

## **Ion Exchange Membranes For Electro Membrane Processes**

Membranes play an enormous role in our life. Biological cell membranes control the fluxes of substances in and out of cells. Artificial membranes are widely used in numerous applications including “green” separation processes in chemistry, agroindustry, biology, medicine; they are used as well in energy generation from renewable sources. They largely mimic the structure and functions of biological membranes. The similarity in the structure leads to the similarity in the properties and the approaches to study the laws governing the behavior of both biological and artificial membranes. In this book, some physico-chemical and chemico-physical aspects of the structure and behavior of biological and artificial membranes are investigated.

This book on solid state chemistry presents studies of chemical, structural, thermodynamic, electronic, magnetic, and optical properties and processes in solids. Research areas include: bonding in solids, crystal chemistry, crystal growth mechanisms, diffusion epitaxy, high-pressure processes, magnetic properties of materials, optical characterisation of materials, order-disorder, phase equilibria and transformation mechanisms, reactions at surfaces, statistical mechanics of defect interactions, structural studies and transport phenomena.

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Fundamental Modelling of Membrane Systems: Membrane and Process Performance summarizes the state-of-the-art modeling approaches for all significant membrane processes, from molecular transport, to process level, helping researchers and students who carry out experimental research save time and accurately interpret experimental data. The book provides an overview of the different membrane technologies, handling micro-, ultra-, and nanofiltration, reverse and forward osmosis, pervaporation, gas permeation, supported liquid membranes, membrane contactors, membrane bioreactors and ion-exchange membrane systems. Examples of hybrid membrane systems are also included. Presents an accessible reference on how to model membranes and membrane processes Provides a clear, mathematical description of mass transfer in membrane systems Written by well-known, prominent authors in the field of membrane science

This book provides a review of the latest advances in anion exchange membrane fuel cells. Starting with an introduction to the field, it then examines the chemistry and catalysis involved in this energy technology. It also includes an introduction to the mathematical modelling of these fuel cells before discussing the system design and performance of real-world systems. Anion exchange membrane fuel cells are an emerging energy technology that has

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the potential to overcome many of the obstacles of proton exchange membrane fuel cells in terms of the cost, stability, and durability of materials. The book is an essential reference resource for professionals, researchers, and policymakers around the globe working in academia, industry, and government. In this book, electro-diffusion of ions in its different aspects is considered as a unified subject.

Nanotechnology has been established in membrane technology for decades. In this book, comprehensive coverage is given to nanotechnology applications in synthetic membrane processes, which are used in different fields such as water treatment, separation of gases, the food industry, military use, drug delivery, air filtration, and green chemistry.

Nanomaterials such as carbon nanotubes, nanoparticles, and dendrimers are contributing to the development of more efficient and cost-effective water filtration processes. Gas separation and carbon capture can be significantly improved in flue gas applications. Nanoporous membrane systems engineered to mimic natural filtration systems are being actively developed for use in smart implantable drug delivery systems, bio artificial organs, and other novel nano-enabled medical devices. The microscopic structure of nanoporous ceramic membranes, mainly focusing on zeolite materials, as well as the energy-saving effect of membrane separation, contribute to various

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chemical synthesis processes. In the food industry, nanotechnology has the potential to create new tools for pathogen detection and packaging. For each application, nanotechnology is mostly used to make composite membranes, and the book provides a detailed look at the mechanisms by which the composite membrane works in each application area.

Ion Exchange Technology serves both as a reference and as a text book for technologists and engineers. While the present book is based mainly on ion exchange as practiced in the United States, the object was to produce a generally useful book which would deal with the fundamental problems, techniques, and operations of ion exchange such as mass transfer, equipment design, properties of ion exchange resins, and deionization. Also include are chapters on two types of applications—those that are used industrially on a large scale, and those which have not yet reached large-scale use but have impressive potentialities. In both the fundamental and applied chapters it was deemed necessary that the successful aspects of ion exchange operation be included. In addition, it was equally important to describe the problems and the inherent complexities encountered in the setting up of an ion exchange process. Wherever possible the economic factors were described realistically.

"The objective of this book is to provide a short but

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reasonably comprehensive introduction to membrane science and technology suitable for graduate students and persons with engineering or natural science background to gain a basic understanding of membranes, their function and application without studying a large number of different reference books."--P. xiii.

