



Mohammad Jawaid
Akil Ahmad
Aatikah Meraj
Editors

Handbook of Lignin



Springer

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Mohammad Jawaaid • Akil Ahmad •
Aatikah Meraj
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Handbook of Lignin

With 363 Figures and 96 Tables

 Springer

Editors

Mohammad Jawaid
Department of Chemical and Petroleum
Engineering, College of Engineering
United Arab Emirates University (UAEU)
Al Ain, United Arab Emirates

Akil Ahmad
Department of Chemistry, College of Sciences
and Humanities
Prince Sattam Bin Abdulaziz University
Al Kharj, Saudi Arabia

Aatikah Meraj
Interdisciplinary Research Center for
Advanced Materials
King Fahd University of Petroleum and
Minerals
Dhahran, Saudi Arabia

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In the Name of Allah, the Most Gracious, the Most Merciful

I dedicate this Handbook of Lignin, my first editorial endeavor, to my beloved father (Dr. Meraj, Consultant Radiologist).



He served as both my mentor and guide, and his invaluable support and guidance were instrumental in facilitating my success. May Allah accept this humble effort and grant my father eternal peace and happiness in the hereafter.

*Your daughter,
Dr. Aatikah Meraj*

Preface

This handbook provides a comprehensive and up-to-date understanding of lignin and its dynamic role in modern science and industry. Lignin, a complex and abundant plant polymer, has been widely researched for its diverse applications in areas such as biofuels, composite materials, and carbon fibers. Despite its immense potential, there is still a great deal of unexplored research on lignin. With growing global emphasis on sustainability, lignin has emerged as a promising renewable resource for energy and as a valuable raw material for chemicals and advanced materials. This handbook provides a comprehensive overview of lignin, encompassing its structure, extraction methods, and characterization techniques, functionalization, surface modification, and properties of lignin-based materials. The functionalization of lignin covers different chemical and physical modification techniques, including oxidation, esterification, and grafting. It also discusses the different functional groups of lignin and their modification to enhance specific material properties. Furthermore, the surface modification of lignin-based materials is explored through the use of nanotechnology and other advanced techniques to enhance their functionality and performance. It also explores how the surface properties of lignin-based materials can be modified to enhance their functionality and performance. It also discusses the potential applications of lignin-based materials in various industries, such as the automotive, packaging, and construction industries. Latest research and developments in the field of lignin-based materials, along with an in-depth understanding of their potential applications in various industries including automotive, packaging, and construction, are also covered.

Overall, this handbook is intended for researchers, students, and professionals in chemistry, materials science, biology, and environmental science who are interested in the dynamic field of lignin and its diverse applications in various fields.

We extend our sincere gratitude to all the qualified researchers, scholars, and experts who contributed their valuable work. The chapters compile cutting-edge research findings on lignin and its applications in various fields. We have compiled contributions from eminent authors on lignin and related research from countries including Spain, Iran, Iraq, Portugal, Australia, India, Malaysia, Saudi Arabia,

Indonesia, Egypt, Morocco, Brazil, France, China, Sweden, Ireland, Pakistan, South Korea, and Bangladesh, resulting in a globally informed and richly contextualized resource.

Al Ain, United Arab Emirates
Al Kharj, Saudi Arabia
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Mohammad Jawaid
Akil Ahmed
Aatikah Meraj

