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# **Lignocellulosic Biomass-Energized Fuel Cells**

**Cases of High-Temperature  
Conversion**

**Xuebing Zhao**

**Wei Liu**

**Yulin Deng**

**J.Y. Zhu**



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# Lignocellulosic Biomass Energized Fuel Cells High Temperature

**Fred L. Van Dusen**



## **Lignocellulosic Biomass Energized Fuel Cells High Temperature:**

**Lignocellulosic Biomass-Energized Fuel Cells** Xuebing Zhao, Wei Liu, Yulin Deng, J.Y. Zhu, 2015-12-11 Fuel cell technology has attracted great interest in recent decades. However, progress in lignocellulosic biomass energized fuel cells has been slow. This is because that lignocellulosic biomass generally cannot be directly used for electricity generation in a fuel cell with high efficiency. As a renewable resource is available in large quantities in many regions of the world, lignocellulosic biomass can be a promising feedstock for sustainable electricity production using fuel cell technologies. In this monograph, we focus on the electricity generation in fuel cells that are operated at high temperatures with high efficiency using lignocellulosic biomass derived fuels. More specifically, we discuss biomass conversion coupled solid oxide fuel cell and direct carbon fuel cell. The state of the art in technology development as well as challenges is outlined and perspectives on future development are provided. Proceedings of the 5th International Conference on Sustainable Civil Engineering Structures and Construction Materials Sheila Belayutham, Che Khairil Izam Che Ibrahim, Anizahyati Alisibramulisi, Hazrina Mansor, Muntasir Billah, 2022-04-06 This book compiles papers presented during the 5th International Conference on Sustainable Civil Engineering Structures and Construction Materials SCESCM held virtually in December 2020. This is the fifth edition of this conference series; the theme for the 5th SCESCM is Transforming the World Foster the Sustainable Development Goals SDGs and it focuses on various issues, novel findings as well as developments in the area of civil and infrastructure conforming to the SDGs. This book caters to postgraduate students, researchers, and practitioners involved in advocating and embedding sustainability in various phases of design, construction, and maintenance of civil engineering structures and infrastructure facilities. **Encyclopedia of Renewable Energy, Sustainability and the Environment**, 2024-08-09 Encyclopedia of Renewable Energy Sustainability and the Environment Four Volume Set comprehensively covers all renewable energy resources including wind, solar, hydro, biomass, geothermal energy, and nuclear power, to name a few. In addition to covering the breadth of renewable energy resources at a fundamental level, this encyclopedia delves into the utilization and ideal applications of each resource and assesses them from environmental, economic, and policy standpoints. This book will serve as an ideal introduction to any renewable energy source for students while also allowing them to learn about a topic in more depth and explore related topics all in a single resource. Instructors, researchers, and industry professionals will also benefit from this comprehensive reference. Covers all renewable energy technologies in one comprehensive resource. Details renewable energy processes from production to utilization in a single encyclopedia. Organizes topics into concise, consistently formatted chapters, perfect for readers who are new to the field. Assesses economic challenges faced to implement each type of renewable energy. Addresses the challenges of replacing fossil fuels with renewables and covers the environmental impacts of each renewable energy. **Mathematical Modeling for Underground Coal Gasification** Preeti Aghalayam, 2017-10-26 Underground coal gasification UCG is an important

