
This book focuses on the chemistry and processes for conversion and utilization of carbon dioxide. Topics include CO2 utilization, its conversion to industrial chemicals and fuels, its conversion via synthesis gas, and new catalysts and chemical processes for conversion.

Addresses materials, technology, and products that could help solve the global environmental crisis once commercialized. This multidisciplinary book encompasses state-of-the-art research on the topics of Carbon Capture and Storage (CCS), and complements existing CCS techniques with the newest research and reviews. It discusses key challenges involved in the CCS materials design, processing, and modeling and provides in-depth coverage of solvent-based carbon capture, sorbent-based carbon capture, membrane-based carbon capture, novel carbon capture methods, computational modeling, carbon capture materials including metal organic frameworks (MOF), electrochemical capture and conversion, membranes and solvents, and geological sequestration. Materials and Processes for CO2 Capture, Conversion, and Sequestration offers chapters on: Carbon Capture in Metal-Organic Frameworks; Metal Organic Frameworks Materials for Post-Combustion CO2 Capture; New Progress of Microporous Metal-Organic Frameworks in CO2 Capture and Separation; In Situ Diffraction Studies of Selected Metal-Organic Framework (MOF) Materials for Guest Capture Applications; Electrochemical CO2 Capture and Conversion; Electrochemical Valorization of Carbon Dioxide in Molten Salts; Microstructural and Structural Characterization of Materials for CO2 Storage using Multi-Scale X-Ray Scattering Methods; Contribution of Density Functional Theory to Microporous Materials for Carbon Capture; and Computational Modeling Study of MnO2 Octahedral Molecular Sieves for Carbon Dioxide Capture Applications. Addresses one of the most pressing concerns of society—that of environmental damage caused by the greenhouse gases emitted as we use fossil fuels—covers cutting-edge capture technology with a focus on materials and technology rather than regulation and cost. Highlights the common and novel CCS materials that are of greatest interest to industrial researchers. Provides insight into CCS materials design, processing, characterization, and computer modeling Materials and Processes for CO2 Capture, Conversion and Sequestration is ideal for materials scientists and engineers, energy scientists and engineers, inorganic chemists, environmental scientists, pollution control scientists, and carbon chemists.

Adopting a unique integrated engineering approach, this text covers all aspects of fuel processing: catalysts, reactors, chemical plant components and integrated system design. While providing an introduction to the subject, it also contains recent research developments, making this an invaluable handbook for chemical, power and process engineers, electrochemists, catalytic chemists, materials scientists and engineers in power technology.

CO2 is an important greenhouse gas leading to global climate change. Capturing CO2 from power plants, i.e., coal-fired and natural gas-fired power plants, has been considered as an effective method to control the atmospheric CO2 concentration. The traditional solid amine adsorbents have been widely studied in CO2 capture process because of their low toxicity, low corrosion to the equipment, and low heat capacity. However, the elevated temperature required for desorbing CO2 from solid amine adsorbents could significantly increase the capture cost and have the potential of degradation. In this research, a novel solid amine adsorbent, amine-immobilized elastomers (i.e., PEI-elastomer), were proposed to efficiently adsorb and desorb CO2 by applying the stretching process. At room temperature, the PEI-elastomers could react with CO2 and form weakly adsorbed CO2, i.e., ammonium carbamates, which can be desorbed under stretching. Desorption of CO2 from the stretched PEI elastomer can be attributed to the reduced amine density and generated heat during stretching. The new concept of PEI-elastomer adsorbents may open up a new low-cost CO2 capture process for coal-fired and natural-gas-fired power plants.

Inorganic solid adsorbents/sorbents are attractive materials for capturing carbon dioxide (CO2) from flue gases after fossil fuel combustion. Post-combustion Carbon
Dioxide Capture Materials introduces the key inorganic materials used as adsorbents/sorbents with specific emphasis on their design, synthesis, characterization, performance, and mechanism. Dedicated chapters cover carbon-based adsorbents, zeolite- and silica-based adsorbents, metal–organic framework (MOF)-based adsorbents, and alkali-metal-carbonate-based adsorbents. The final two chapters are devoted to other adsorbents used in carbon dioxide capture from flue gases. Edited and written by world-renowned scientists in each class of the specific material, this book will provide a comprehensive introduction for advanced undergraduates, postgraduates and researchers from both academic and industrial fields wishing to learn about the topic.