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About the Editors



Dr. Mohammad Jawaid is currently working as Distinguished Professor at Chemical and Petroleum Engineering Department, United Arab Emirates University, UAE. He has more than 25 years of experience in teaching, research, and industries. His areas of research interests include hybrid composites, lignocellulosic reinforced/filled polymer composites, advance materials: graphene/nanoclay/fire retardant, modification and treatment of lignocellulosic fibers and solid wood, biopolymers and biopolymers for packaging applications, nanocomposites and nanocellulose fibers, and polymer blends. So far, he has published 100 books, more than 100 book chapters, more than 500 peer-reviewed international journal papers, and several published review papers under top 25 hot articles in ScienceDirect during 2013–2020. He also obtained 6 Patents and 6 Copyrights/Industrial design. H-index and citations in Scopus are 103 and 44,525, and in Google scholar, H-index and citations are 122 and 59,693. Forty Ph.D. and 17 master's students graduated under his supervision in 2014–2024 in the fields of hybrid composites, green composites, nanocomposites, natural fiber-reinforced composites, nanocellulose, etc. He secured various research grants at university, national, and international levels on polymer composites of around USD 3 million. He also delivered plenary and invited talks in international conferences related to composites in India, Turkey, Malaysia, Thailand, the United Kingdom, France, Saudi Arabia, Egypt, China, Germany, Indonesia, Spain, the UAE, Portugal, etc. Besides that, he is also a member of technical committees of several national and international conferences

on composites and material science. He is founding Series Editor of Springer Three Book Series. He worked as guest editor of special issues of several peer-reviewed journals. Besides that, he is also reviewer of several high-impact international peer-reviewed journals of Elsevier, Springer, Wiley, Sage, ACS, RSC, Frontiers, etc. He also received several awards at national and international levels. He is also Winner of Newton-Ungku Omar Coordination Fund: UK-Malaysia Research and Innovation Bridges Competition 2015. He is also professional member of ACS, SPE, APA, MySET, etc. He is Fellow and Chartered Scientist of The Institute of Materials, Minerals & Mining (IOM3), UK. He is also Clarivate 1% Highly cited Researcher—2023.



Dr. Akil Ahmad is currently working at Prince Sattam bin Abdulaziz University, Saudi Arabia, as Assistant Professor in Chemistry and having the experience of seven years as Research Fellow, Teaching Fellow, Postdoc, and Visiting Researcher from Universiti Teknologi Malaysia, Universiti Sains Malaysia, University of KwaZulu-Natal, South Africa, and Universiti Kebangsaan Malaysia, Malaysia. He has completed Ph.D. in Analytical Chemistry (2011) with the topic “Modification of resin for their use in the separation, preconcentration and determination of metal ions” from Aligarh Muslim University (AMU), India. His research interests are in the areas of environmental pollutants and their safe removal, synthesis of nanoparticles and nano-sorbents (GO, CNT), photo-degradation and antimicrobial effects, water and wastewater treatment, and adsorption and ion-exchange. He has published more than 200 research articles and chapters in journals and publishers of international repute such as *Chemical Engineering Journal*, *Science of the Total Environment*, *Applied Water Science*, *Journal of Industrial and Engineering Chemistry*, *Journal of Molecular Liquids*, etc. He has also edited more than ten books of Springer and Elsevier. He is reviewer of several high-impact international peer-reviewed journals of Elsevier, Springer, Wiley, ACS, RSC, MDPI, Frontiers, etc. He is also guest editor of many reputed journals, namely, *Adsorption Science and Technology*—Hindawi, *Polymers* MDPI, *Frontiers in Environmental Chemistry*, and

Journal of Chemistry—Hindawi. H-index and citations in Scopus are 39 and 6142, and in Google scholar, H-index and citations are 43 and 7849. He is listed as Top 2% researcher in the world by Elsevier/Stanford University 2024, 2023, 2022.