Fundamental study and industrial application of ion exchange membranes started over half a century ago. Through ongoing research and development, ion exchange membrane technology is now applied to many fields and contributes to the improvement of our standard of living. Ion Exchange Membranes, 2nd edition states the ion exchange membrane technology from the standpoint of fundamentals and applications. It discusses not only various phenomena exhibited by membranes but also their applications in many fields with economical evaluations. This second edition is updated and revised, featuring ten expanded chapters. New to this edition is a computer simulation program of ion-exchange membrane electro dialysis for water desalination that provides a guideline for designing, manufacturing and operating a practical-scale electro dialyzer. Meant to replace experiments, this program will be an important asset to those with time and monetary budgets. New edition features ten revised and expanded chapters, providing the latest developments in ion exchange membrane

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technology Computer simulation program, accessible through a companion website, provides a guideline for designing, manufacturing and operating practical-scale electro dialyzers Attractive visual presentation, including many figures and diagrams This book is a printed edition of the Special Issue "Seven Years of Membranes: Feature Paper 2017" that was published in Membranes

Today, membranes and membrane processes are used as efficient tools for the separation of liquid mixtures or gases in the chemical and biomedical industry, in water desalination and wastewater purification. Despite the fact that various membrane processes, like reverse osmosis, are described in great detail in a number of books, processes involving ion-exchange membranes are only described in a fragmented way in scientific journals and patents; even though large industrial applications, like electro dialysis, have been around for over half a century. Therefore, this book is emphasizing on the most relevant aspects of ion-exchange membranes. This book provides a comprehensive overview of ion-exchange membrane separation processes covering the fundamentals as well as recent developments of the different products and processes and their applications. The audience for this book is heterogeneous, as it includes plant managers and process engineers as well as research scientists and graduate students. The

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separate chapters are based on different topics. The first chapter describes the relevant Electromembrane processes in a general overview. The second chapter explains thermodynamic and physicochemical fundamentals. The third chapter gives information about ion-exchange membrane preparation techniques, while the fourth and fifth chapter discusses the processes as unit operations giving examples for the design of specific plants. First work on the principles and applications of electrodialysis and related separation processes Presently no other comprehensive work that can serve as both reference work and text book is available Book is suited for teaching students and as source for detailed information

Membranes are an energy efficient separation technology that are now the basis for many water treatment and food processing applications. However, there is the potential to improve the operating performance of these separations and to extend the application of membranes to energy production, gas separations, organic solvent-based separations, and biomedical applications through novel membrane materials. This book contains 20 chapters written by leading academic researchers on membrane fabrication and modification techniques and provides a comprehensive overview on the recent developments of membrane technology. Membranes can be manufactured from a range of

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materials including polymeric compounds, and ceramic materials, and both these materials are considered in the book. There are 5 chapters on water and wastewater membranes that cover the fabrication of thin film (TFC) composite membranes for nanofiltration(NF)/reverse osmosis (RO)/forward osmosis (FO) applications, stimuli responsive membranes, electrospun membranes, porous ceramic membranes, and polymeric ultrafiltration (UF) manufacture and modification. There are another 6 chapters on gas separation that consider carbon membranes, zeolite membranes, silica template and metal oxide silica membranes, TFC membranes, silica membranes, and metal organic framework (MOF) membranes. Zeolite membranes are also considered for organic solvent applications, as are solvent-resistant membranes manufactured by phase inversion, ceramic-supported composite membranes, and ceramic NF membranes. The emerging areas of membranes for energy and biomedical applications have 3 and 2 chapters, respectively. Energy applications consider ion exchange membranes for use in fuel cells, membranes for electrodialysis, and membranes for use in microbial fuel cells. For biomedical applications the chapters focus on hemodialysis membranes and redox responsive membranes. This book presents novel techniques to evaluate electrodialysis processes, to synthesize ionic

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membranes and to characterize their properties. It shows the potential use of membrane process to the treatment of effluents generated in many industrial sectors such as refineries, leather industries, mining and electroplating processes. The book is based on the results obtained by the author's research group during the past decade. It is useful for students, researchers and engineers interested in membrane technologies for water reuse.

