. This important book: • Explores the fundamental concepts and rules in bioelectrochemistry and details the latest advancements • Presents principles of electrocatalysis, electroactive microorganisms, types and mechanisms of electron transfer at electrode-electrolyte interfaces, electron

transfer kinetics in bioelectrocatalysis, and more • Covers microbial electrochemical systems and discusses bioelectrosynthesis and biosensors, and bioelectrochemical wastewater treatment • Reviews microbial biosensor, microfluidic and lab-on-chip devices, flexible electronics, and paper and stretchable electrodes Written for researchers, technicians, and students in chemistry, biology, energy and environmental science, Bioelectrochemical Interface Engineering provides a strong foundation to this advanced field by presenting the core concepts, basic principles, and newest advances.
Biofilms represent the natural living style of microbial communities and play a pivotal role in biogeochemical cycles and natural attenuation. Biofilms can be engineered for biodegradation and biotransformation of organic and inorganic contaminants, for both in situ bioremediation and ex situ treatment in bioreactors. This book focuses on microbial biofilms and their potential technological applications for sustainable development. It covers recent advances in biofilm technologies for contaminant remediation coupled to recovery of resources and serves as a complete reference on the science and technology behind biofilm mediated bioremediation and wastewater treatment.
Some microorganisms dynamically alter their metabolic states in response to changes in the environmental conditions, such as availability of compatible electron donors and acceptors. A prominent example is nitrate, which is the most energetically favorable electron acceptor in the absence of oxygen and often dominantly controls microbial reactions taking place in anoxic systems. Solid electrodes present another substrate

that can regulate microbial reactions, serving as an electron donor and/or electron acceptor for microbes capable of extracellular electron transfer (EET). Electrode-mediated microbial metabolisms are central in bioelectrochemical systems (BESs), an emerging technology with a variety of potential applications, including a novel experimental platform to study the dynamic change of microbial metabolisms with real-time monitoring under controlled conditions. A better characterization of microbial reactions associated with such key substrates has important implications to understand microbial reactions in anoxic environments and also developing biological processes that exploit relevant microbial metabolisms. This research investigated the capabilities and constraints of microbial metabolisms at the nexus of electrode- and nitrate-mediated respirations relevant to wastewater treatment processes. The facultative metabolic shift between anode electrode reduction and nitrate reduction was investigated in anode-reducing biofilms to study the effects of alternative metabolic options on exoelectrogenic biofilms in BESs. This has important implications not only to explain the fundamental ecology and performance of these systems, but also to develop reliable integrated nutrient removal strategies in BESs, which potentially involve nitrate that can support/induce alternative metabolisms. Using the exoelectrogenic nitrate reducer Geobacter metallireducens, the critical conditions controlling those alternative metabolisms were investigated in two-chamber, potentiostatically controlled BESs at various anode potentials, biofilm thicknesses, and

nitrate concentrations. Results showed that anode-reducing biofilms preferentially reduced nitrate at all tested anode potentials (-150 to + 900 mV vs Standard Hydrogen Electrode) with a rapid metabolic shift, despite the fact that the biofilms had no prior nitrate exposure. The critical nitrate concentration that triggered a significant decrease in BES performance was a function of anode biofilm thickness but not anode potential. This indicates that these alternative metabolisms were controlled by the availability of nitrate, which is a function of nitrate concentration in the bulk solution and its diffusion into an anode-reducing biofilm. Coulombic recovery decreased as a function of nitrate dose due to electron-acceptor substrate competition, and nitrate-induced suspended biomass growth decreased the effluent quality. This nitrate-induced metabolic shift of anode-reducing biofilms was further investigated in the context of a shift between two different electrode-mediated metabolisms, electrode reduction and electrode oxidation. The characterization of metabolic shifts among different electrode-mediated reactions such as anode reduction and cathode oxidation is important to understand EETs in natural settings and also to develop stable BESs. This part of the research investigated the capability of anodically-grown G. metallireducens biofilms to shift from anode reduction to cathode oxidation. In tests with potentiostatically controlled graphite electrodes, G. metallireducens biofilms demonstrated a quick and alternative shift between anode reduction and cathode oxidation as a function of electrode potential and availability of the co-substrates nitrate and acetate. Cathodic electrode oxidation was