Dr. Aatikah Meraj is currently working as a Postdoctoral Fellow at the Interdisciplinary Research Center for Advanced Materials, King Fahd University of Petroleum and Minerals, Dhahran, Saudi Arabia. She completed her Ph.D. in Materials Science from Universiti Putra Malaysia, located in Serdang, Selangor, Malaysia. She pursued both her master's and bachelor's degrees in Organic Chemistry, Department of Chemistry, Aligarh Muslim University, Aligarh, India. Her research areas include lignin, micro- and nanocrystalline cellulose, natural deep eutectic solvents, modifications and treatments of lignocellulosic biomass, biopolymers and their derivatives, and CO₂ adsorption and packaging applications. Her research experience also encompasses biocomposites and lignin-based composites. She has published her research in high-impact journals, including Q1 and Q2 Quartiles, such as *Industrial Crops and Products*, *Journal of Polymers and the Environment*, *Biomass Conversion and Biorefinery*, and *Scientific Reports*. She was awarded the Graduate on Time (GOT) recognition by Universiti Putra Malaysia in 2024. She has also received a research grant (GP-IPS, UPM) during her research. She has presented her research at international conferences and national conferences, and workshops, and has published book chapters with Elsevier and Springer Nature on topics including lignin-based adsorbents, nanocellulose composites, and biopolymer processing. She has also edited books for Springer Nature. She is proficient in various analytical techniques, including TEM, FESEM/SEM, FTIR, UV/Vis, XRD, DSC, TGA/DTG, and PSA. She also has hands-on experience with planetary ball milling (PM 100). She has also completed coursework in entrepreneurship, focusing on innovation and innovation methodology.

Contributors

Asmaa AbdelAziz Fabrication Technology Research Department, Advanced Technology and New Materials Research Institute, City of Scientific Research and Technological Applications (SRTA-City), Borg Al-Arab, Alexandria, Egypt

Mahdi Abdollahi Polymer Reaction Engineering Department, Faculty of Chemical Engineering, Tarbiat Modares University, Tehran, Iran

Ali Abdulkhani Department of Wood and Paper Science and Technology, University of Tehran, Karaj, Iran

S. Abdullah Materials Science Department, Institute of Graduate Studies and Research, Alexandria University, Elshatby, Alexandria, Egypt

Akil Ahmad Department of Chemistry, College of Sciences and Humanities, Prince Sattam Bin Abdulaziz University, Al Kharj, Saudi Arabia

Kübra Al Energy Systems Engineering Department, Faculty of Engineering, Yalova University, Yalova, Türkiye

Mustafa A. Alheety Department of Nursing, Al-Hadi University College, Baghdad, Iraq

Aisha H. Ali Department of Tikrit Education, Directorate of Salah El-din, Ministry of Education, Tikrit, Iraq

Rakesh Kumar Ameta Shri M.M. Patel Institute of Sciences & Research, Kadi Sarva Vishwavidhyalaya, Gandhinagar, Gujarat, India

Department of Chemistry, Gandhinagar Institute of Science, Gandhinagar University, Gandhinagar, Gujarat, India

Harits Atika Ariyanta Research Center for Biomass and Bioproducts, National Research and Innovation Agency, Cibinong, West Java, Indonesia

Komal Arooj Department of Chemistry, COMSATS University Islamabad, Islamabad, Pakistan

Tarsila Rodrigues Arruda Food Packaging Laboratory, Federal University of Viçosa, Viçosa, Brazil

Nurhani Aryana Research Center for Chemistry, National Research and Innovation Agency (BRIN), South Tangerang, Indonesia

Nur Izyan Wan Azelee Institute of Bioproduct Development, Universiti Teknologi Malaysia, Johor, Malaysia

Faculty of Chemical and Energy Engineering, Universiti Teknologi Malaysia, Johor, Malaysia

Seema Azmat Department of Civil Engineering, Chandigarh University, Gharuan, India

Shakiba Bagheri Department of Wood and Paper Science and Technology, University of Tehran, Karaj, Iran

Ramin Bairami Habashi Department of Polymer Engineering, School of Chemical Engineering, College of Engineering, University of Tehran, Tehran, Iran

Thangsei Nengneilhing Baite Department of Chemical Engineering, Polytechnique Montréal, Montréal, QC, Canada

Katarina Banjanac Innovation Center of the Faculty of Technology and Metallurgy, University of Belgrade, Belgrade, Serbia

Debabrata Barik Department of Mechanical Engineering, Karpagam Academy of Higher Education, Coimbatore, Tamil Nadu, India

Mukul M. Barwant Department of Botany, Sanjivani Arts Commerce and Science College Kopargoan, Ahilyanagar, Maharashtra, India

Sibel Başakçılardan Kabakcı Energy Systems Engineering Department, Faculty of Engineering, Yalova University, Yalova, Türkiye