### Ion-Exchange Membrane Separation Processes Elsevier

This multivolume work covers all aspects of membrane science and technology - from basic phenomena to the most advanced applications and future perspectives. Modern membrane engineering is critical to the development of process-intensification strategies and to the stimulation of industrial growth. The work presents researchers and industrial managers with an indispensable tool toward achieving these aims. Covers membrane science theory and economics, as well as applications ranging from chemical purification and natural gas enrichment to potable water Includes contributions and case studies from internationally recognized experts and from up-and-coming researchers working in this multi-billion dollar field Takes a unique, multidisciplinary approach that stimulates research in hybrid technologies for current (and future) life-saving applications (artificial organs, drug delivery) Electro-osmosis is an established method of consolidating soft fine-grained soils. Its efficiency is

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controlled by the electrical resistance of the soil-electrode system. Because of an increase in soil electrical resistance during treatment, its cost efficiency is reduced, limiting the widespread use of this technique, especially in developed nations. One of the main causes of electrical resistance is hydrolysis of water molecules around the electrodes. The acidification of the anode, in particular, reduces the negative surface charge of clay particles and, thus, the zeta potential. According to the Helmholtz-Smoluchowski model, the zeta potential is directly proportional to the electro-osmotic permeability. This article studies the use of ion exchange membranes to assess their ability to prevent flow of hydrogen ions into the soil. The test with an anion exchange membrane showed minimal change of the pH in the soil around the anode compared to a control, which is better for electro-osmotic consolidation.

Electromembrane processes offer a multitude of applications, allowing for the recovery of water, other products, and energy. This book is a collection of contributions on recent advancements in electromembrane processes attained via experiments and/or models. The first paper is a comprehensive review article on the applications of electrodialysis for wastewater treatment, highlighting current status, technical challenges, and key points for future perspectives. The second paper focuses on ZSM-5 zeolite/PVA mixed matrix CEMs with high monovalent permselectivity for recovering either acid or  $\text{Li}^+$ . The third paper regards direct numerical simulations of electroconvection in an electrodialysis dilute channel with

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forced flow under potentiodynamic and galvanodynamic regimes. The fourth paper investigates the reasons for the formation and properties of soliton-like charge waves in overlimiting conditions. The fifth paper focuses on the characterization of AEMs functionalized by surface modification via poly(acrylic) acid yielding monovalent permselectivity for reverse electrodialysis. In the sixth paper, CFD simulations of reverse electrodialysis systems are performed. The seventh paper proposes an integrated membrane process, including electrochemical intercalation–deintercalation, for the preparation of  $\text{Li}_2\text{CO}_3$  from brine with a high  $\text{Mg}^{2+}/\text{Li}^+$  mass ratio. Finally, the eighth paper is a perspective article devoted to the acid–base flow battery with monopolar and bipolar membranes.

The two-volume work presents applications of integrated membrane operations in agro-food productions with significant focus on product quality, recovery of high added-value compounds, reduction of energy consumption and environmental impact. Volume 1. Dairy, Wine and Oil Processing. Volume 2. Wellness Ingredients and Juice Processing.

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Focuses on the application of membrane technologies in removing toxic metals/metalloids from water. Particular attention is devoted to the removal of arsenic, uranium, and fluoride. These compounds are all existing in the earth's crust at levels between two and five thousands micrograms per kg (parts per million) on average and these compounds can be considered highly toxic to humans, who are exposed to them primarily from air, food and water. In order to comply with the new maximum contaminant level, numerous studies have been undertaken to improve established treatments or to develop novel treatment technologies for removing toxic metals from contaminated surface and groundwater. Among the technologies available, applicable for water treatment, membrane technology has been identified as a promising technology to remove such toxic metals from water. The book describes both pressure driven (traditional processes, such as Nanofiltration, Reverse Osmosis, Ultrafiltration, etc) and more advanced membrane processes (such as forward osmosis, membrane distillation, and membrane bio-reactors) employed in the application of interest. Key aspect of this book is to provide information on both the basics of membrane technologies and on the results depending on the type of technology employed.

Industrial application of ion exchange membranes started from saline water desalination. However, now it extends widely in many fields such as drinking water or wastewater treatment, demineralisation of amino acid,

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whey, sugar liquor, recovery of useful components, treatment of organic substances and contributes to the improvement of our standard of living. The application of ion exchange membranes must expand further if we pay attention to unique functions of the membranes for separating ionic species from non-ionic substances or other kinds of ionic species. This book discusses the performance of an electrodialyser from the stand point of fundamental and practical views.