coupled with nitrate reduction by metabolically active biofilms with a large cathodic current of ~ 3.68 A/m2. This metabolic shift from anode reduction to nitrate reduction took place quicker than the metabolic shift from ferric reduction to nitrate reduction. The presence of nitrate-reducing enzyme in the anode-reducing biofilms cells in the absence of nitrate, measured as specific in-vitro nitrate-reducing enzyme activity, was thought to enable such a quick metabolic shift to start nitrate reduction. Cyclic voltammetry and the analysis of its first derivative provided insights into the electron transfer mechanisms of these biofilms. Finally, the potential occurrence of dissimilatory nitrate reduction to ammonium (DNRA), a microbial nitrate-reducing metabolism that involves the sequential reduction of nitrate to nitrite and then nitrite to ammonium, was investigated in two full-scale wastewater treatment plants. DNRA in biological wastewater treatment systems and BESs is largely unstudied despite its potential impacts on system performance. This part of the research examined differential expression and diversity of nrfA, a key marker gene for DNRA, in activated sludge from full-scale domestic wastewater treatment plants with one designed for enhanced biological phosphorus removal (EBPR). Expression of nrfA, which encodes the penta-heme nitrite reductase NrfA catalyzing the nitrite ammonification step of DNRA, was observed in anaerobic and anoxic mixed liquor, but not in aerobic mixed liquor samples. The expression of nrfA under anaerobic and anoxic conditions suggests an overlooked potential for DNRA activity to occur in biological wastewater treatment systems. Some

retrieved nrfA sequences were related to sequences associated with a microbial community with anammox activity, and the nrfA diversity in this wastewater treatment system differed from that observed in soil systems. Retrieved nrfA sequences both in genomic DNA and transcript samples were dominated by sequences associated with Actinobacteria, which are often abundant in EBPR processes. These results suggested potential occurrence of DNRA in wastewater activated sludge and encourage further studies in different types of wastewater treatment systems and with chemical tracer analyses to obtain comprehensive understanding of DNRA in this context. This research investigated dissimilatory nitrate reduction in electrode-respiring biofilms and full-scale wastewater treatment processes. Elucidating the dynamics of nitrate-dependent reactions of electrode-respiring G. metallireducens in the contexts of a competitive reaction to anode reduction and an alternative electrode-mediated reaction have implications for BES development. Moreover, the experimental frameworks that were developed to address those problems would be applicable to study other electrode-mediated microbial metabolisms. Findings of nrfA expression and its diversity in full-scale wastewater treatment processes indicated potential occurrences of DNRA in wastewater treatment processes, which would have implications for energy and chemical utilization in these systems, and broadened the representation of diversity in the rather limited nrfA database.

In the context of wastewater treatment, Bioelectrochemical Systems (BESs) have

gained considerable interest in the past few years, and several BES processes are on the brink of application to this area. This book, written by a large number of world experts in the different sub-topics, describes the different aspects and processes relevant to their development. Bioelectrochemical Systems (BESs) use micro-organisms to catalyze an oxidation and/or reduction reaction at an anodic and cathodic electrode respectively. Briefly, at an anode oxidation of organic and inorganic electron donors can occur. Prime examples of such electron donors are waste organics and sulfides. At the cathode, an electron acceptor such as oxygen or nitrate can be reduced. The anode and the cathode are connected through an electrical circuit. If electrical power is harvested from this circuit, the system is called a Microbial Fuel Cell; if electrical power is invested, the system is called a Microbial Electrolysis Cell. The overall framework of bio-energy and bio-fuels is discussed. A number of chapters discuss the basics - microbiology, microbial ecology, electrochemistry, technology and materials development. The book continues by highlighting the plurality of processes based on BES technology already in existence, going from wastewater based reactors to sediment based bio-batteries. The integration of BESs into existing water or process lines is discussed. Finally, an outlook is provided of how BES will fit within the emerging biorefinery area.