M. Battestini-Vives Division of Chemical Engineering, Department of Process and Life Science Engineering, Lund University, Lund, Sweden

Ashish Bhardwaj TIT College, Bhiwani, Haryana, India

Jyoti Bhattacharjee Department of Chemical Engineering, University College of Science and Technology, University of Calcutta, Kolkata, India

Asit Baran Biswas Department of Chemical Engineering, University College of Science and Technology, University of Calcutta, Kolkata, India

Biswanath Biswas Department of Chemical Engineering, University College of Science and Technology, University of Calcutta, Kolkata, India

Fernando José Borges Gomes Department of Forest Products, Universidade Federal Rural do Rio de Janeiro, Rio de Janeiro, Brazil

R. Bouhfid Moroccan Foundation for Advanced Science, Innovation and Research (MAScIR), Mohammed VI Polytechnic University, Ben Guerir, Morocco

Tanushri Chatterji Department of Biosciences, Institute of Management Studies Ghaziabad (University Courses Campus), Ghaziabad, India

Diana Catalina Cubides-Román Department of Forest Products, Universidade Federal Rural do Rio de Janeiro, Rio de Janeiro, Brazil

Omar Dagdag Department of Mechanical Engineering, Gachon University, Seongnam, Republic of Korea

Bhaskar Chandra Das Department of Chemical Engineering, University of Calcutta, Kolkata, India

Taíla Veloso de Oliveira Food Packaging Laboratory, Federal University of Viçosa, Viçosa, Brazil

Simons Dhara Department of Chemical Engineering, Indian Institute of Technology Guwahati, Guwahati, Assam, India

J. D. Ekhe Department of Chemistry, Visvesvaraya National Institute of Technology, Nagpur, India

Fahmida-E-Karim Department of Textile Engineering, Ahsanullah University of Science and Technology (AUST), Dhaka, Bangladesh

Obie Farobie Department of Mechanical and Biosystem Engineering, IPB University, Bogor, Indonesia

B. Nazreen Fathima Department of Chemistry, Amrita Vishwa Vidyapeetham, Amritapuri, Kerala, India

Widya Fatriasari Research Center for Biomass and Bioproducts, National Research and Innovation Agency, Cibinong, West Java, Indonesia

Research Collaboration Center of Biomass-Based Nano Cosmetic, in collaboration with National Research and Innovation Agency (BRIN), Samarinda, East Kalimantan, Indonesia

Julia de Cristo Figueiredo Department of Forest Products, Universidade Federal Rural do Rio de Janeiro, Rio de Janeiro, Brazil

Juhi Firdous Department of Advanced Sciences, NIMS University, Jaipur, Rajasthan, India,

Isabel Lim Fong Department of Paraclinical Sciences, Faculty of Medicine and Health Sciences, Universiti Malaysia Sarawak (UNIMAS), Kota Samarahan, Malaysia

Razieh Ghanipour-Meybodi Department of Biomaterials Nanotechnology and Tissue Engineering, School of Advanced Technology in Medicine, Isfahan University of Medical Science, Isfahan, Iran

S. Gokulkumar Department of Mechanical Engineering, KPR Institute of Engineering and Technology, Coimbatore, Tamil Nadu, India

Jelena Gržetić Department for Materials and Protection, Military Technical Institute, Belgrade, Serbia

Piyush Kumar Gupta Centre for Development of Biomaterials & Department of Life Sciences, Sharda School of Bio-Science and Technology, Sharda University, Greater Noida, Uttar Pradesh, India

Centre for Research Impact & Outcome, Chitkara University Institute of Engineering and Technology, Chitkara University, Rajpura, Punjab, India

Amina Hachaichi Department of Material Sciences, Faculty of Science and Technology, University Mohamed El Bachir El Ibrahimi, El Anasser, Algeria

Swattick Halder Department of Chemical Engineering, University of Calcutta, Kolkata, India

Rajesh Haldhar School of Chemical Engineering, Yeungnam University, Gyeongsan, Republic of Korea