technique for future coal utilization It has the potential to be a clean technology and to tap un mineable deep coal deposits across the world Commercialization of UCG has been riddled with a variety of issues including public perception and a lack of clear comprehension about underlying physicochemical phenomena This book will bridge the gap in knowledge and highlight the modern findings related to the complex interactions in UCG With a focus on the chemical reactions in UCG and treating the underground coal cavity as nature s own chemical reactor various mathematical modeling studies that serve to unravel some of the mysteries of this decades old technique will be revealed *Graphical Thermodynamics and Ideal Gas Power Cycles* Mufid I. Hilal, 2017-07-12 In this book an almost new approach to modern thermodynamics has been applied One or more useful qualitative discussion statements have been extracted from each equation These and other important statements were numbered and their titles were situated in an index titled Hilal and Others statements definitions and rules This ensures very quick obtaining of the required statements rules definitions equations and their theoretical base that will ease readers qualitative discussions and calculations *Sustainable Bioenergy* Mahendra Rai, Avinash P. Ingle, 2019-05-30 Sustainable Bioenergy Advances and Impacts presents a careful overview of advances and promising innovation in the development of various bioenergy technologies It covers the production of bio jet fuel algal biofuels recent developments in bioprocesses nanotechnology applications for energy conversion the role of different catalysts in the production of biofuels and the impacts of those fuels on society The book brings together global experts to form a big picture of cutting edge research in sustainable bioenergy and biofuels It is an ideal resource for researchers students energy analysts and policymakers who will benefit from the book s overview of impacts and innovative needs Explores the most recent advances in biofuels and related energy systems including innovations in catalysts and biocatalysts Provides an overview of the impacts of bioenergy and its sustainability aspects Discusses real life cases of implementation of bioenergy systems on an industrial scale Perspectives of Chemicals Synthesis as a Green Alternative to Fossil Fuels Luis Puigjaner, Antonio Espuña, Mar Pérez-Fortes, Ana Somoza-Tornos, 2022-01-05 *Solar Energy Update* , 1984 Bioethanol Marco Aurelio Pinheiro Lima, 2012-02-01 Recent studies have shown strong evidence of human activity impact on the climate of the planet Higher temperatures and intensification of extreme weather events such as hurricanes are among the consequences This scenario opens up several possibilities for what is now called green or low carbon economy We are talking about creating new businesses and industries geared to develop products and services with low consumption of natural resources and reduced greenhouse gases emission Within this category of business biofuels is a highlight and the central theme of this book The first section presents some research results for first generation ethanol production from starch and sugar raw materials Chapters in the second section present results on some efforts around the world to develop an efficient technology for producing second generation ethanol from different types of lignocellulosic materials While these production technologies are being developed different uses for ethanol could also be studied The chapter in the third section points to the use of

hydrogen in fuel cells where this hydrogen could be produced from ethanol

### **Catalytic Upgrading of Lignocellulosic Biomass to Liquid Fuels, Solvents, and Polymer Precursors**

Raka Ghosh Dastidar, 2024

As a burgeoning population continues to exhaust the planet's resources we need to discover new routes for energy and chemical production from renewable feedstock to ensure the development of a robust circular economy Lignocellulosic biomass consisting of non food plant materials like sawdust and rice husks is the most abundant renewable feedstock on Earth for carbon based fuels and chemicals Due to its varied composition and recalcitrant nature numerous catalytic technologies to upgrade lignocellulosic biomass have been investigated in this work Chapter 3 focuses on supercritical methanol depolymerization and hydrodeoxygenation SCM DHDO of whole biomass into fuel range monoalcohols in a single stage reactor over CuMgAlOx catalysts Using cellulose derived 1,2-propanediol and isotopic  $^{13}\text{C}$  methanol we employ quantitative  $^{13}\text{C}$  NMR to elucidate the competing reaction pathways involved including C-C coupling retro aldol condensation C-O scission and esterification We also determine how reaction rates can be controlled by varying reactant partial pressures and temperature Chapter 4 delves into the Guerbet coupling of ethanol to diesel fuel precursors DFPs over CuMgAlOx catalysts with low Cu loadings 0.1-0.6 wt% We demonstrate how the selectivity to DFPs can be increased by using catalysts with low Cu loadings due to decreased ethyl acetate and acetone formation We also observe trends between alcohol ester selectivity and BET surface area base site count of the catalyst Chapter 5 studies ethylene oligomerization to linear  $\alpha$  olefins LAOs over carbon supported cobalt oxide CoOx/C catalysts for use in jet fuel production We show that high temperature treatment HTT of the carbon support results in higher selectivity to LAOs than acid washed AW carbon since the latter develops oxidized functional groups that lead to isomerization of LAOs to undesired linear internal olefins We also extensively characterize the catalysts with X-ray diffraction XRD X-ray photoelectron spectroscopy XPS and inductively coupled plasma atomic emission spectroscopy ICP-AES In Chapter 6 we delve into the production of a five carbon C5 chemical tetrahydropyran THP THP is a cyclic ether that is non carcinogenic non peroxide forming economically competitive with tetrahydrofuran THF as a solvent We demonstrate that THP can be synthesized from renewable biomass at 99.8% selectivity and 98% yield via hydrogenation of 3,4-dihydropyran DHP over Ni/SiO<sub>2</sub> We also carry out Conductor-like Screening Model for Real Solvents COSMO-RS and molecular dynamic MD simulations with 1,008 solvents and 8 common plastics to determine which solvents are most similar to THP and which plastics can be dissolved in THP in order to be recycled In Chapter 7 we reveal a novel route to valerolactone DVL production from dehydrogenation of 2-hydroxytetrahydropyran HTHP DVL is a C5 cyclic ester that can undergo ring opening polymerization to yield biodegradable polyesters We perform catalyst screening to determine which catalyst has the highest rates and selectivities to DVL production Since little is known about HTHP and the side products we also carry out density functional theory DFT calculations to determine the thermochemistry of the competing reactions involved Furthermore we develop a kinetic model to predict DVL selectivity as a function of temperature and contact time