The experimental results of CO2 adsorption and desorption in a packed column indicated that the concentration wave front at the center of the packed column differs from those which are close to the wall of column filled with adsorbent material even though the ratio of column diameter to the particle size is greater than 20. The comparison of the experimental results with one dimensional model of packed column shows that in order to simulate the average breakthrough in a packed column a two dimensional (radial and axial) model of packed column is needed. In this paper the mathematical model of a non-slip flow through a packed column with 2 inches in diameter and 18 inches in length filled with 5A zeolite pellets is presented. The comparison of experimental results of CO2 absorption and desorption for the mixed and central breakthrough of the packed column with numerical results is also presented.

Strong evidence exists that anthropogenic emissions of CO2 have contributed significantly to global climate change. Therefore, it is essential to mitigate anthropogenic CO2 emissions. Unfortunately, current technology for CO2 capture relying on amine scrubbing is costly because of the energy requirements for amine regeneration. Accordingly, alternative CO2 capture technologies are sought. Among these, the use of solid adsorbents appears most promising in reducing the cost of CO2 capture. This project focused on the development of amine-based solid sorbents with a low CO2 desorption activation energy and a high CO2 sorption capacity. Three different porous materials including nanoporous titanium oxyhydrate (TiO(OH)2), modified carbon nanotubes (MCNTs), and poly(divinylbenzene/2-ethylhexyl methacrylate) (polyHIPE) have been prepared as adsorbent supports. The first two CO2 adsorbents were prepared by immobilizing tetraethylenepentamine (TEPA) onto TiO(OH)2 and MCNTs resulting in TiO(OH)2/TEPA and MCNTs/TEPA adsorbents. Polyethyleneimine (PEI) was used to prepare a polyHIPE/PEI adsorbent through impregnation. TiO(OH)2/TEPA was used as an adsorbent for the removal of CO2 at a low concentration (1 vol.% CO2 in N2). At optimal conditions, the CO2 sorption capacity reached 3.1 mmol CO2/g-sorbent at 60 °C. It was observed that the activation energies for CO2 adsorption and desorption of TiO(OH)2/TEPA are 19.6 kJ/mol and 51.1 kJ/mol, respectively. This low CO2 desorption activation energy can contribute to a lower CO2 capture cost. MCNTs/TEPA and polyHIPE/PEI adsorbents were also evaluated for CO2 capture using 10 vol.% CO2 in N2. At the optimal conditions CO2 sorption capacity reached 5 mmol CO2/g-sorbent with MCNTs/TEPA and 4 mmol CO2/g-sorbent with polyHIPE/PEI. Kinetic and thermodynamic adsorption/desorption studies found activation energies for CO2 desorption are 39.9 kJ/mol for MCNTs/TEPA and 36.12 kJ/mol for polyHIPE/PEI. The low activation energies for CO2 desorption using the prepared adsorbents can contribute to a lower CO2 capture cost. Therefore, the prepared adsorbents have potential for application to CO2 capture from gas mixtures.

The aim of this book has been to explore the variety of phenomena associated with the major forms of the material, while laying the foundation for a clear and detailed working and understanding of the materials. We tried to present new types of advanced materials, which are currently a hot topic, and provide readers with a selective review of important improvements in the field. I believe that every chapter in this book presents the progress in the subject and describes the latest advances in microporous and mesoporous materials.

The goal of this program was to develop a low cost novel sorbent to remove carbon dioxide from flue gas and gasification streams in electric utilities. Porous materials named metal–organic frameworks (MOFs) were found to have good capacity and selectivity for the capture of carbon dioxide. Several materials from the initial set of reference MOFs showed extremely high CO2 adsorption capacities and very desirable linear isotherm shapes. Sample preparation occurred at a high level, with a new family of materials suitable for intellectual property protection prepared and characterized. Raman spectroscopy was shown to be useful for the facile characterization of MOF materials during adsorption and especially, desorption. Further, the development of a Raman spectroscopic-based method of determining binary adsorption isotherms was initiated. It was discovered that a stronger base functionality will need to be added to MOF linkers in order to enhance CO2 selectivity over other gases via a chemisorption mechanism. A concentrated effort was expended on being able to accurately predict CO2 selectivities and on the calculation of predicted MOF surface area values from first principles. A method of modeling hydrolysis on MOF materials that correlates with experimental data was developed and refined. Complimentary experimental data were recorded via utilization of a combinatorial chemistry heat treatment unit and high-throughput X-ray diffractometer. The three main Deliverables for the project, namely (a) a MOF for pre-combustion (e.g., IGCC) CO2 capture, (b) a MOF for post-combustion (flue gas) CO2 capture, and (c) an assessment of commercial potential for a MOF in the IGCC application, were completed. The key properties for MOFs to work in this application - high CO2 capacity, good adsorption/desorption rates, high adsorption selectivity for CO2 over other gases such as methane and nitrogen, high stability to contaminants, namely moisture, and easy regenerability, were all addressed during this program. As predicted at the start of the program, MOFs have high potential for CO2 capture in the IGCC and flue gas applications.