Quan He Faculty of Agriculture, Department of Engineering, Dalhousie University, Truro, NS, Canada

Sahab Hedjazi Department of Paper Sciences and Engineering, Faculty of Wood and Paper Engineering, Gorgan University of Agricultural Sciences and Natural Resources, Gorgan, Iran

Miria Hespanhol Miranda Reis Department of Chemical Engineering, Federal University of Uberlândia (UFU), Uberlândia, Minas Gerais, Brazil

Jaber Hosseinzadeh Department of Wood and Paper Science and Technology, University of Tehran, Karaj, Iran

Yulin Hu Faculty of Sustainable Design Engineering, University of Prince Edward Island, Charlottetown, PE, Canada

Hamisu Shuaibu Idris Centre for Development of Biomaterials & Department of Life Sciences, Sharda School of Bio-Science and Technology, Sharda University, Greater Noida, Uttar Pradesh, India

Shahidul Islam Department of Textile Engineering, BGMEA University of Fashion and Technology (BUFT), Dhaka, Bangladesh

Ahmad Safwan Ismail Chemical Engineering Programme, Faculty of Engineering, Universiti Malaysia Sabah, Kota Kinabalu, Sabah, Malaysia

Maya Ismayati Research Center for Biomass and Bioproducts, National Research and Innovation Agency (BRIN), Bogor, Indonesia

Lina Jadhav University Institute of Chemical Technology, Kavayitri Bahinabai Chaudhari North Maharashtra University, Jalgaon, India

R. Jagatheesan Vivekananda College of Arts and Sciences for Women (Autonomous), Namakkal, Tamilnadu, India

M. Sarwar Jahan Pulp and Paper Research Division, Bangladesh Council of Scientific and Industrial Research, Dhaka, Bangladesh

S. Jalani Department of Pharmacy, Faculty of Engineering and Technology (FEAT), Annamalai University, Chidambaram, Tamilnadu, India

Milad Jalilian Faculty of Sustainable Design Engineering, University of Prince Edward Island, Charlottetown, PE, Canada

Mohammad Jawaid Department of Chemical and Petroleum Engineering, College of Engineering, United Arab Emirates University (UAEU), Al Ain, United Arab Emirates

V. Jeevanantham Vivekananda College of Arts and Sciences for Women (Autonomous), Namakkal, Tamilnadu, India

G. Jeevitha Department of Mechanical Engineering, KPR Institute of Engineering and Technology, Coimbatore, Tamil Nadu, India

Yuehan Jiang College of Environmental Sciences, Sichuan Agricultural University, Chengdu, Sichuan, PR China

P. M. Kalyani Department of Chemistry, Amrita Vishwa Vidyapeetham, Amritapuri, Kerala, India

S. Kandil Materials Science Department, Institute of Graduate Studies and Research, Alexandria University, Elshatby, Alexandria, Egypt

Misook Kang Department of Chemistry, College of Natural Science, Yeungnam University, Gyeongsan, Republic of Korea

Komal Kasana Apeejay Stya University, Gurugram, India

Narinder Kaur PMSE Department, Jaypee Institute of Information and Technology, Noida, India

Mohamed Aymen Kethiri Laboratoire de Génie Energétique et Matériaux, LGEM, University Mohamed Khider of Biskra, Biskra, Algeria

Dipartimento di Ingegneria Civile e Ambientale, Politecnico di Milano, Milan, Italy

Sabina Khan Shri M.M. Patel Institute of Sciences & Research, Kadi Sarva Vishwavidhyalaya, Gandhinagar, Gujarat, India

Sarmad Habib Khan National University of Sciences & Technology (NUST), Islamabad, Pakistan

Shoaib Khan Department of Chemistry, Abbottabad University of Science and Technology Abbottabad, Abbottabad, Pakistan

Yousaf Khan Department of Chemistry, COMSATS University Islamabad, Islamabad, Pakistan