*Design and Testing of a*

*Microbial Fuel Cell for the Conversion of Lignocellulosic Biomass Into Electricity* Kyla Gregoire, 2010      High-temperature Solid Oxide Fuel Cells for the 21st Century Kevin Kendall, Michaela Kendall, 2015-06-01 High temperature Solid Oxide Fuel Cells Second Edition explores the growing interest in fuel cells as a sustainable source of energy The text brings the topic of green energy front and center illustrating the need for new books that provide comprehensive and practical information on specific types of fuel cells and their applications This landmark volume on solid oxide fuel cells contains contributions from experts of international repute and provides a single source of the latest knowledge on this topic A single source for all the latest information on solid oxide fuel cells and their applications Illustrates the need for new more comprehensive books and study on the topic Explores the growing interest in fuel cells as viable sustainable sources of energy      High-temperature Fuel Cell Research and Development , 1979      **High-temperature Fuel Cells** R. D. Pierce, 1986      **High-temperature Fuel Cell Research and Development** J. Juul Rasmussen, Ronald Guidotti, P. Lessing, 1978      Lignocellulosic Biomass Refining for Second Generation Biofuel Production Ponnusami V., Kiran Babu Uppuluri, Rangabhashiyam S, Pardeep Singh, 2023-07-14 This book compiles research aspects of second generation 2G biofuel production derived specifically from lignocellulose biomass using biorefinery methods It focuses on the valorization of different sources of 2G biofuels and their relative importance The constituents of lignocelluloses and their potential characteristics different methods of treating lignocellulose various means of lignocellulose bioconversion and biofuel production strategies are discussed Features Describes technological advancements for bioethanol production from lignocellulosic waste Provides the roadmap for the production and utilization of 2G biofuels Introduces the strategic role of metabolic engineering in the development of 2G biofuels Discusses technological advancements life cycle assessment and prospects Explores the novel potential lignocellulosic biomass for 2G biofuels This book is aimed at researchers and professionals in renewable energy biofuel bioethanol lignocellulose conversion fermentation and chemical engineering      **Hydrothermal Carbonization of Lignocellulosic Biomass** Mohammad Toufiqur Reza, 2011 Hydrothermal carbonization HTC or wet torrefaction is a pretreatment process for lignocellulosic biomass where the biomass is treated with hot compressed water The solid product of HTC is HTC biochar which is friable hydrophobic and increased in mass and energy densification compared to the raw biomass HTC biochar also is similar regardless of the type of biomass used A liquid solution of five carbon and six carbon sugars along with various organic acids and 5 HMF is also produced from HTC of lignocellulosic biomass The gaseous phase product consists mostly of CO<sub>2</sub> Different types of lignocellulosic biomass were used for HTC under different conditions Every type of biomass shows a significant decrease in mass yield with a significant increase in the energy densification ratio Oxygen content decreases with increasing HTC reaction temperature The oxygen carbon ratio decreases and as a result HTC biomass has the same characteristics as a low rank coal To optimize the reaction temperature and reaction time for HTC reaction kinetics was studied for loblolly pine which is a lignocellulosic biomass A special two chamber reactor was design

