

Metalurgia Extractiva de Tierras Raras

Extractive Metallurgy of Rare Earths

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Resumen

Debido a su estructura electrónica los elementos de las tierras raras tienen un comportamiento químico similar. Por lo tanto antiguamente ningún método de separación química era adecuado y se utilizaron solamente métodos físicos para separar sus sales. Inicialmente la cristalización fraccionada fue el único método utilizado por los primeros investigadores. Más tarde, se aplicaron el intercambio iónico y la extracción con solventes. Las tierras raras no son ni raras ni tierras. La industria comenzó en Viena (Austria) por Carl Auer von Welsbach a finales del siglo XIX, con la producción de capas de gas para el alumbrado. Fue el inicio de su uso, luego se ha desarrollado en nuevas direcciones para convertirse en materia prima para la actual alta tecnología.

Abstract

Due to their electronic structure the rare earth elements have similar chemical behavior. As a result no chemical method of separation was available and only physical methods were used for separating their salts. Initially fractional crystallization was the only method used by the pioneer researchers. Later, ion exchange and solvent extraction were successfully applied. The rare earths are neither rare nor they are earths. The industry started in Vienna, Austria by Carl Auer von Welsbach at the end of the 19th century to produce gas mantles for lighting streets. It then prospered in new directions to become essential for today's high technology.

INTRODUCTION

Originally, the term rare earths was only used for the oxides, R_2O_3 , which are similar to one other in their chemical and physical properties and are therefore difficult to separate. Within the rare earth group, the elements scandium, yttrium, and lanthanum differ in their atomic structure from the elements cerium to lutetium (the lanthanides, Ln). Scandium occupies a special position with respect to this classification and its other properties, and therefore does not belong to either of these groups. The rare earth elements always occur in nature in association with each other. The isolation of groups of rare earth elements or of individual elements requires costly separation and fractionation processes owing to the great similarity of the chemical and physical properties of their compounds, which explains why the history of their discovery has extended for about two hundred years.

The word "rare", when used to describe this group of elements, originates from the fact it was thought that these elements could only be isolated from very rare minerals. Considering their abundance in the Earth's crust, the term rare is now inappropriate. These elements are lithophilic and are therefore concentrated in oxidic compounds such as carbonates, silicates, titanotantaloniobates, and phosphates.

The abundance of the rare earth elements taken together is quite considerable. Cerium, the most common rare earth, is more abundant than cobalt. Yttrium is more abundant than lead, whereas Lu and Tm are as abundant as Sb, Hg, Bi, and Ag. Promethium does not occur in nature. It forms only in nuclear reactors.

Extractive Metallurgy Of Rare Earths

Evan S. Beach, Soumen Kundu



Extractive Metallurgy Of Rare Earths:

Extractive Metallurgy of Rare Earths Nagaiyar Krishnamurthy, Chiranjib Kumar Gupta, 2015-12-02 New Edition Now Covers Recycling Environmental Issues and Analytical Determination Employing four decades of experience in the rare metal and rare earths industry the authors of Extractive Metallurgy of Rare Earths Second Edition present the entire subject of rare earth elements with depth and accuracy This second edition updates the most impor Extractive Metallurgy of Rare Earths Nagaiyar Krishnamurthy, 2004-12-20 Extractive Metallurgy of Rare Earths compiles information from scattered sources that is often available only to specialists It provides a complete and usable survey of the rare earth resources extraction and production of numerous end products that translates to both laboratory and industrial settings This book is a source of industry expertis Extractive Metallurgy of Rare Earths Gyan Singh, 2017-02 **Extractive Metallurgy of Niobium** A.K. Suri, 2017-11-13 The growth and development witnessed today in modern science engineering and technology owes a heavy debt to the rare refractory and reactive metals group of which niobium is a member Extractive Metallurgy of Niobium presents a vivid account of the metal through its comprehensive discussions of properties and applications resources and resource processing chemical processing and compound preparation metal extraction and refining and consolidation Typical flow sheets adopted in some leading niobium producing countries for the beneficiation of various niobium sources are presented and various chemical processes for producing pure forms of niobium intermediates such as chloride fluoride and oxide are discussed The book also explains how to liberate the metal from its intermediates and describes the physico chemical principles involved It is an excellent reference for chemical metallurgists hydrometallurgists extraction and process metallurgists and minerals processors It is also valuable to a wide variety of scientists engineers technologists and students interested in the topic **Extractive Metallurgy of Rare Earths** Chiranjib Kumar (Bhabha Atomic Research Centre Gupta, *SME Mineral Processing and Extractive Metallurgy Handbook* Courtney A. Young, 2019-02-01 This landmark publication distills the body of knowledge that characterizes mineral processing and extractive metallurgy as disciplinary fields It will inspire and inform current and future generations of minerals and metallurgy professionals Mineral processing and extractive metallurgy are atypical disciplines requiring a combination of knowledge experience and art Investing in this trove of valuable information is a must for all those involved in the industry students engineers mill managers and operators More than 192 internationally recognized experts have contributed to the handbook s 128 thought provoking chapters that examine nearly every aspect of mineral processing and extractive metallurgy This inclusive reference addresses the magnitude of traditional industry topics and also addresses the new technologies and important cultural and social issues that are important today Contents Mineral Characterization and Analysis Management and Reporting Comminution Classification and Washing Transport and Storage Physical Separations Flotation Solid and Liquid Separation Disposal Hydrometallurgy Pyrometallurgy Processing of Selected Metals