Kiran Khandare Division of Chemical Engineering, Center of Innovative and Applied Bioprocessing (CIAB), Mohali, Punjab, India

Namrata Khanna Department of Biochemistry, M A Rangoonwala College of Dental Sciences and Research Centre, Pune, India

Heng Yen Khong Faculty of Applied Sciences, Universiti Teknologi MARA, Kota Samarahan, Sarawak, Malaysia

Hansang Kim Department of Mechanical Engineering, Gachon University, Seongnam, Republic of Korea

Kaushal Kishor Department of Textile Technology, Uttar Pradesh Textile Technology Institute, Kanpur, India

Ajay Kumar School of Bioengineering and Biosciences, Lovely Professional University, Phagwara, Punjab, India

Prasann Kumar Department of Agronomy, School of Agriculture, Lovely Professional University, Phagwara, Punjab, India

Rohit Kumar Centre for Development of Biomaterials & Department of Life Sciences, Sharda School of Bio-Science and Technology, Sharda University, Greater Noida, Uttar Pradesh, India

Saran S. Kumar Department of Chemistry, Amrita Vishwa Vidyapeetham, Amritapuri, Kerala, India

Mamta Kumari Department of Pharmacy, Sumandeep Vidyapeeth, Deemed to be University, Vadodara, Gujarat, India

F. Lipnizki Division of Chemical Engineering, Department of Process and Life Science Engineering, Lund University, Lund, Sweden

Lu Liu School of Food and Pharmacy, Zhejiang Ocean University, Zhoushan, China

Rafiq Lone Department of Botany, Central University of Kashmir, Jammu and Kashmir, India

Nilton Louvem da Silva Junior Department of Forest Products, Universidade Federal Rural do Rio de Janeiro, Rio de Janeiro, Brazil

Madhulika Madhavan Bioprospecting Laboratory, Centre for Bioenergy, School of Chemical and Biotechnology, SASTRA Deemed University, Thirumalaisamudram, Thanjavur, India

Md. Mahmud Department of Chemical Engineering, Jashore University of Science and Technology, Jashore, Bangladesh

Subhankar Maity Department of Textile Technology, Uttar Pradesh Textile Technology Institute, Kanpur, India

Lorranne Marins-Gonçalves Department of Chemical Engineering, Federal University of Uberlândia (UFU), Uberlândia, Minas Gerais, Brazil

Clara Suprani Marques Federal Institute of Mato Grosso – Campus Campo Novo do Parecis, Campo Novo do Parecis, Brazil

Sabrina Mayer de Almeida Department of Forest Products, Universidade Federal Rural do Rio de Janeiro, Rio de Janeiro, Brazil

Md. Redwanul Islam Department of Textile Engineering, Ahsanullah University of Science and Technology (AUST), Dhaka, Bangladesh

Md. Tanvir Hossain Department of Textile Engineering, Bangladesh University of Business and Technology (BUBT), Dhaka, Bangladesh

Department of Materials Science and Engineering, Michigan Technological University, Houghton, MI, USA

Aatikah Meraj Interdisciplinary Research Center for Advanced Materials, King Fahd University of Petroleum and Minerals, Dhahran, Saudi Arabia

Satyendra Mishra University Institute of Chemical Technology, Kavayitri Bahinabai Chaudhari North Maharashtra University, Jalgaon, India

Abeera Moin Department of Food Science and Technology, University of Karachi, Karachi, Pakistan

Anila Mukhtiar Department of Chemistry, COMSATS University Islamabad, Islamabad, Pakistan

Aravindh Murugan Centre for Research and Development and Department of Mechanical Engineering, KPR Institute of Engineering and Technology, Coimbatore, India

S. Deva Nanda Department of Chemistry, Amrita Vishwa Vidyapeetham, Amritapuri, Kerala, India

Mohammad Ali Nasiri Department of Inorganic Chemistry, Institute of Molecular Science (ICMol) and Institute of Materials Science (ICMUV), University of Valencia, Valencia, Spain

Greg Naterer Faculty of Sustainable Design Engineering, University of Prince Edward Island, Charlottetown, PE, Canada