and built to perform kinetic studies It is found that hemicelluloses and cellulose degradation follow two parallel first order reactions Hemicelluloses degrade much faster than cellulose as the activation energy is lower for hemicelluloses than cellulose Lignin behaves as an inert in the studied temperature range of 200 260 C and aqueous solubles are generated almost instantaneously in the reaction scheme After a certain reaction time the mass yield of HTC becomes steady but it varies with the reaction temperature Lignin in the HTC biochar shows glass transition behavior in the temperature range of 135 165 C HTC biochar pellets were produced using a hydraulic press operating at 140 C temperature and 1000 MPa As the lignin content becomes higher at elevated HTC temperatures the HTC biochar pellets are more durable abrasion resistant and mass and energy denser than raw biomass pellets The higher heating value HHV of the pellets is similar to the HHV of HTC biochar However the energy density is significantly higher as the pellets have a higher mass density HTC biochar pellets have a lower modulus of elasticity and a higher ultimate compressive strength relative to raw biomass The trend of modulus of elasticity shows it lessens with increasing HTC treatment temperature The HTC biochar pellets are more hydrophobic than raw biomass pellets The equilibrium moisture content EMC of the HTC biochar pellets are in the same range as HTC biochar but the pellets take 7 10 days more to reach equilibrium

**The Development of a High Temperature Fuel Cell** Fred L. Van Dusen, 1964

**Lignocellulosic Biomass to Liquid Biofuels** Abu Yousuf, Filomena Sannino, Domenico Pirozzi, 2019-11-20 Lignocellulosic Biomass to Liquid Biofuels explores the existing technologies and most recent developments for the production of second generation liquid biofuels providing an introduction to lignocellulosic biomass and the processes for its conversion into biofuels The book demonstrates biorefinery concepts compared with petro refinery as well as the challenges of second generation biofuels processing In addition to current pre treatment techniques and their technical environmental and economic implications chapters included also further examine the particularities of conversion processes for bioethanol biobutanol and biodiesel through chemical biochemical and combined approaches Finally the book looks into concepts and tools for techno economic and environmental analysis which include supply chain assessment by products zero waste techniques and process evaluation and optimization Lignocellulosic Biomass to Liquid Biofuels is particularly useful for researchers in the field of liquid biofuels seeking alternative chemical and biochemical pathways or those interested advanced methods to calculate maximum yield for each process and methods to simulate the implications and costs of scaling up Furthermore with the introduction provided by this volume researchers and graduate students entering the field will be able to quickly get up to speed and identify knowledge gaps in existing and upcoming technology the book s comprehensive overview Examines the state of the art technology for liquid biofuels production from lignocellulosic biomass Provides a comprehensive overview of the existing chemical and biochemical processes for second generation biofuel conversion Presents tools for the techno economic and environmental analysis of technologies as well as for the scale up simulation of conversion processes

Pre-treatment Methods of Lignocellulosic Biomass for Biofuel

Production Shyamal Roy, 2021-08-31 Bioconversion of lignocellulosic biomass to biofuel is materially obstructed by the compositional and chemical complexity of biomaterials resulting in a challenge in using these as raw materials for the biofuel production process This book explains various lignocellulosic biomass pre treatment methods with emphasis on concepts practicability mechanisms of action and advantages and disadvantages and potential for industrial applications It also highlights the main challenges and suggests possible ways to make these pre treatment technologies feasible for the biofuel industry Features Presents different pre treatment technologies available for lignocellulosic biomass in a concise manner Covers use of different pre treatment methods in laboratory to industrial scales Includes combined pre treatment and deep eutectic solvents methods Discusses problems related to industrial adaptation and corresponding economics of different techniques Explores significant fuels and chemicals derived from lignocellulosic biomass This book is aimed at graduate students and researchers working on biomass conversion characterization cellulose hemicellulose lignin microbial enzymes fermentation technology and industrial biotechnology



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### **Lignocellulosic Biomass Energized Fuel Cells High Temperature Introduction**

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