CO2 capture and sequestration from coal-fired power plant flue gas is an attractive technique to control CO2 emissions. Polyamine-based sorbent is considered as a promising sorbent for CO2 capture due to its low equipment corrosion and regeneration energy penalty. One critical aspect of development of polyamine-based CO2 capture process is to understand the nature of the adsorbed species with amine and their evolution in adsorption / desorption process. Fourier transform infrared (FTIR) spectroscopy is a powerful and versatile tool that can provide the insitu information at molecular level to address these scientific issues. This dissertation is focusing on using in-situ FTIR spectroscopy to discuss several important topics in CO2 capture and utilization processes, including (i) the structure and binding energy of adsorbed...
CO2/H2O on solid amine sorbent. (ii) the role of H2O in CO2 adsorption/desorption on liquid amine films, (iii) mechanism of water-enhancement on CO2 capture by amine, and (iv) photoelectrocatalytic reduction of CO2 on polyaniline/TiO2 thin film. H2O vapor in flue gas has dramatic effects on polyaniline-based sorbent. H2O could affect CO2 capture capacity, regeneration of the catalyst, and degradation of the polyaniline film. The results revealed that CO2 adsorbed on primary amine as ammonium carbamate while H2O adsorbed on secondary amine and promoted the formation of carbamic acid. Adsorbed H2O increases the binding strength of CO2 with amine and protects sorbent from SO2 poisoning. The results of this study clarify the role of H2O in polyaniline-based sorbent for CO2 capture and provide a molecular basis for the design and operation of polyaniline-based CO2 capture processes. The use of FTIR spectroscopy in the investigation of role of water on CO2 capture by amine has enabled us to verify the reaction processes. The results unraveled that adsorption of CO2 on the 25 °C tetraethylenepentamine (TEPA) film at 50 °C followed a zwitterion-intermediate pathway: zwitterion → ammonium carbamate. H2O in the mixed TEPA/H2O (5:1) film decreased the rate of CO2 adsorption, but increased the amine efficiency. The presence of H2O promotes the formation of carbamic acid and produces a broad IR band centered at 2535 cm⁻¹, which can be assigned to (O-H) of hydronium carbamate, -COO⁻ → -OH²+. The broadness of this 2535 cm⁻¹ band ranging from 2100 cm⁻¹ to 2800 cm⁻¹ persists at 120 °C. These broad components of the band can be ascribed to (N-H) in hydrogen-bonded ammonium carbamate, a R-NH⁺/R1R2-NH₃⁺···-NCOO⁻ moiety. The binding strength of adsorbed species on the TEPA film increases in the order: adsorbed H2O

This book provides a detailed description of metal–complex functionalized carbon allotrope forms, including classic (such as graphite), rare (such as M– or T–carbon), and nanoforms (such as carbon nanotubes, nanodiamonds, etc.). Filling a void in the nanotechnology literature, the book presents chapters generalizing the synthesis, structure, properties, and applications of all known carbon allotropes. Metal–complex composites of carbons are described, along with several examples of their preparation and characterization, soluble metal–complex carbon composites, cost–benefit data, metal complexes as precursors of carbon allotropes, and applications. A lab manual on the synthesis and characterization of carbon allotropes and their metal–complex composites is included. Provides a complete description of all carbon allotropes, both classic and rare, as well as carbon nanostructures and their metal–complex composites; Contains a laboratory manual of experiments on the synthesis and characterization of metal–complex carbon composites; Discusses applications in diverse fields, such as catalysis on supporting materials, water treatment, sensors, drug delivery, and devices.

Cleaner Combustion and Sustainable World is the proceedings of the 7th International Symposium on Coal Combustion which has a significant international influence. It concerns basic research on coal combustion and clean utilization, techniques and equipments of pulverized coal combustion, techniques and equipments of fluidized bed combustion, basic research and techniques of emission control, basic research and application techniques of carbon capture and storage (CCS), etc. Professor Haiying Qi and Bo Zhao both work at the Tsinghua University, China.