Fahimeh Nourabi Department of Chemical Engineering, Sahand University of Technology, Tabriz, Iran

Huda A. Nuaman Department of Water Resources Engineering, College of Engineering, Mustansiriyah University, Baghdad, Iraq

Wessam S. Omara Materials Science Department, Institute of Graduate Studies and Research, Alexandria University, Elshatby, Alexandria, Egypt

Oyepeju Ruth Oyeleke Faculty of Sustainable Design Engineering, University of Prince Edward Island, Charlottetown, PE, Canada

Lalduhsanga Pachuau Department of Pharmaceutical Science, Assam University, Silchar, Assam, India

Sadanand Pandey Department of Chemistry, College of Natural Science, Yeungnam University, Gyeongsan, Republic of Korea

School of Bioengineering and Food Technology, Faculty of Applied Sciences and Biotechnology, Shoolini University, Himachal Pradesh, India

Zia ur Rehman Panizai Department of Environmental Sciences, Balochistan University of Information Technology, Engineering and Management Sciences (BUITEMS), Quetta, Pakistan

Gopi Patel Department of Chemistry, Anand Pharmacy College, Anand, Gujarat, India

Rahul Patil University Institute of Chemical Technology, Kavayitri Bahinabai Chaudhari North Maharashtra University, Jalgaon, India

Y.C.S.P. Mandal's Dadasaheb Digambar Shankar Patil Arts, Commerce and Science College, Jalgaon, India

Satish V. Patil School of Life Sciences, Kavayitri Bahinabai Chaudhari North Maharashtra University, Jalgaon, India

Vikas Patil University Institute of Chemical Technology, Kavayitri Bahinabai Chaudhari North Maharashtra University, Jalgaon, India

Kamleshwar L. Patle Department of Chemistry, Visvesvaraya National Institute of Technology, Nagpur, India

Utchimahali Muthu Raja Pitchai Centre for Research and Development and Department of Mechanical Engineering, KPR Institute of Engineering and Technology, Coimbatore, India

A. E. K. Qaiss Moroccan Foundation for Advanced Science, Innovation and Research (MAScIR), Mohammed VI Polytechnic University, Ben Guerir, Morocco

M. Mostafizur Rahman Pulp and Paper Research Division, Bangladesh Council of Scientific and Industrial Research, Dhaka, Bangladesh

M. Raji Moroccan Foundation for Advanced Science, Innovation and Research (MAScIR), Mohammed VI Polytechnic University, Ben Guerir, Morocco

Rabia Rashid Department of Botany, North Campus, University of Kashmir, Jammu and Kashmir, India

Nazima Rasool Department of Botany, North Campus, University of Kashmir, Jammu and Kashmir, India

Shenthilkumar Rathinasamy Radhamani Centre for Research and Development and Department of Mechanical Engineering, KPR Institute of Engineering and Technology, Coimbatore, India

Aiman Rehman Department of Chemistry, COMSATS University Islamabad, Islamabad, Pakistan

Witta Kartika Restu Research Center for Chemistry, National Research and Innovation Agency (BRIN), South Tangerang, Indonesia

Selim Reza Department of Textile Engineering, Dhaka University of Engineering and Technology, Gazipur, Bangladesh

Iqra Riaz National University of Sciences & Technology (NUST), Islamabad, Pakistan

Subhasis Roy Department of Chemical Engineering, University College of Science and Technology, University of Calcutta, Kolkata, India

Fahriya Puspita Sari Research Center for Biomass and Bioproducts, National Research and Innovation Agency (BRIN), Bogor, Indonesia

Appukuttan Saritha Department of Chemistry, Amrita Vishwa Vidyapeetham, Amritapuri, Kerala, India

S. Sathish Department of Mechanical Engineering, Karpagam Academy of Higher Education, Coimbatore, Tamil Nadu, India

Niyati Shah Department of Pharmacy, Sumandeep Vidyapeeth, Deemed to be University, Vadodara, Gujarat, India

