

Handbook of Chlor-Alkali Technology

Volume I: Fundamentals



Thomas F. O'Brien, Tilak V. Bommaraju,
and Fumio Hine

Handbook Of Chlor Alkali Technology

Supramaniam Srinivasan



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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 *Handbook of Chlor-Alkali Technology* Thomas F. O'Brien, Tilak V. Bommaraju, Fumio Hine, 2005 Made from common salt and water chlorine and its co product caustic soda are two of the most basic building blocks used for a wide range of products valued by society The Handbook of Chlor Alkali Technology provides comprehensive and concise treatments of all aspects of technology and handling directly related to the products of electrolysis A long awaited comprehensive treatment 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 While membrane cells are considered state of the art the handbook does not ignore mercury and diaphragm cells They are considered both from a historical perspective and as examples of current technology that yet evolves Special attention is paid 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 The coverage of membranes is both fundamental and applied The underlying transport processes and practical experience with existing types of membrane both are covered as is 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 while the appendix offers selected physical property data The authors each with extensive experience in chlor alkali technology but with diverse backgrounds and fields of specialization achieve both breadth and depth 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 Handbook offers not only broad coverage but also in depth treatment of each topic It will be an asset to managers process engineers and operating personnel working in the chlor alkali industry This book provides valuable information to engineers and scientists involved in development of chlor alkali technology and in the design of new plant or upgrading of existing plants It will be especially valuable to universities as it begins with fundamentals and

progresses methodically through each step involved in chlor alkali production including environmental issues from the Foreword by Barrie S Gilliatt Executive Director Euro Chlor 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 Handbook of chlor-alkali technology Thomas F. O'Brien, Tilak V. Bommaraju, Fumio Hine, 2005 Annotation 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

Handbook of chlor-alkali technology Thomas F. O'Brien, Tilak V. Bommaraju, Fumio Hine, 2005 Annotation 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 cell technologies. **Modern Chlor-Alkali Technology** N.M. Prout, J.S. Moorhouse, 2012-12-06 The papers in this book were submitted for the 1988 London International Chlorine Symposium This was the fifth symposium organised by the Electro chemical Technology Group of the Society of Chemical Industry and proved as popular as ever attracting a record number of 294 delegates from 31 countries Twenty seven papers were presented during the two and a half day event covering the latest developments in chlor alkali technology The field of membranes and membrane cells was well represented by some 15 papers reflecting the importance of membrane technology to the future of the industry This is particularly relevant in view of increasing environmental pressures and rising costs However papers relating to the more traditional mercury and diaphragm cell technologies were also presented together with a paper concerned with sodium chlorate manufacture In addition there were presentations covering the commercial and safety aspects of the chlor alkali industry The Electrochemical Technology Group of the Society of Chemical Industry offer thanks to the many people and organisations whose help ensured the success of this symposium In particular we would like to thank 1 The contributors of the papers 2 The session chairmen Dr R G Smerko The Chlorine Institute Inc Mr B Lott The Associated Octel Company Limited Mr T F O'Brien United Engineers and Constructors Dr B S Gilliatt ICI Chemicals and Polymers Limited Mr D Bell Hays Chemicals Limited 3 The Chlorine Institute for assistance with printing costs and for active participation

Handbook of Industrial Chemistry and Biotechnology James A. Kent, Tilak V. Bommaraju, Scott D. Barnicki, 2017-08-01 This widely respected and frequently consulted reference work provides a wealth of information and guidance on industrial chemistry and biotechnology Industries covered span the spectrum from salt and soda ash to advanced dyes chemistry the nuclear industry the rapidly evolving biotechnology industry and most recently electrochemical energy storage devices and fuel cell science and technology Other topics of surpassing interest to the world at large are covered in chapters on fertilizers and food production pesticide manufacture and use and the principles of sustainable chemical practice referred to as green chemistry Finally considerable space and attention in the Handbook are devoted to the subjects of safety and emergency preparedness It is worth noting that virtually all of the chapters are written by individuals who are embedded in the industries whereof they write so knowledgeably

Fuel Cells Supramaniam Srinivasan, 2006-12-31 This concise sourcebook of the electrochemical engineering and economic principles involved in the development and commercialization of fuel cells offers a thorough review of applications and techno economic assessment of fuel cell technologies plus in depth discussion of conventional and novel approaches for generating energy Parts I and II explain basic and applied electrochemistry relevant to an understanding of fuel cells Part III covers engineering and technology aspects The book is useful for undergraduate and graduate students and scientists interested in fuel cells Unlike any other current book on fuel cells each chapter includes problems based on the discussions in the text