Minerals and Materials *Separation Hydrometallurgy of Rare Earth Elements* Jack Zhang, Baodong Zhao, Bryan Schreiner, 2016-02-10 This book describes in a comprehensive manner the technical aspects of separation of rare earth elements into individual elements for industrial and commercial use The authors include details on and differentiate among the effective separation of rare earth elements for various parts of the world They introduce new applications of separation of rare earth elements from concentrates of diverse ore types *Hydrometallurgy of Rare Earths* Dezhi Qi, 2018-05-15 Hydrometallurgy of Rare Earths Extraction and Separation provides the basic knowledge for rare earth extraction and separation including flow sheet selection criteria and related technology The book includes the latest research findings on all rare earth separation processes methods of controlling operation costs and strategies that help lower wastewater and waste solid discharge It discusses many real process parameters and actual situations in rare earth separation plants also examining the basic principles technologies process parameters and advances and achievements in the area of rare earth extraction and separation In addition the book covers extraction separation theory as developed by Professor Guanxian Xu and Professor Chunhua Yan and the creative use of a computational simulation program to replace the bench scale and pilot plant tests and directly design rare earth extraction separation processes Outlines the theory of solvent extraction and separation of rare earths REs Provides the necessary tools for a REs separation plant design Includes a unique simulation program for the calculation of all process parameters Includes Chinese nomenclature that is useful for identifying the various processes also comparing it to the global literature **New Directions in Mineral Processing, Extractive Metallurgy, Recycling and Waste Minimization** Ramana G. Reddy, Alexandra Anderson, Corby G. Anderson, Camille Fleuriault, Erik D. Spiller, Mark Strauss, Edgar E. Vidal, Mingming Zhang, 2023-02-13 This collection addresses new research and technology for increased efficiency energy reduction and waste minimization in mineral processing extractive metallurgy and recycling Professor Patrick R Taylor and his students have been studying these topics for the past 45 years Chapters include new directions in Mineral Processing Hydrometallurgy Pyrometallurgy Electrometallurgy Metals and E waste recycling Waste minimization including by product recovery Innovations in metallurgical engineering education and curriculum development **Handbook on the Physics and Chemistry of Rare Earths** , 2015-11-21 Handbook on the Physics and Chemistry of Rare Earths is a continuous series of books covering all aspects of rare earth science including chemistry life sciences materials science and physics The main emphasis of the handbook is on rare earth elements Sc Y and the lanthanides La through Lu but whenever relevant information is also included on the closely related actinide elements The individual chapters are comprehensive broad up to date critical reviews written by highly experienced invited experts The series which was started in 1978 by Professor Karl A Gschneidner Jr combines and integrates both the fundamentals and applications of these elements now publishing two volumes a year Individual chapters are comprehensive broad critical reviews on the topic of rare earths Contributions are written by highly experienced invited experts Up to date overviews of developments in the

field Includes update on many of the closely related actinide elements *The Rare Earth Elements* J.H.L.