Biomass, Biofuels, Biochemicals encompasses the potential of microbial electrochemical technologies, delineating their role in developing a technology for

abating environmental crisis and enabling transformation to a sustainable future. The book provides new and futuristic methods for bioelectrogenesis, multiple product synthesis, waste remediation strategies, and electromicrobiology generation which are widely essential to individuals from industry, marketing, activists, writers, etc. In addition, it provides essential knowledge transfer to researchers, students and science enthusiasts on Microbial Electrochemical Technologies, detailing the functional mechanisms employed, various operational configurations, influencing factors governing the reaction progress and integration strategies. With these key topics and features, the book generates interest among a wide range of people related to renewable energy generation and sustainable environmental research. Depicts the holistic view of the multiple applications of Microbial Electrochemical Technologies (METs) in a unified comprehensible manner Provides strategic integrations of MET with various bioprocesses that are essential in establishing a circular biorefinery Widens the scope of the existing technologies, giving up-to date, state-of-the-art information and knowledge on research and commercialization Contains topics that are lucid, providing interdisciplinary knowledge on the environment, molecular biology, engineering, biotechnology, microbiology and economic aspects Includes more than 75 illustrations, figures, diagrams, flow charts, and tables for further study

This book focuses on value addition to various waste streams, which include industrial waste, agricultural waste, and municipal solid and liquid waste. It addresses the utilization of waste to generate valuable products such as electricity, fuel, fertilizers, and chemicals, while placing special emphasis on environmental concerns and presenting a multidisciplinary approach for handling waste. Including chapters authored by prominent national and international experts, the book will be of interest to researchers, professionals and policymakers alike.

Water Recycling and Resource Recovery in Industry: Analysis, Technologies and Implementation provides a definitive and in-depth discussion of the current state-of-the-art tools and technologies enabling the industrial recycling and reuse of water and other resources. The book also presents in detail how these technologies can be implemented in order to maximize resource recycling in industrial practice, and to integrate water and resource recycling in ongoing industrial production processes. Special attention is given to non-process engineering aspects such as systems analysis, software tools, health, regulations, life-cycle analysis, economic impact and public participation. Case studies illustrate the huge potential of environmental technology to optimise resource utilisation in industry. The large number of figures, tables and case

studies, together with the book's multidisciplinary approach, makes Water Recycling and Resource Recovery in Industry: Analysis, Technologies and Implementation the perfect reference work for academics, professionals and consultants dealing with industrial water resources recovery. Contents Part I: Industrial reuse for environmental protection Part II: System analysis to assist in closing industrial resource cycles Part III: Characterisation of process water quality Part IV: Technological aspects of closing industrial cycles Part V: Examples of closed water cycles in industrial processes Part VI: Resource protection policies in industry

Bioelectrochemical Systems (BESs) are innovative and sustainable devices. They combine biological and electrochemical processes to engineer sensors, treat wastewater and/or produce electricity, fuel or high-value chemicals. In BESs, scientists have managed to incorporate biological catalysts, i.e. enzymes and/or microorganisms, and make them work in advanced electrochemical cells. BESs operate under mild conditions — at close to ambient temperature and pressure and at circumneutral pH — and represent a sustainable alternative to precious metal-based systems. Incorporating biological catalysts into devices while maintaining their activity and achieving electrical communication with electrode surfaces is a critical challenge when trying to advance the field of

