



# Perfluorinated Ionomer Membranes

**Howard L. Yeager**



## **Perfluorinated Ionomer Membranes:**

**Perfluorinated Ionomer Membranes** Howard L. Yeager, 1982      Modification and Characterization of Nafion  
Perfluorinated Ionomer Membrane for Polymer Electrolyte Fuel Cells Nadzrinahamin Ahmad Nazir, 2011 Nafion perfluorinated ionomer membrane has been regarded as a benchmark material in proton electrolyte membrane fuel cells PEMFC due to its excellent perm selectivity properties However the excessive swelling and low operating temperature window up to 80 C of Nafion marked its vital shortcomings in the proton fuel cell operations This dissertation is focused on the modification of hydrophobic fluorocarbon matrix and hydrophilic ionic domains clusters of Nafion to alleviate the aforementioned shortcomings The first modification is via solution blending of Nafion with copolymer of poly vinylidene fluoride trifluoroethylene or PVDF TrFE which modified the fluorocarbon matrix of Nafion while the second is via simple in situ impregnation of Nafion with several kinds of functionalized supramolecules which locally alters the properties of the ionic domains clusters Nafion PVDF TrFE blends revealed an hourglass type phase diagram consisting of single phase crystal Cr1 and crystal liquid Cr1 L2 and liquid liquid L1 L2 coexistence regions Blends of Nafion with PVDF TrFE demonstrated swelling reduction upon hydration as confirmed by Fourier transform infrared FTIR spectroscopy and water uptake measurements The 60 40 Nafion PVDF TrFE blend with bicontinuous morphology exhibits both capacitor and proton conductivity properties This blend was found to have lower proton conductivity with a decreasing trend upon increasing temperature Supramolecules of photocurable hyperbranched polyester HBPEAc COOH were used in the first part of in situ impregnation attempt Of particular importance is that the present study is the first to successfully incorporate polymer molecules networks into the Nafion ionic domains by means of impregnation with hyperbranched supramolecules followed by photopolymerization in situ HB impregnated Nafion membranes were found to render swelling suppression as well as improved mechanical stability This impregnated membrane exhibited an increasing trend of proton conductivity with increasing temperature which eventually surpassed that of neat Nafion above 100 C Two unique supramolecules terminated with hydroxyl Noria and tert butyloxycarbonyl Noria BOC which resembles a waterwheel were used in the second impregnation attempt We anticipated that these waterwheel supramolecules Noria in particular will have potential utility as the solid proton carrier in proton fuel cells to substitute the role of water at high temperatures Noria and Noria BOC impregnated membranes exhibited excellent swelling suppression and the mechanical stability of both impregnated membranes increased beyond the existing neat Nafion Only Noria impregnated membrane shows improved proton conductivity at elevated temperature whereas Noria BOC impregnated membrane revealed a plummet in the proton conductivity at high temperatures similar to that of neat Nafion      **Morphological Modification of Perfluorinated Ionomer Membranes** Michael Dean Heaney, 1985      **Perfluorinated Polymer Electrolyte Membranes for Fuel Cells** Tatsuhiro Okada, Morihiro Saito, Kikuko Hayamizu, 2008 In this book the authors focus on the ion and water transport

characteristics in Nafion and other perfluorinated ionomer membranes that are recently attracting attention in various fields such as water electrolysis mineral recovery electrochemical devices and energy conversion Methodology of measurements and data analysis is first presented that enables basic characterisation of transport parameters in the perfluorinated ionomer membranes Cation exchange isotherm data are collected in binary cation systems with the aim to see the behaviours of cationic species that exist with H in the membrane Water transference coefficients ionic transference numbers ionic mobilities and other membrane transport parameters are measured in single and mixed counter cation systems using electrochemical methods Diffusion coefficients of water and cations are also measured by pulsed field gradient spin echo NMR PGSE NMR at various temperatures in different kinds of perfluorinated ionomer membranes The results are discussed in two perspectives One is to predict the hydration state in perfluorosulfonated ionomer membranes in relation to the possible degradation of performances in fuel cells under contaminated conditions with foreign cations An analytical formulation of membrane transport equations with proper boundary conditions is proposed and using various parameters of membrane transport a simple diagnosis of water dehydration problem is carried out This analysis leads one to an effective control of fuel cell operation conditions especially from viewpoint of proper water management The others are to elucidate the ion and water transport mechanisms in the membrane in relation to polymer structures e g different ion exchange capacity and to propose a new design concept of polymer electrolyte membranes for fuel cell applications Additionally for this purpose methanol and other alcohols are penetrated into the membrane and alcohol permeability membrane swelling ionic conductivity and diffusion coefficients of water and CH<sub>3</sub> are measured systematically for various kinds of membranes to cope with the problem of methanol crossover in direct methanol fuel cells DMFCs It is found that in order to realise a high ionic conductivity in the membrane one should aim at a polymer structure through molecular design that takes into account the relative size of ions with a hydration shell against the size and atmosphere of ionic channels For DMFC a partially cross linked polymer chain with high degree of hydrophilic ion transport paths based on phase separated structures is recommended Various possibilities of such polymer electrolytes are discussed