The first up-to-date summary and review for the fundamental principles and industrial practice of adsorption separation processes in more than 30 years. Emphasizes the understanding of adsorption column dynamics and the modeling of adsorption systems, as well as fundamental aspects of kinetics and equilibria.

This book focuses on modelling issues and their implications for the correct design of reactive absorption–desorption systems. In addition, it addresses the case of carbon dioxide (CO2) post-combustion capture in detail. The book proposes a new perspective on these systems, and provides technological solutions with comparisons to previous treatments of the subject. The model that is proposed is subsequently validated using experimental data. In addition, the book features graphs to guide readers with immediate visualizations of the benefits of the methodology proposed. It shows a systematic procedure for the steady-state model-based design of a CO2 post-combustion capture plant that employs reactive absorption–stripping, using monoethanolamine as the solvent. It also discusses the minimization of energy consumption, both through the modification of the plant flowsheet and the set-up of the operating parameters. The book offers a unique source of information for researchers and practitioners alike, as it also includes an economic analysis of the complete plant. Further, it will be of interest to all academics and students whose work involves reactive absorption–stripping design and the modelling of reactive absorption–stripping systems.

This volume is a complete progress report on the various aspects of zeolite synthesis on a molecular level. It provides many examples that illustrate how zeolites can be crystallized and what the important parameters are that control crystallization. Forty-two chapters cover such topics as: crystallization techniques; gel chemistry; crystal size and morphology; the role of organic compounds; and novel synthesis procedures. It offers a complete review of zeolite synthesis as well as the latest finding in this important field. Contains benchmark contributions from many notable pioneers in the field, including R.M. Barrer, W. Robson, and Robert Milton.

CO2 sorption studies were conducted for Raniganj coals of India from the point of view of CO2 adsorption & desorption and the effect of temperature, coal particle size and media pH. Adsorption and desorption studies were conducted for 4 samples with the highest adsorption capacity reported as 11.09ml/g of coal and lowest as 5.15ml/g at 30°C. Desorption studies revealed the existence of both positive and negative hysteresis curves. The minimum desorption capacity was attained for S-2, 1.29ml/g at the pressure of 22.614Psi. Hysteresis was minimum for sample 1. While sample 3 and sample 5 showed maximum positive hysteresis. The hysteresis increases with increasing pressure initially and extended till 600Psi. Experimental data were verified using several adsorption isotherms such as Langmuir, BET, Dubinin–Astakhov (D–A) and Dubinin–Radushkevich (D–R). The Langmuir isotherm model was failed to predict the data accurately. The D–A model gave an enough satisfactory representation suggesting that the pore filling model proposed by the Polanyi. Sorption studies conducted at 30, 31.1, 40 and 50°C revealed that adsorption decreased with increase in temperature. These values were also compared with those obtained through the characteristic plots defined by the Dubinin–Astakhov equation. CO2 adsorption behavior at new temperature fit in with the experimental data reported for CO2 adsorption below its critical temperature. The effect of particle size was studied by considering samples
of 150μm, 650μm and 850μm and it was found that adsorption capacity decreased with increase in particle size. As far as the effect of pH was concerned, the adsorption capacity was highest for acidic media followed by alkaline media and neutral media.

The sorbents for separation of CO2 from ultra dilute gas streams are required to be able to achieve high CO2 sorption capacities, although CO2 concentrations of such gases are extremely low. They are also expected to have fast adsorption kinetics at low temperature ranges (e.g., 5-30°C). In addition, their CO2 desorption kinetics should be fast, as is expected for any other sorbents. An alternative amine-based sorbent (referred as RFAS) developed in this work was assessed under various conditions. Studies showed that the CO2 sorption capacities of the sorbent increased considerably with N loading, slowly with increasing temperature (apparently contrary to the prediction with the isothermal equation of exothermic sorption), and gradually with the decrease of gas flow rate in the tested range. In addition, CO2 sorption capacity increased and then decreased with increasing N2O:CO2 mole ratio and the stoichiometric ratio 1:1 is the turning point. The CO2 sorption capacities achieved by the sorbent with 8.07 mmol N/g for air with 400 ppm CO2 and the CO2 –N2 gas mixtures containing 1 vol-% CO2 were 1.78 mmol CO2 /g and 1.92 mmol CO2 /g, respectively, higher than those reported in the most recent literature. A kinetic model corresponding to three proposed pathways was derived and expected to quantitatively predict the CO2 sorption characteristics given that the involved parameters can be established in the future. The half-CO2 adsorption and desorption times of the sorbent along with temperatures were used to evaluate the dynamics of the sorbent. The adsorbed CO2 can be completely desorbed at only 80°C within as short as 30 minutes. The CO2 sorption capacities of the sorbent within 10 sorption-desorption cycles are repeatable. All the results confirmed that the sorbent is a highly adsorptive, reversibly dynamic, and regenerable sorbent for capture of ultradilute CO2 from gas mixtures. Key words: carbon dioxide emissions, carbon dioxide capture and sequestration, amine-based solid sorbents, air capture, adsorption capacity.