Voncken,2015-12-24 This book deals with the rare earth elements REE which are a series of 17 transition metals scandium yttrium and the lanthanide series of elements lanthanum cerium praseodymium neodymium promethium samarium europium gadolinium terbium dysprosium holmium erbium thulium ytterbium and lutetium They are relatively unknown to the wider public despite their numerous applications and their critical role in many high tech applications such as high temperature superconductors phosphors for energy saving lamps flat screen monitors and flat screen televisions rechargeable batteries household and automotive very strong permanent magnets used for instance in wind turbines and hard disk drives or even in a medical MRI application This book describes the history of their discovery the major REE ore minerals and the major ore deposits that are presently being exploited or are planned to be exploited in the very near future the physical and chemical properties of REEs the mineral processing of REE concentrates and their extractive metallurgy the applications of these elements their economic aspects and the influential economical role of China and finally the recycling of the REE which is an emerging field **Advanced Coal Preparation and Beyond** S. Komar Kawatra,2020-01-27

Updating content from the author's 2001 book Coal Desulfurization this new title focuses on CO₂ sequestration and utilization It includes information on the theory and practical approaches to CO₂ capture and recent advances in the use of sequestered CO₂ Avoiding these pollutants requires either forgetting about the 250 billion tons of coal reserves the United States possesses or capturing and utilizing the pollutants in a profitable and environmentally responsible fashion The book covers postcombustion and precombustion capture approaches for coal and postcombustion capture can be generalized to many other fuels Recent practical implementations at full scale power facilities around the world are discussed The book covers sequestering CO₂ via underground oceanic biological and other long term CO₂ storage methods It also includes recent advances in utilizing CO₂ for enhanced oil recovery advances in storage with depleted oil and gas reservoirs and deep saline aquifers and additional topics The book also examines specific applications of pure CO₂ and covers chemical conversion of CO₂ to useful compounds It answers questions like Can we create methanol from coal or Can we create ethanol from coal It is found that methanol and ethanol cannot be sustainably produced from coal power alone However oxalic acid can be created at a much lower energy cost than methanol or ethanol Oxalic acid can be used to extract rare earths which are not currently produced anywhere in the United States but are typically concentrated in coal ash Aimed at researchers and industry professionals in chemical environmental and energy engineering this book provides insight and inspiration into capturing CO₂ not merely as a response to regulatory pressure and climate change but as an inherently profitable and valuable venture **Recovery of Values from Low-Grade and Complex Minerals** Elvis Fosso-Kankeu,Bhekia B. Mamba,Antoine F.

Mulaba-Bafubiandi,2024-04-24 Recovery of Values from Low Grade and Complex Minerals The book elaborates on various physicochemical properties of minerals and technological developments to improve the recovery of metals while ensuring

cost effectiveness and minimal environmental impact The mineral industry is undergoing significant cultural organizational and technological transformations to address some of the major limitations and challenges related to the environmental and productivity domains As far as productivity is concerned the decrease of high grade ores has been one of the stumbling blocks toward the achievement of maximum recovery of metals while on the other hand the complexity of minerals therein makes it difficult to profitably extract metals using only conventional methods This book presents eight specialized chapters that focus on the exploration of the complexity of minerals that are likely to negatively influence the recovery of values as well as the development of adequate technologies capable of improving the process of mineral concentration and or metal recovery from complex minerals in a sustainable manner It reviews the various physicochemical properties of minerals that are likely to pose a challenge during the attempt to recover values using conventional methods It also elaborates on the recent technological development that has been considered by researchers to improve the recovery of metals from gangue dominated minerals while ensuring cost effectiveness and minimal adverse environmental impact Audience This book will be of interest to academic researchers from the fields of mineral processing hydrometallurgy geochemistry environment chemistry engineering and professionals including mining plant operators environmental managers in the industries government regulatory bodies officers and environmentalists

Physical Separation and Enrichment Saeed

Farrokhpay,2020-04-01 This book includes 12 papers from around the world on topics related to physical separation and enrichment in mineral processing Physical separation is commonly used in the mineral industry to separate valuable minerals from gangues using differences in their physical properties Physical separation methods have several advantages over other mineral processing techniques due to their high efficiency low capital and operating costs no additional chemicals required and consequently lower environmental hazard They can be applied to the ores from mines or tailings or in the recycling stage for scavenging the desired elements