**Ionomers** Shulamith Schlick, 1996-01-15

The molecular structure and composition of ionomers lead to a complex superposition of properties of organic chains and of polyelectrolytes The potential use of this class of polymers in applications such as surfactants ion selective membranes in electrochemical processes coatings fuel cells and batteries has sparked a vast amount of research

**Anion Transport in Perfluorinated Ionomer Membranes [microform]** America Herrera, 1986 [Handbook of Chlor-Alkali Technology](#)

Thomas F. O'Brien, Tilak V. Bommaraju, Fumio Hine, 2007-12-31 Foreword It is surprising that we had to wait so long for a new book that gives a comprehensive treatment of chlor alkali manufacturing technology Technologists are largely still making do with the classical book edited by Sconce but that is more than thirty years old At the time of its publication metal anodes were just beginning to appear and ion exchange membrane technology was confined to laboratories The various

encyclopedias of industrial technology have more up to date information but they are necessarily limited in their scope Schmittinger recently provided an excellent shorter treatment of the broad field of chlorine technology and applications After discussing electrolysis and the principal types of cell this too gives rather brief coverage to brine and product processing It then follows on with descriptions of the major derivatives and direct uses of chlorine and a discussion of environmental issues The last feature named above has relieved the authors of this work of the obligation to cover applications in any detail Instead they provide a concentrated treatment of all aspects of technology and handling directly related to the products of electrolysis It covers the field from a history of the industry through the fundamentals of thermodynamics and electrochemistry to the treatment and disposal of the waste products of manufacture Membrane cells are considered the state of the art but the book does not ignore mercury and diaphragm cells They are considered both from a historical perspective and as examples of current technology that is still evolving and improving Dear to the heart of a director of Euro Chlor the book also pays special attention to safe handling of the products the obligations of Responsible Care and process safety management Other major topics include corrosion membranes electrolyzer design brine preparation and treatment and the design and operation of processing facilities Perhaps uniquely the book also includes a chapter on plant commissioning The coverage of membranes is both fundamental and applied The underlying transport processes and practical experience with existing types of membrane both are covered The same is true of electrolyzer design The book explores the basic electrode processes and the fundamentals of current distribution in electrolyzers as well as the characteristics of the leading cell designs The authors have chosen to treat the critical subject of brine treatment in two separate chapters The chapter on brine production and treatment first covers the sources of salt and the techniques used to prepare brine It then explains the mechanisms by which brine impurities affect cell performance and outlines the processes by which they can be removed or controlled While pointing out the lack of fundamental science in much of the process it describes the various unit operations phenomenologically and discusses methods for sizing equipment and choosing materials of construction The chapter on processing and handling of products is similarly comprehensive Again it is good to see that the authors have included a lengthy discussion of safe methods and facilities for the handling of the products particularly liquid chlorine While the discussion of the various processing steps includes the topic of process control there is also a separate chapter on instrumentation which is more hardware oriented Other chapters deal with utility systems cell room design and arrangement with an emphasis on direct current supply alternative processes for the production of either chlorine or caustic without the other the production of hypochlorite industrial hygiene and speculations on future developments in technology There is an Appendix with selected physical property data The authors individually have extensive experience in chlor alkali technology but with diverse backgrounds and fields of specialization This allows them to achieve both the breadth and the depth which are offered here The work is divided into five volumes successively treating