IPCC Report on sources, capture, transport, and storage of CO2, for researchers, policy-makers and engineers.

This multi-authored book provides a comprehensive overview of the latest developments in porous CO2 capture materials, including ionic liquid-derived carbonaceous adsorbents, porous carbons, metal-organic frameworks, porous aromatic frameworks, micro porous organic polymers. It also reviews the sorption techniques such as cyclic uptake and desorption reactions and membrane separations. In each category, the design and fabrication, the comprehensive characterization, the evaluation of CO2 sorption/separation and the sorption/degradation mechanism are highlighted. In addition, the advantages and remaining challenges as well as future perspectives for each porous material are covered. This book is aimed at scientists and graduate students in such fields as separation, carbon, polymer, chemistry, material science and technology. Others will use and appreciate this information for its special contribution to the latest, authoritative reviews. Dr. An-Hui Lu is a Professor at the State Key Laboratory of Fine Chemicals, School of Chemical Engineering, Faculty of Chemical, Environmental and Biological Science and Technology, Dalian University of Technology, China. Dr. Sheng Dai is a Corporate Fellow and Group Leader in the Chemical Sciences Division at Oak Ridge National Laboratory (ORNL) and a Professor of Chemistry at the University of Tennessee, USA.

Fossil fuels still need to meet the growing demand of global economic development. Yet, they are often considered as one of the main sources of the CO2 release in the atmosphere. CO2, which is the primary greenhouse gas (GHG), is periodically exchanged among the land surface, ocean, and atmosphere where various creatures absorb and produce it daily. However, the balanced processes of producing and consuming the CO2 by nature are unfortunately faced by the anthropogenic release of CO2. Decreasing the emissions of these greenhouse gases is becoming more urgent. Therefore, carbon sequestration and storage (CSS) of CO2, its utilization in oil recovery, as well as its conversion into fuels and chemicals emerge as active options and potential strategies to mitigate CO2 emissions and climate change, energy crises, and challenges in the storage of energy.

This collection focuses on energy efficient technologies including innovative ore beneficiation, smelting technologies, recycling and waste heat recovery. The volume also covers various technological aspects of sustainable energy ecosystems, processes that improve energy efficiency, reduce thermal emissions, and reduce carbon dioxide and other greenhouse emissions. Papers addressing renewable energy resources for metals and materials production, waste heat recovery and other industrial energy efficient technologies, new concepts or devices for energy generation and conversion, energy efficiency improvement in process engineering, sustainability and life cycle assessment of energy systems, as well as the thermodynamics and modeling for sustainable metallurgical processes are included. This volume also includes topics on CO2 sequestration and reduction in greenhouse gas emissions from process engineering, sustainable technologies in extractive metallurgy, as well as the materials processing and manufacturing industries with reduced energy consumption and CO2 emission. Contributions from all areas of non-nuclear and non-traditional energy sources, such as solar, wind, and biomass are also included in this volume. Papers from the following symposia are presented in the book: Energy Technologies and CO2 Management Advanced Materials for Energy Conversion and Storage Deriving Value from Challenging Waste Streams: Recycling and Sustainability Joint Session Solar Cell Silicon Stored Renewable Energy in Coal