Handbook of Membrane Reactors Angelo Basile, 2013-04-04 Membrane reactors are increasingly replacing conventional separation

process and conversion technologies across a wide range of applications Exploiting advanced membrane materials they offer enhanced efficiency are very adaptable and have great economic potential There has therefore been increasing interest in membrane reactors from both the scientific and industrial communities stimulating research and development The two volumes of the Handbook of membrane reactors draw on this research to provide an authoritative review of this important field Volume 2 reviews reactor types and industrial applications beginning in part one with a discussion of selected types of membrane reactor and integration of the technology with industrial processes Part two goes on to explore the use of membrane reactors in chemical and large scale hydrogen production from fossil fuels Electrochemical devices and transport applications of membrane reactors are the focus of part three before part four considers the use of membrane reactors in environmental engineering biotechnology and medicine Finally the book concludes with a discussion of the economic aspects of membrane reactors With its distinguished editor and international team of expert contributors the two volumes of the Handbook of membrane reactors provide an authoritative guide for membrane reactor researchers and materials scientists chemical and biochemical manufacturers industrial separations and process engineers and academics in this field Discusses integration of membrane technology with industrial processes Explores the use of membrane reactors in chemical and large scale hydrogen production from fossil fuels Considers electrochemical devices and transport applications of membrane reactors

Modern Chlor-alkali Technology Kevin Wall,1986 **Kent and Riegel's Handbook of Industrial Chemistry and Biotechnology** James A. Kent,2007-10-08 This substantially revised and updated classic reference offers a valuable overview and myriad details on current chemical processes products and practices No other source offers as much data on the chemistry engineering economics and infrastructure of the industry The two volume Handbook serves a spectrum of individuals from those who are directly involved in the chemical industry to others in related industries and activities Industrial processes and products can be much enhanced through observing the tenets and applying the methodologies found in the book's new chapters

Modern Chlor-Alkali Technology C. Jackson,1983 **Chemicals without Harm** Ken Geiser,2015-06-19 A proposal for a new chemicals strategy that we work to develop safer alternatives to hazardous chemicals rather than focusing exclusively on controlling them Today there are thousands of synthetic chemicals used to make our clothing cosmetics household products electronic devices even our children's toys Many of these chemicals help us live longer and more comfortable lives but some of these highly useful chemicals are also persistent toxic and dangerous to our health and the environment For fifty years the conventional approach to hazardous chemicals has focused on regulation barriers and protection In Chemicals without Harm Ken Geiser proposes a different strategy based on developing and adopting safer alternatives to hazardous chemicals rather than focusing exclusively on controlling them Geiser reviews past government policies focused on controlling chemicals describes government initiatives outside the United States that have begun to implement a more sustainable chemical policy and offers an overview of the chemicals industry and market He

develops a safer chemicals policy framework that includes processes for characterizing classifying and prioritizing chemicals generating and using new chemical information and promoting transitions to safer chemicals The shift in strategy described by Geiser will require broad changes in science the chemicals economy and government policy Geiser shows that it is already beginning identifying an emerging movement of scientists corporate managers environmental activists and government leaders who are fashioning a new twenty first century approach to chemicals

Current Trends and Future Developments on (Bio-) Membranes Angelo Basile,Kamran Ghasemzadeh,2023-09-14 Current Trends and Future Developments on Bio Membranes Recent Achievements for Ion Exchange Membranes focuses on introducing and analyzing ion exchange membranes performance and overviewing recent achievements in the structural development of ion exchange membranes in various applications Hence this book is a key reference text for R D managers in who are interested in the development of ion exchange membrane technologies as well as academic researchers and postgraduate students working in the wider area of strategic treatments separation and purification processes Reviews the ion exchange membranes including fundamentals and processes Provides thorough coverage of transport aspects and fundamentals of various ion exchange membranes systems such as fuel cells electrodialysis and more Describes the two main categories of ion exchange membranes inorganic and organic Covers numerous new applications of ion exchange membranes

Mercury Stories Henrik Selin,Noelle Eckley Selin,2020-10-20 An interdisciplinary analysis of human interactions with mercury through history that sheds light on efforts to promote and achieve sustainability In Mercury Stories Henrik Selin and Noelle Eckley Selin examine sustainability through analyzing human interactions with mercury over thousands of years They explore how people have made beneficial use of this volatile element how they have been harmed by its toxic properties and how they have tried to protect themselves and the environment from its damaging effects Taking a systems approach they develop and apply an analytical framework that can inform other efforts to evaluate and promote sustainability After introducing the framework which uses the lens of a human technical environmental system and a matrix based approach to analyze mercury use and exposure the authors examine five topical mercury systems that each illustrate important issues in mercury science and governance global cycling of mercury through the atmosphere land oceans and societies mercury s dangers to human health including from occupational medical and dietary exposure mercury emissions to the atmosphere from industrial sources mercury in commercial products and production processes and mercury use in artisanal and small scale gold mining Finally looking across the five mercury systems they distill insights for sustainability analysis more broadly and draw lessons for researchers decision makers and concerned citizens