fundamentals brine preparation and treatment production technology support systems such as utilities and instrumentation and ancillary topics Anyone with interest in the large field of chlor alkali manufacture and distribution and indeed in industrial electrochemistry in general will find something useful here The work is recommended to students chlor alkali technologists electrochemists engineers and producers shippers packagers distributors and consumers of chlorine caustic soda and caustic potash This book is thoroughly up to date and should become the standard reference in its field Barrie S Gilliatt Executive Director Euro Chlor     Ionomers M.R. Tant,K.A. Mauritz,G.L. Wilkes,2012-12-06 Polymers have achieved an enviable position as the class of materials having the highest volume of production exceeding that of both metals and ceramics The meteoric rise in the production and utilization of polymers has been due to advances in polymer synthesis which allow the creation of specific and well defined molecular structures to new knowledge concerning the relationships between polymer structure and properties and to an improved understanding of how processing can be used as a tool to develop morphological features which result in desired properties Polymers have truly become engineered materials in every sense of the term Polymer scientists and engineers are forever seeking to modify and improve the properties of synthetic polymeric systems for use in specific applications Towards this end they have often looked to nature for advice on how to design molecules for specific needs An excellent illustration of this is the use of noncovalent bonding ionic hydrogen and van der Waals in lipids proteins and nucleic acids where these noncovalent bonds acting both intra and intermolecularly precisely control the structure and thus the function of the entire system The utilization of ionic bonding in particular in man made polymers has attracted widespread interest in recent years since ionic interactions exert a similar strong influence on the structure and properties of these synthetic systems     *Scanning Probe Microscopy of Perfluorinated Ionomer Membranes* Paul John James,2000     **Proceedings of the Symposium on Diaphragms, Separators, and Ion-Exchange Membranes** John William Van Zee,1986     *Electrochemical Polymer Electrolyte Membranes* Jianhua Fang,Jinli Qiao,David P. Wilkinson,Jiujun Zhang,2015-04-17 *Electrochemical Polymer Electrolyte Membranes* covers PEMs from fundamentals to applications describing their structure properties characterization synthesis and use in electrochemical energy storage and solar energy conversion technologies Featuring chapters authored by leading experts from academia and industry this authoritative text Disc     **Transport Properties of Perfluorinated and Aromatic Ionomer Membranes [microform]** Steck, Alfred Eduard,1983     **Structure and Properties of Ionomers** Michel Pineri,Adi Eisenberg,2012-12-06 Ionomers that is polymers containing a low concentration of charged units along the chain have been the subject of increasing interest during the past twenty years The presence of ionic groups in the poly mer changes some of its properties dramatically Increases in the modulus and the viscosity of several orders of magnitude have been observed and changes in the glass transition of hundreds of degrees are possible In addition diffusion coefficients can be modified drastically These changes are due primarily to the presence of reversible ionic cross links in these materials Because of the low dielectric constant of most

organic polymers the ions or ionic dipoles tend to aggregate this aggregation process however is limited because the ionic groups are covalently bonded to the organic chain Host of the fundamental research done on these materials has been devoted to a determination of the extent of association the structure of the aggregates the limiting factors and the correlations between molecular and supermolecular structure and the resulting properties *Ion Exchange Membranes* Toshikatsu Sata, 2007-10-31 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

**Ion-Exchange Membrane Separation Processes** H Strathmann, 2004-01-29 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 electrodialysis 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 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 **Handbook of Membrane Separations** Anil K. Pabby, Syed S.H. Rizvi, Ana Maria Sastre Requena, 2008-07-07 The Handbook of Membrane Separations Chemical Pharmaceutical and Biotechnological Applications provides detailed information on membrane separation technologies as they have evolved over the past decades To provide a basic understanding of membrane technology this book documents the developments dealing with these technologies It explores chemical pharmaceutical food processing and biotechnological applications of membrane processes ranging from selective separation to solvent and

material recovery This text also presents in depth knowledge of membrane separation mechanisms transport models membrane permeability computations membrane types and modules as well as membrane reactors

**Electroanalytical Chemistry Research Developments** P. N. Jiang, 2007 Electroanalytical chemistry as the name implies involves the analysis of chemical species through the use of electrochemical methods Generally alterations are measured in the concentration of a chemical species by measuring changes in current in response to an applied voltage with respect to time According to Faraday's law the charge is directly proportional to the amount of species undergoing a loss oxidation or gain reduction of electrons Constant potential amperometry high speed chronoamperometry fast cyclic voltammetry FCV and differential pulse voltammetry DPV are the most common voltammetric techniques used to detect monoamine neurotransmitters ie serotonin dopamine norepinephrine Each method has its pros and cons In constant potential amperometry a uniform potential is applied and the change in current is monitored as a function of time The advantage of this technique is that the time resolution is limited only by the data collection frequency of the instrument

**Polymer Membranes** T. deV. Naylor, 1996 This report describes the constitution and application of polymeric membranes in separation processes The separation processes covered are reverse osmosis and nanofiltration ultrafiltration gas separation pervaporation and ion exchange An additional indexed section containing several hundred abstracts from the Rapra Polymer Library database provides useful references for further reading

*Membrane Technology* Sundergopal Sridhar, 2018-09-03 Contributed by multiple experts the book covers the scientific and engineering aspects of membrane processes and systems It aims to cover basic concepts of novel membrane processes including membrane bioreactors microbial fuel cell forward osmosis electro dialysis and membrane contactors Maintains a pragmatic approach involving design operation and cost analysis of pilot plants as well as scaled up counterparts

**Electroactive Polymer (EAP) Actuators as Artificial Muscles** Yoseph Bar-Cohen, 2004 Covers the field of EAP with attention to all aspects and full infrastructure including the available materials analytical models processing techniques and characterization methods This second edition covers advances in electric EAP electroactive polymer gels ionomeric polymer metal composites and carbon nanotube actuators



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