There is a mounting consensus that human behavior is changing the global climate and its consequence could be catastrophic. Reducing the 24 billion metric tons of carbon dioxide emissions from stationary and mobile sources is a gigantic task involving both technological challenges and monumental financial and societal costs. The pursuit of sustainable energy resources, environment, and economy has become a complex issue of global scale that affects the daily life of every citizen of the world. The present mitigation activities range from energy conservation, carbon-neutral energy conversions, carbon advanced combustion process that produce no greenhouse gases and that enable carbon capture and sequestration, to other advanced technologies incorporated in near and far future. This handbook will provide a single source of this information. The book will be divided into the following sections:
Zeolites have been the focus of intensive activity and growth in applications over the past 25 years in ion exchange, in adsorption and in catalytic process technology. Beginning with the synthetic zeolites A, X and Y, continuing into the emerging ZSM series, and including selected natural zeolites, applications span the range from large-scale purification and separation to such major petroleum and petrochemical processes as catalytic cracking and aromatics alkylation. The future promises several new areas of significant use as our energy resource base is expanded. As a result, a NATO Advanced Study Institute on Zeolites was held in Alcabideche, Portugal, May 1-12, 1983. Its purpose was to summarize the state-of-the-art in zeolite science and technology, with particular emphasis on recent developments. This summary is intended to complement presentations of the latest research results at the 1983 International Zeolites Association meeting in Reno, Nevada - USA. Both the fundamentals concepts and industrial applications are addressed in the lectures of the Institute. Individual chapters cover historical development, structure, crystallography and synthesis techniques. Basic principles of adsorption, diffusion, ion exchange and acidity are reviewed. A section on catalysis addresses shape selectivity, transition metals, bifunctional catalysis and "methanol to-gasoline". Included in the section on industrial applications are chapters on reactor and adsorber design, catalytic cracking, xylene and n-paraffins isomerization, as well as ion exchange and adsorption.

To achieve goals for climate and economic growth, "negative emissions technologies" (NETs) that remove and sequester carbon dioxide from the air will need to play a significant role in mitigating climate change. Unlike carbon capture and storage technologies that remove carbon dioxide emissions directly from large point sources such as coal power plants, NETs remove carbon dioxide directly from the atmosphere or enhance natural carbon sinks. Storing the carbon dioxide from NETs has the same impact on the atmosphere and climate as simultaneously preventing an equal amount of carbon dioxide from being emitted. Recent analyses found that deploying NETs may be less expensive and less disruptive than reducing some emissions, such as a substantial portion of agricultural and land-use emissions and some transportation emissions. In 2015, the National Academies published Climate Intervention: Carbon Dioxide Removal and Reliable Sequestration, which described and initially assessed NETs and sequestration technologies. This report acknowledged the relative paucity of research on NETs and recommended development of a research agenda that covers all aspects of NETs from fundamental science to full-scale deployment. To address this need, Negative Emissions Technologies and Reliable Sequestration: A Research Agenda assesses the benefits, risks, and "sustainable scale potential" for NETs and sequestration. This report also defines the essential components of a research and development program, including its estimated costs and potential impact.

Using inorganic solid adsorbents/sorbents is a promising approach for carbon dioxide (CO2) capture and is attracting intense attention from both academic and industrial fields. Pre-combustion Carbon Dioxide Capture Materials presents a range of the different inorganic materials that can be used as pre-combustion CO2 adsorbents/sorbents with specific emphasis on their design, synthesis, characterization, performance, and mechanism. Dedicated chapters cover layered double hydroxide (LDH) derived adsorbents, MgO-based adsorbents, CaO-based sorbents and alkali ceramics based sorbents. Edited and written by world-renowned scientists in each class of CO2 capture material, this book will provide a comprehensive introduction for advanced undergraduates, postgraduates and researchers wishing to learn about the topic.
An innovative, low-cost, and low-energy-consuming carbon dioxide (CO2) capture technology was developed, based on CO2 adsorption on a high-capacity and durable carbon sorbent. This technology, which is formed as it is formed, can make a major contribution to achieving this. The challenge is to find solid adsorbents with sufficient CO2 capacity that can work in the right temperature window over repeated adsorption-desorption cycles. The book presents a highly detailed characterization of the materials, together with an accurate measurement of their adsorption properties under dry conditions and in the presence of steam. It demonstrates that even small quantities of graphite oxide provide superior thermal stability to hydrotalcites due to their compatible layered structure, making them well suited as volume-efficient adsorbents for CO2. Lastly, it identifies suitable catalysts for the overall sorption-enhanced water gas shift process.

This book summarises the advanced CO2 capture technologies that can be used to reduce greenhouse gas emissions, especially those from large-scale sources, such as power-generation and steel-making plants. Focusing on the fundamental chemistry and chemical processes, as well as advanced technologies, including absorption and adsorption, it also discusses other aspects of the major CO2 capture methods: membrane separation; the basic chemistry and process for CO2 capture; the development of materials and processes; and practical applications, based on the authors’ R&D experience. This book serves as a valuable reference resource for researchers, teachers and students interested in CO2 problems, providing essential information on how to capture CO2 from various types of gases efficiently. It is also of interest to practitioners and academics, as it discusses the performance of the latest technologies applied in large-scale emission sources.