Salinity gradient energy, also known as blue energy and osmotic energy, is the energy obtainable from the difference in salt concentration between two feed solutions, typically sea water and river water. It is a large-scale renewable resource that can be harvested and converted to electricity. Efficient extraction of this energy is not straightforward, however. *Sustainable Energy from Salinity Gradients* provides a comprehensive review of resources, technologies and applications in this area of fast-growing interest. Key technologies covered include pressure retarded osmosis, reverse electrodialysis and accumulator mixing. Environmental and economic aspects are also considered, together with the possible synergies between desalination and salinity gradient energy technologies. *Sustainable Energy from Salinity Gradients* is an essential text for R&D professionals in the energy & water industry interested in salinity gradient power and researchers in academia from post-graduate level upwards. For more than ten years the Editors have been sharing substantial research activities in the fields of renewable energy and desalination, successfully participating to a number of European Union research

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projects and contributing to the relevant scientific literature with more than 100 papers and 2 books on Desalination technologies and their coupling with Renewable Energy. They are intensely working in the field of Salinity Gradient Power, carrying out research with specific focus on open-loop and closed-loop reverse electrodialysis and pressure retarded osmosis. Covers applications of pressure retarded osmosis, reverse electrodialysis, and capacitive mixing for salinity gradient power in one convenient volume Presents the environmental aspects and economics of salinity gradient energy Explores possible synergies between desalination and salinity gradient energy

Membrane processes have wide industrial application This handbook reviews the published literature covering many existing and emerging technologies, presents an in-depth description of common uses in the chemical, petrochemical, petroleum, commercialized membrane processes, and gives a state-of-the-art review of new membrane processes environmental, water treatment, pharmaceutical, medical, food, dairy, beverage, paper, textiles concepts under development. It is intended for chemical and electronic industries. The existing literature to be a single source of underlying principles, membranes, membrane modules, process applications include: (1) dialysis for the purification of human blood (the artificial kidney), (2) signaling applications, and cost estimates. It is also electrodialysis for the desalination of brackish water a first attempt to bridge the gap between the water to produce potable water, (3) reverse theory and practice. osmosis for the desalination of seawater, (4) There are several groups which may

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benefit ultrafiltration for the concentration of large pro from this handbook. It can be used as educa tein molecules from cheese, casein whey, and tional material for industrial personnel engaged milk, and (5) microfiltration for the sterilization in membrane separations. For scientists and of pharmaceutical and medical products, beer, engineers active in research and development in wine, and soft drinks. Since membrane pro synthetic membranes, it will serve as a single cesses generally have low capital investment, as source of reference for the entire field.

Various separation membranes have been developed since their discovery over half a century ago, providing numerous benefits and fulfilling many applications in our everyday lives. They lend themselves to techniques ranging from microfiltration and gas separation, to what can be considered as the most advanced technique - ion exchange. This book, aimed at academic researchers, engineers and industrialists, contains a brief history of ion exchange and goes on to explain the preparation, characterization, modification and applications of these important membranes. Discussions include the use of ion exchange in analytical and medical techniques, as well as the development of future applications.

Membranes have emerged over the last 30 years as a viable water treatment technology. Earth's population is growing and the need for alternative ways to generate potable water is rising. The recent advent of nanotechnology opens the door to improving processes in membrane technology, which is a promising step on the way to solving the earth's potable water problem.

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Current performance is enhanced and new concepts are possible by engineering on the nanoscale. This book presents key areas of nanotechnology such as fouling tolerant and robust membranes, enhanced destruction of pollutants and faster monitoring of water quality.

'Functional Nanostructured Materials and Membranes for Water Treatment' is part of the series on Materials for Sustainable Energy and Development edited by Prof. G.Q. Max Lu. The series covers advances in materials science and innovation for renewable energy, clean use of fossil energy, and greenhouse gas mitigation and associated environmental technologies.

Ion-exchange Technology I: Theory and Materials describes the theoretical principles of ion-exchange processes. More specifically, this volume focuses on the synthesis, characterization, and modelling of ion-exchange materials and their associated kinetics and equilibria. This title is a highly valuable source not only to postgraduate students and researchers but also to industrial R&D specialists in chemistry, chemical, and biochemical technology as well as to engineers and industrialists.