Electrochemical Engineering Across Scales Richard C. Alkire,Philip N. Bartlett,Jacek Lipkowski,2015-02-09 In Volume XV in the series Advances in Electrochemical Science and Engineering various leading experts from the field of electrochemical engineering share their insights into how different experimental and computational methods are used in transferring molecular scale discoveries into processes and products Throughout the

focus is on the engineering problem and method of solution rather than on the specific application such that scientists from different backgrounds will benefit from the flow of ideas between the various subdisciplines A must read for anyone developing engineering tools for the next generation design and control of electrochemical process technologies including chemical mechanical and electrical engineers as well as chemists physicists biochemists and materials scientists

Electrochemistry of Carbon Electrodes Richard C. Alkire, Philip N. Bartlett, Jacek Lipkowski, 2015-11-23 The book sets the standard on carbon materials for electrode design For the first time the leading experts in this field summarize the preparation techniques and specific characteristics together with established and potential applications of the different types of carbon based electrodes An introductory chapter on the properties of carbon together with chapters on the electrochemical characteristics and properties of the different modifications of carbon such as carbon nanotubes graphene carbon fiber diamond or highly ordered pyrolytic graphite provide the reader with the basics on this fascinating and ubiquitous electrode material Cutting edge technologies such as carbon electrodes in efficient supercapacitors Li ion batteries and fuel cells or electrodes prepared by screen printing are discussed giving a complete but concise overview about the topic The clearly structured book helps newcomers to grasp easily the principles of carbon based electrodes while researchers in fundamental and applied electrochemistry will find new ideas for further research on related key technologies

Applications Of X-ray Techniques To Nanomaterials For Energy Research Li-chyong Chen, Wei-fu Chen, 2024-01-22 Nanomaterials have become a key component for energy related applications Their design principle synthesis and applications are well discussed in various scientific and engineering books but a gap remains in discussions regarding the application of cutting edge X ray techniques to these materials This volume provides insights from the latest development of X ray techniques to investigate nanomaterials in specific energy fields bridging the gap between X ray analytical scientists and material researchers We aim to provide researchers with a tool to choose suitable X ray techniques carry them out with the right procedure and analyze the data to give the best reliable results The approach is microscopic and specific Among the applications emphasized by the chapters in this book are x ray techniques in heterogeneous catalysis electrocatalysis for fuel cells photocatalysis for water splitting and carbon dioxide reduction organic photovoltaics and other energy related applications

Mercury — Cadmium — Lead Handbook for Sustainable Heavy Metals Policy and Regulation M.J. Scoullou, Gerrit H. Vonkeman, I. Thornton, Z. Makuch, 2012-12-06 Although this is a handbook for policy and regulation the major part of it is filled with data on the three heavy metals that served as examples mercury cadmium and lead Their stocks productions prices trade flows uses and applications recovery and recycling as well as their eco toxicological characteristics have been collected and presented to their fullest extent In addition they are thoroughly analysed for consistency future developments and trends and of course their consequences for sustainable development and future policy and regulation The second part on policy and regulation begins with an extensive and fundamental consideration on the characteristics of a

sustainable heavy metals policy whereby innovative policy tools are developed In many aspects these considerations are also valid for other metals and even non metallic persistent substances Addressing the European Union in particular its policy making structure and practice are critically analysed in order to develop feasible and viable guidelines for long medium and short term EU policy measures The results of this exercise are then applied to the three heavy metals In each of these three chapters all existing EU measures are presented in detail and confronted with better practices elsewhere resulting in many suggestions and recommendations for the future In the last chapter the main conclusions and recommendations are carefully summarised Together with a very extended table of contents this makes the book easily accessible in spite of its volume This Handbook is a must for policy makers and administrators at all levels as well as for their counterparts in a wide variety of industries In addition it is well suited for environmental science courses at academic or higher professional level

Electrochemical Dictionary Allen J. Bard, György Inzelt, Fritz Scholz, 2012-08-30 This second edition of the highly successful dictionary offers more than 300 new or revised terms A distinguished panel of electrochemists provides up to date broad and authoritative coverage of 3000 terms most used in electrochemistry and energy research as well as related fields including relevant areas of physics and engineering Each entry supplies a clear and precise explanation of the term and provides references to the most useful reviews books and original papers to enable readers to pursue a deeper understanding if so desired Almost 600 figures and illustrations elaborate the textual definitions The Electrochemical Dictionary also contains biographical entries of people who have substantially contributed to electrochemistry From reviews of the first edition the creators of the Electrochemical Dictionary have done a laudable job to ensure that each definition included here has been defined in precise terms in a clear and readily accessible style The Electric Review It is a must for any scientific library and a personal purchase can be strongly suggested to anybody interested in electrochemistry Journal of Solid State Electrochemistry The text is readable intelligible and very well written Reference Reviews Electrochemical Energy Systems Artur Braun, 2018-12-03 This book is for anyone interested in renewable energy for a sustainable future of mankind Batteries fuel cells capacitors electrolyzers and solar cells are explained at the molecular level and at the power plant level in their historical development in their economical and political impact and social change Cases from geophysics and astronomy show that electrochemistry is not confined to the small scale Examples are shown and exercised

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