The aim of the book is to provide an understanding of the current science underpinning Carbon Capture and Sequestration (CCS) and to provide students and interested researchers with sufficient background on the basics of Chemical Engineering, Material Science, and Geology that they can understand the current state of the art of the research in the field of CCS. In addition, the book provides a comprehensive discussion of the impact of CCS on the energy landscape, society, and climate as these topics govern the success of the science being done in this field. The book is aimed at undergraduate students, graduate students, scientists, and professionals who would like to gain a broad multidisciplinary view of the research that is being carried out to solve one of greatest challenges of our generation. Contents:Energy and ElectricityThe Atmosphere and Climate ModelingThe Carbon CycleIntroduction to Carbon CaptureAdsorptionMembranesIntroduction to Geological SequestrationLitigation and ClaimsLarge-Scale Geological Carbon SequestrationLand Use and Geo-EngineeringList of SymbolsCreditsReadership: Students taking courses on environmental sciences and environmental engineering. Fundamentals of Adsorption serves as an excellent reference and may be used as a primary text for a graduate level course on adsorption research or as a secondary text for a course on any of the disciplines mentioned above.

Carbon capture is essential for reduction of carbon dioxide (CO2) pollution from flue gas which is emitted during fossil fuel combustion. The flue gas is mainly composed of 15% CO2 and 85% N2 and it requires high selectivity for gas purification. Some methods have been developed for carbon capture such as Pressure Swing Adsorption (PSA) and Temperature Swing Adsorption (TSA). Unfortunately, these techniques use a lot of energy during the desorption step that reduces power generation efficiency. An ideally effective carbon capture technique needs to promote CO2 adsorption and desorption at the proper times during the separation cycles, without incurring a large parasitic energy load. A new gas adsorption technique is presented, Supercapacitive Swing Adsorption (SSA), in which CO2 is either actively adsorbed or desorbed by repeated capacitive charge and discharge of supercapacitor carbon electrodes and energy used in adsorption can principally be recovered upon desorption. It is shown that reversible adsorption/desorption of CO2 from a 15% CO2 and 85% N2 gas mixture can be achieved when an electrically conducting high surface area porous carbon material is brought into contact with carbon dioxide gas and an aqueous sodium chloride electrolyte. When the supercapacitor carbon electrodes are charged, the electrolyte ions are spontaneously organized into an electric double layer at the surface of each porous carbon electrode. The presence of this double layer leads to reversible adsorption of CO2 and desorption and discharged. Moreover, it is also shown that SSA has the ability to separate CO2 from N2, with a high selectivity for CO2 and only a weak dependence on the CO2 partial pressure in a CO2/N2 gas mixture. The amount of adsorbed CO2 scales with applied voltage and with the mass of the porous carbon sorbent, which is inexpensive, robust and environmentally friendly. The effect barely depends on temperature.