Water is the most valuable resource for all human development. With increasing global population the demand for water increases whereas the sources of clean water are decreasing. recycling and reuse of wastewater has become an imperative which demands the development of new, efficient and environmentally friendly treatment methods. Current Trends and Future Developments in (Bio-) Membranes: Recent Achievements in Wastewater and Water Treatments

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provides a comprehensive coverage of the existing wastewater treatment including, but not exclusively, membrane-based methods. The book presents most common used methods compares and evaluates them depending on their particular application. It illustrates many aspects of the various treatment systems used in water and wastewater purification and lists the advantages of membrane-based methods to non-membrane based technologies. This book focuses on introducing, applications, advantages/disadvantages, evaluating of membrane-based technologies and comparing it with other non-membrane based systems. It also analyses the various limitations of each method. Hence, the book is a key reference text for R&D managers in industry interested in the development of water/waste treatment technologies as well as academic researchers and postgraduate students working in the wider area of the strategic treatment, separation and purification processes. Provides the state-of-the-art of water and wastewater treatments by various technologies Describes novel and emerging technologies for waste/water treatment Discusses a number of case studies of popular applications Offers an economic evaluation of various technologies

Proceedings of the NATO Advanced Study Institute on Ion Exchange: Science and Technology, Troia, Portugal, July 14-26, 1985

Water of very low mineral content, i.e. low ionic conductivity, is required in many industrial processes and laboratory applications. The demand for total output volume and purity of such water has been significantly

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increasing during the last decades. Electromembrane processes provide a more sustainable and cost effective water purification compared to alternative processes like distillation and ion-exchange deionization. In the first part of the publication a review of processes used for deionization of water is presented and main physicochemical phenomena occurring in electromembrane processes will be discussed. The subsequent parts are devoted to the experimental verification of novel improvements for two electromembrane processes: electrodialysis and continuous electrodeionization. Considering electrodialysis, an investigation on ion-exchange membranes with profiled surfaces will be presented. It includes a section of appropriate membrane manufacturing procedures and desalination tests with profiled membranes. It turns out that electrodialysis with profiled ion-exchange membranes is superior to conventional electrodialysis with flat membranes and spacers, in particular with respect to desalination degree and reduced energy consumption. Considering continuous electrodeionization, experimental studies concerning improvements of continuous electrodeionization with bipolar membranes will be presented and discussed. Influence of ion-exchange membrane permselectivity on the product water quality is demonstrated and proposed improvements are aimed to reduce this influence. Concepts with a so-called protection compartment will be discussed and compared experimentally with a concept where the concentrate compartments are filled with ion exchange resin beads. It

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will be shown that improved continuous electrodeionization with bipolar membranes is able to produce ultrapure water in a quality comparable to conventional mixed-bed ion-exchangers but in a more cost effective and sustainable way.

Electrochemically Enabled Sustainability: Devices, Materials and Mechanisms for Energy Conversion covers topics related to current research in electrochemical power sources, highlighting some of the latest concepts in electrochemical conversion for sustainability. The book examines the most recent and innovative technologies employed in battery and fuel cell technology. It introduces the fundamental concepts applied to these electrochemical power sources and provides in-depth discussion on the materials, design, and performance of these devices. Written by internationally acclaimed experts, the chapters illustrate how key technologies for sustainability are enabled by electrochemical conversion. Topics include the reduction of carbon dioxide to resolve issues of carbon capture, energy storage, and generation of portable fuel; turning waste into energy using microbial fuel cells; the promise of vanadium redox flow batteries for massive energy storage; and improved performance of hybrid devices. The book addresses numerous aspects of lithium-type batteries for vehicle propulsion and energy storage, presenting a broad range of lithium batteries, and considering nano-structuring issues, layered-structure materials, and hierarchical structure. This book provides timely coverage of critical issues in emerging and conventional technologies, presenting a wide range of

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electrochemical devices, related materials, and operation mechanisms. It stimulates an appreciation for the novelty of these electrochemical power sources and offers a projection of future integration of these devices in practice.

This book presents a detailed discussion of the fundamentals and practical applications of membrane technology enhancement in a range of industrial processes, energy recovery, and resource recycling. To date, most books on the applications of membrane technology have mainly focused on gas pollution removal or industrial wastewater treatment. In contrast, the enhancement of various membrane processes in the areas of energy and the environment has remained largely overlooked. This book highlights recent works and industrial products using membrane technology, while also discussing experiments and modeling studies on the membrane enhancement process.

Fundamental study and industrial application of ion exchange membranes started over half a century ago. Through the ongoing research and development, the ion exchange membrane technology is now applied to many fields and contributes to the improvement of our standard of living. Ion Exchange Membranes states the ion exchange membrane technology from the standpoint of fundamentals and applications. Discussing not only various phenomena exhibited by the membranes but also their applications in many fields with economical evaluations. \* This volume looks at the latest developments in ion exchange membrane technology \* Provides a full and wide explanation of ion exchange

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membranes \* Easy-to-understand layout, including many figures and tables

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