BESs. From implantable enzymatic biosensors to microbial electrosynthesis, and from laboratory-scale systems and fundamental studies to marketed devices, this book provides a comprehensive overview of recent advances related to functional electrodes for BESs. Suitable for researchers and graduate students of chemistry, biochemistry, materials science and environmental science and technology. Contents: Fundamentals: Fundamentals of Enzymatic Electrochemical Systems (Victoria Flexer and Nicolas Brun)Fundamentals of Microbial Electrochemical Systems (Stefano Freguia, Kun Guo, and Pablo Ledezma)Continuum in Enzymatic and Microbial Bioelectrocatalysis (Frédéric Barrière)Electron Transfer Between Bacteria and Electrodes (Lucie Semenec, Sanja Aracic, Elizabeth R Mathews, and Ashley E Franks)Electrodes for Enzymatic Electrochemical Systems: Architectures of Enzyme Electrodes Using Redox Mediators (Victoria Flexer, Antonin Prévoteau, and Nicolas Brun)Functional Electrodes for Enzymatic Electrosynthesis (Lin Zhang, Mathieu Etienne, Neus Vilà, and Alain Walcarius)Redox Hydrogels as an Efficient Strategy for Immobilization of Enzymes at Electrode Interfaces (Joshua W Gallaway, and Scott Calabrese Barton)Conducting Polymer Hydrogels and Their Applications as Electrode Materials (Yu Zhao, Lanlan Li, Lijia Pan, Guihua Yu, and Yi Shi)Nanocarbon-Based Enzymatic Electrodes (Nicolas Brun, Mohammed

Baccour, and Victoria Flexer)Carbonaceous Electrodes Featuring Tunable Mesopores for Use as Enzyme Electrodes (Seiya Tsujimura)Electrodes for Microbial Electrochemical Systems: Materials and Their Surface Modification for Use as Anode in Microbial Bioelectrochemical Systems (Kun Guo, Antonin Prévoteau, Sunil A Patil, and Korneel Rabaey)Electrodes for Cathodic Microbial Electrosynthesis Processes: Key-Developments and Criteria for Effective Research and Implementation (Ludovic Jourdin and David Strik)Non-Carbonaceous Electrodes for Microbial Electrochemical Systems (Hernán Romeo, Diego Massazza, Rodrigo Parra, and Juan Pablo Busalmen)Imaging and Characterization of Bioelectrodes: Imaging and Characterization of Microbial Electrodes (Yang Lu and Bogdan C Donose)Spectroscopic Methods for Characterizing Redox Chemistry at Metalloprotein-Modified Electrodes (Philip A Ash and Kylie A Vincent)Spectroelectrochemistry of Microbial Biofilms (Diego Millo and Bernardino Virdis)Scanning Electrochemical Microscopy: A New Tool for Studying Enzymatic Reactions (Dodzi Zigah and Olivier Fontaine) Readership: Suitable for researchers, postgraduate and graduate students of chemistry, biochemistry and environmental sci

The depletion of fossil resources and an ever-growing human population create an increasing demand for the development of sustainable processes for the

utilization of renewable resources. As autotrophic microorganisms offer numerous metabolic pathways for the fixation of carbon dioxide and the metabolic utilization of light, electricity and inorganic energy donors, they are expected to play a pivotal role in an emerging carbon neutral society. This text-book presents the metabolic principles of autotrophy and current efforts for their utilization in biotechnology, including photoautotrophic, chemolithoautotrophic and electroautotrophic organisms. It outlines how modern molecular biology and process engineering create technologies that allow to use industrial off-gases and inorganic energy for the synthesis of bio-based plastics, materials and other chemical products. The text-book is ideally suited for students in advanced graduate and master courses and offers a reference for PhD students, engineers, chemists, biologists and all with an interests in biotechnology and renewable resources.

This book introduces the 3R concept applied to wastewater treatment and resource recovery under a double perspective. Firstly, it deals with innovative technologies leading to: Reducing energy requirements, space and impacts; Reusing water and sludge of sufficient quality; and Recovering resources such as energy, nutrients, metals and chemicals, including biopolymers. Besides targeting effective C,N&P removal, other issues such as organic micropollutants,

gases and odours emissions are considered. Most of the technologies analysed have been tested at pilot- or at full-scale. Tools and methods for their Economic, Environmental, Legal and Social impact assessment are described. The 3R concept is also applied to Innovative Processes design, considering different levels of innovation: Retrofitting, where novel units are included in more conventional processes; Re-Thinking, which implies a substantial flowsheet modification; and Re-Imagining, with completely new conceptions. Tools are presented for Modelling, Optimising and Selecting the most suitable plant layout for each particular scenario from a holistic technical, economic and environmental point of view.