An innovative, low-cost, and low-energy-consuming carbon dioxide (CO2) capture technology was developed, based on CO2 adsorption on a high-capacity and durable carbon sorbent. This report describes the (1) performance of the concept on a bench-scale system; (2) results of parametric tests to determine the optimum operating conditions; (3) results of the testing with a flue gas from coal-fired boiler; and (4) evaluation of the technical and economic viability of the technology. The process uses a falling bed of carbon sorbent microbeads to separate the flue gas into two streams: a CO2–lean flue gas stream from which 90% of the CP2 is removed and...
a pure stream of CO2 that is ready for compression and sequestration. The carbon sorbent microbeads have several unique properties such as high CO2 capacity, low heat of adsorption and desorption (25 to 28 kJ/mole), mechanically robust, and rapid adsorption and desorption rates. The capture of CO2 from the flue gas is performed at ambient temperature in which the carbon sorbent microbeads flow down by gravity counter-current with the up-flow of the flue gas. The adsorbed CO2 is stripped by heating the CO2-loaded sorbent to ~ 100°C, in contact with low-pressure (~5 psig) steam in a section at the bottom of the adsorber. The regenerated sorben is dehydrated by adsorbed moisture, cooled, and lifted back to the adsorber. The CO2 from the desorber is essentially pure and can be dehydrated, compressed, and transported to a sequestration site. Bench-scale tests using a simulated flue gas showed that the integrated system can be operated to provide >90% CO2 capture from a 15% CO2 stream in the adsorber and produce >98% CO2 at the outlet of the stripper. Long-term tests (1,000 cycles) showed that the system can be operated reliably without sorbent agglomeration or attrition. The bench-scale reactor was also operated using a flue gas stream from a coal-fired boiler at the University of Toledo campus for about 135 h, comprising 7,000 cycles of adsorption and desorption using the desulfurized flue gas that contained only 4.5% v/v CO2. A capture efficiency of 85 to 95% CO2 was achieved under steady-state conditions. The CO2 adsorption capacity did not change significantly during the field test, as determined from the CO2 adsorption isotherms of fresh and used sorbents. The process is also being tested using the flue gas from a PC-fired power plant at the National Carbon Capture Center (NCCC), Wilsonville, AL. The cost of electricity was calculated for CO2 capture using the carbon sorbent and compared with the no-CO2 capture and CO2 capture with an amine-based system. The increase in the levelized cost of electricity (L-COE) is about 37% for CO2 capture using the carbon sorbent in comparison to 80% for an amine-based system, demonstrating the economic advantage of C capture using the carbon sorbent. The 37% increase in the L-COE corresponds to a cost of capture of $30/ton of CO2, including compression costs, capital cost for the capture system, and increased plant operating and capital costs to make up for reduced plant efficiency. Preliminary sensitivity analyses showed capital costs, pressure drops in the adsorber, and steam requirement for the regenerator are the major variables in determining the cost of CO2 capture. The results indicate that further long-term testing with a flue gas from a pulverized coal fired boiler should be performed to obtain additional data relating to the effects of flue gas contaminants, the ability to reduce pressure drop by using alternate structural packing, and the use of low-cost construction materials.

Carbon dioxide (CO2) capture and storage (CCS) is the one advanced technology that conventional power generation cannot do without. CCS technology reduces the carbon footprint of power plants by capturing, and storing the CO2 emissions from burning fossil-fuels and biomass. This volume provides a comprehensive reference on the state of the art research, development and demonstration of carbon storage and utilisation, covering all the storage options and their environmental impacts. It critically reviews geological, terrestrial and ocean sequestration, including enhanced oil and gas recovery, as well as other advanced concepts such as industrial utilisation, mineral carbonation, biofixation and photocatalytic reduction. Foreword written by Lord Oxburgh, Climate Science Peer Comprehensively examines the different methods of storage of carbon dioxide (CO2) and the various concepts for utilisation Reviews geological sequestration of CO2, including coverage of reservoir sealing and monitoring and modelling techniques used to verify geological sequestration of CO2

This book is intended to present for the first time experimental methods to measure equilibria states of pure and mixed gases being adsorbed on the surface of solid materials. It has been written for engineers and scientists from industry and academia who are interested in adsorption based gas separation processes and/or in using gas adsorption for characterization of the porosity of solid materials. This book is the result of a fruitful collaboration of a theoretician (JUR) and an experimentalist (RS) over more than twelve years in the field of gas adsorption systems at the Institute of Fluid- and Thermodynamics (IFT) at the University of Siegen, Siegen, Germany. This collaboration resulted in the development of several new methods to measure not only pure gas adsorption, but gas mixture or coadsorption equilibria on inert porous solids. Also several new theoretical results could be achieved leading to new types of so-called adsorption isotherms based on the concepts of molecular association and – phenomenologically speaking – on that of thermodynamic phases of fractal dimension. Naturally, results of international collaboration of the authors over the years (1990–2000) also are included.

Atoms and molecules in all states of matter are subject to continuous irregular movement. This process, referred to as diffusion, is among the most general and basic phenomena in nature and determines the performance of many technological processes. This book provides an introduction to the fascinating world of diffusion in micro- and meso- porous solids. Jointly written by three well-qualified experts, rather than as separate treatments, topics of separate treatises, rather than in a single comprehensive book. Based on the book Diffusion in Zeolites and other Microporous Solids, originally published in 1992, it illustrates the remarkable speed with which this field has developed since that time. Specific topics include: new families of nanoporous materials, micro-imaging and single-particle tracking, direct monitoring of transient profiles by interference microscopy, single-file diffusion and new approaches to molecular modeling.

This book contains papers presented in the 3rd International Conference on Separation Technology 2020 (ICTST 2020) held from 15 to 16th August 2020 at Johor, Malaysia. This proceeding contains papers presented by academics and industrial practitioners showcasing the latest advancements and findings in field of separation technology. The papers are categorized under the following tracks and topics of research: Environment Engineering Biotechnology Absorption and Adsorption Technology Wastewater Treatment...