Sustainable Utilization of Metals Bernd Friedrich,2020-05-23

The high demand for advanced metallic materials raises the need for an extensive recycling of metals and such a sustainable use of raw materials Sustainable Utilization of Metals Processing Recovery and Recycling comprises the latest scientific achievements in efficient production of metals and such addresses sustainable resource use as part of the circular economy strategy This policy drives the present contributions aiming on the recirculation of EoL streams such as Waste Electric and Electronic Equipment WEEE multi metal alloys or composite materials back into metal production This needs a holistic approach resulting in the maximal avoidance of waste Considering both aspects circular economy and material design recovery and use of minor metals play an essential role since their importance for technological applications often goes along with a lack of supply on the world market Additionally their ignoble character and low concentration in recycling materials cause an insufficient recycling rate of these metals awarding them the status of critical metals In order to minimize losses and energy consumption this issue explores concepts for the optimization concerning the interface between mechanical and thermal pre

treatment and metallurgical processes Such new approaches in material design structural engineering and substitution are provided in the chapters *Tools for Green Chemistry, Volume 10* Evan S. Beach, Soumen Kundu, 2017-06-12 Volume 10 in the Handbook of Green Chemistry series provides useful and practical tools databases and laboratory approaches to support chemists working in both academia and industry in achieving their green chemistry goals Among many other helpful techniques covered the authors offer prediction software life cycle assessment methodology and screening tools

Hydrometallurgy Michael L. Free, 2021-11-30 This revised new edition retains its class tested coverage of how metals behave in water while updating and expanding information about metals processing methods The book further retains its emphasis on predicting and engineering the way metals are extracted from ore sources separated from unwanted entities recovered as metals and purified using water based processing The transformation of minerals to metals requires hydrometallurgical processing for nearly all of the nonferrous metals we use This book elucidates the associated fundamentals and processing applications as well as related tools to assess processes and performance The new edition further includes additional photographs updated drawings supplementary data updated descriptive information and new detail on rare earth elements processing as well as recycling and byproduct recovery of metals *9th International Symposium on High-Temperature Metallurgical Processing* Jiann-Yang Hwang, Tao Jiang, Mark William Kennedy, Dean Gregurek, Shijie Wang, Baojun Zhao, Onuralp Yücel, Ender Keskinilic, Jerome P Downey, Zhiwei Peng, Rafael. Padilla, 2018-01-16 In recent years global metallurgical industries have experienced fast and prosperous growth High temperature metallurgical technology is the backbone to support the technical environmental and economical needs for the growth This collection features contributions covering the advancements and developments of new high temperature metallurgical technologies and their applications to the areas of processing of minerals extraction of metals preparation of metallic refractory and ceramic materials treatment and recycling of slag and wastes and saving of energy and protection of environment The volume will have a broad impact on the academics and professionals serving the metallurgical industries around the world *Chemical Metallurgy* Chiranjib Kumar Gupta, 2006-03-06 Chemical metallurgy is a well founded and fascinating branch of the wide field of metallurgy This book provides detailed information on both the first steps of separation of desirable minerals and the subsequent mineral processing operations The complex chemical processes of extracting various elements through hydrometallurgical pyrometallurgical or electrometallurgical operations are explained In the choice of material for this work the author made good use of the synergy of scientific principles and industrial practices offering the much needed and hitherto unavailable combination of detailed treatises on both compiled in one book

Mining, Materials, and the Sustainable Development Goals (SDGs) Cristian Parra, Brandon Lewis, Saleem H. Ali, 2020-10-13 Mining Materials and the Sustainable Development Goals SDGs 2030 and Beyond provides a systematic assessment of how the mining and materials sector contributes to the 17 sustainable development goals SDGs set forth by

the United Nations in 2015 While the target date of 2030 is considered a benchmark for reaching these goals the book looks beyond this date and considers a longer term vision FEATURES Written by a consortium of authors from developing and developed countries Offers coverage of environmental economic and social dimensions of the SDGs Follows the 17 SDGs and includes a short chapter on each followed by a case example Includes longer conceptual chapters that consider cross cutting issues as well Aimed at those working in minerals mining and materials this work offers readers a practical vision of how these sectors can have a positive impact on meeting these vital global targets

Adopting the Melody of Expression: An Psychological Symphony within **Extractive Metallurgy Of Rare Earths**

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