Fei Shen College of Environmental Sciences, Sichuan Agricultural University, Chengdu, Sichuan, PR China

Ruqian Shen College of Environmental Sciences, Sichuan Agricultural University, Chengdu, Sichuan, PR China

Rahul Kumar Shringirishi Department of Textile Technology, Dr B R Ambedkar National Institute of Technology Jalandhar, Jalandhar, Punjab, India

Karoline Ferreira Silva Biomaterials Engineering, Federal University of Lavras, Lavras, Brazil

Balwant Singh Department of Botany, K. S. Saket PG College, Dr. Ram Manohar Lohia Avadh University Ayodhya, Ayodhya, India

Joginder Singh Department of Botany, Nagaland University, Nagaland, India

Manali Singh Centre for Development of Biomaterials & Department of Life Sciences, Sharda School of Bio-Science and Technology, Sharda University, Greater Noida, Uttar Pradesh, India

Ajithkumar Sitharaj Centre for Research and Development and Department of Mechanical Engineering, KPR Institute of Engineering and Technology, Coimbatore, India

P. Snega Vivekananda College of Arts and Sciences for Women (Autonomous), Namakkal, Tamilnadu, India

Nissa Nurfajrin Solihat Research Center for Biomass and Bioproducts, National Research and Innovation Agency (BRIN), Bogor, Indonesia

Santhi Somaraj TKMIT, Kollam, Kerala, India

Shatakshi Srivastava Apeejay Stya University, Gurugram, India

Fubao Sun Key Laboratory of Industrial Biotechnology, Ministry of Education, School of Biotechnology, Jiangnan University, Wuxi, China

Meghraj Suryawanshi Department of Pharmaceutics, Sandip Institute of Pharmaceutical Sciences (SIPS), Nashik, Maharashtra, India

School of Pharmaceutical Sciences, Jaipur National University, Jaipur, Rajasthan, India

Sarra Tablit Laboratory Multiphas Polymeric Materials (LMPMP), Faculty of Technology, University Ferhat Abbas Setif-1, Setif, Algeria

Mohamad Nurul Azman Mohammad Taib Institute for Advanced Studies (IAS), University of Malaya, Kuala Lumpur, Malaysia

Abhinay Thakur Department of Chemistry, School of Chemical Engineering and Physical Sciences, Lovely Professional University, Phagwara, Punjab, India

Dong Tian College of Environmental Sciences, Sichuan Agricultural University, Chengdu, Sichuan, PR China

Kiran Babu Uppuluri Bioprospecting Laboratory, Centre for Bioenergy, School of Chemical and Biotechnology, SASTRA Deemed University, Thirumalaisamudram, Thanjavur, India

M. Vinitha Vivekananda College of Arts and Sciences for Women (Autonomous), Namakkal, Tamilnadu, India

M. Vishnuvarthanan Department of Mechanical Engineering, Kalasalingam Academy of Research and Education, Srivilliputhur, Tamil Nadu, India

O. Wallberg Division of Chemical Engineering, Department of Process and Life Science Engineering, Lund University, Lund, Sweden

Tingjiao Wang College of Environmental Sciences, Sichuan Agricultural University, Chengdu, Sichuan, PR China

K. L. Wasewar Department of Chemical Engineering, Visvesvaraya National Institute of Technology, Nagpur, India

E. S. Zainudin Laboratory of Biocomposite Technology, Institute of Tropical Forestry and Forest Products, Universiti Putra Malaysia, Serdang, Selangor, Malaysia

Advanced Engineering Materials and Composites Research Centre (AEMC), Department of Mechanical and Manufacturing Engineering, Universiti Putra Malaysia, Serdang, Selangor, Malaysia

Hadi Zare-Zardini Department of Biomedical Engineering, Meybod University, Meybod, Iran

Bin Zhang School of Food and Pharmacy, Zhejiang Ocean University, Zhoushan, China

Yadong Zhao School of Food and Pharmacy, Zhejiang Ocean University, Zhoushan, China

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