

Green Chemistry

Cutting-edge research for a greener sustainable future

rsc.li/greenchem

The Royal Society of Chemistry is the world's leading chemistry community. Through our high impact journals and publications we connect the world with the chemical sciences and invest the profits back into the chemistry community.

IN THIS ISSUE

ISSN 1463-9262 CODEN GRCHFJ 25(11) 4141–4580 (2023)



Cover

See Oliver Y. Gutiérrez *et al.*, pp. 4222–4233.

Image reproduced by permission of Pacific Northwest National Laboratory from *Green Chem.*, 2023, **25**, 4222.

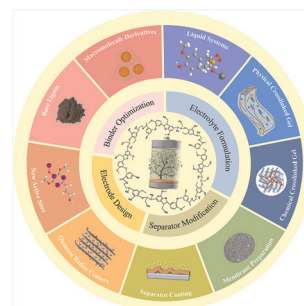
Artwork by Stephanie King.

CRITICAL REVIEW

4154

Renewable lignin and its macromolecule derivatives: an emerging platform toward sustainable electrochemical energy storage

Xueru Yang, Yufei Zhang, Minghui Ye, Yongchao Tang, Zhipeng Wen, Xiaoqing Liu* and Cheng Chao Li*

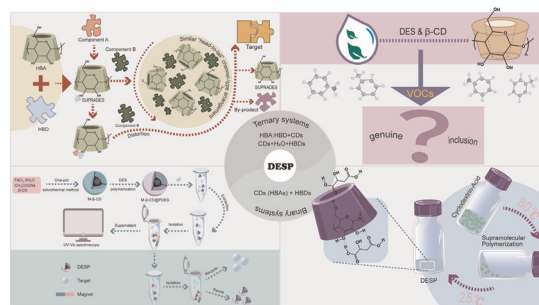


TUTORIAL REVIEWS

4180

Green materials with promising applications: cyclodextrin-based deep eutectic supramolecular polymers

Jingyu Zhang, Liping Yao, Shang Li, Shiqi Li, Yongsong Wu, Zuguang Li* and Hongdeng Qiu*



Editorial Staff

Executive Editor

Michael A. Rowan

Deputy Editor

Vikki Pritchard

Development Editors

Bee Hockin, Andrea Carolina Ojeda Porras

Editorial Production Manager

Gisela Scott

Publisher

Jeanne Andres

Senior Publishing Editor

Robin Brabham

Publishing Editors

Catherine Au, Isabel Darlington, Konoya Das, Alexandre Dumon, Amy Lucas, Kieran Nicholson, Charlotte Pugsley, Hugh Ryan

Editorial Assistant

Daphne Houston

Publishing Assistant

Robert Griffiths

For queries about submitted articles please contact Gisela Scott, Editorial Production Manager, in the first instance. E-mail green@rsc.org

For pre-submission queries please contact

Michael A. Rowan, Executive Editor.

E-mail green-rsc@rsc.org

Green Chemistry electronic:

ISSN 1463-9270 is published 24 times

a year by the Royal Society of Chemistry,

Thomas Graham House, Science Park, Milton Road,

Cambridge, CB4 0WF, UK.

All orders, with cheques made payable to the Royal Society of Chemistry, should be sent to the Royal Society of Chemistry Order Department, Royal Society of Chemistry, Thomas Graham House, Science Park, Milton Road, Cambridge, CB4 0WF, UK
Tel +44 (0)1223 432398; E-mail orders@rsc.org

2023 Annual electronic subscription price: £2578; US\$4544. Customers in Canada will be subject to a surcharge to cover GST. Customers in the EU subscribing to the electronic version only will be charged VAT.

If you take an institutional subscription to any Royal Society of Chemistry journal you are entitled to free, site-wide web access to that journal. You can arrange access via Internet Protocol (IP) address at www.rsc.org/ip

Customers should make payments by cheque in sterling payable on a UK clearing bank or in US dollars payable on a US clearing bank.

Whilst this material has been produced with all due care, the Royal Society of Chemistry cannot be held responsible or liable for its accuracy and completeness, nor for any consequences arising from any errors or the use of the information contained in this publication. The publication of advertisements does not constitute any endorsement by the Royal Society of Chemistry or Authors of any products advertised. The views and opinions advanced by contributors do not necessarily reflect those of the Royal Society of Chemistry which shall not be liable for any resulting loss or damage arising as a result of reliance upon this material. The Royal Society of Chemistry is a charity, registered in England and Wales, Number 207890, and a company incorporated in England by Royal Charter (Registered No. RC000524), registered office: Burlington House, Piccadilly, London W1J 0BA, UK, Telephone: +44 (0) 207 4378 6556.

Advertisement sales:

Tel +44 (0) 1223 432246; Fax +44 (0) 1223 426017;

E-mail advertising@rsc.org

For marketing opportunities relating to this journal, contact marketing@rsc.org

Green Chemistry

Cutting-edge research for a greener sustainable future

rsc.li/greenchem

Green Chemistry focuses on cutting-edge research that attempts to reduce the environmental impact of the chemical enterprise by developing a technology base that is inherently non-toxic to living things and the environment.

Editorial Board

Chair

Professor Doctor Javier Pérez-Ramírez, ETH Zurich, Switzerland

Associate Editors

Professor Aiwen Lei, College of Chemistry and Molecular Sciences, The Institute for Advanced Studies, Wuhan University, P. R. China

Dr Elsje A. Quadrelli, CNRS and CPE Lyon, France

Professor Magdalena Titirici, Imperial College London, UK

Dr Keiichi Tomishige, Tohoku University, Japan

Members

Dr François Jérôme, University of Poitiers, France

Professor Laurel Shafer, The University of British Columbia, Canada

Dr Helen Sneddon, University of York, UK

Dr Tao Zhang, Dalian Institute of Chemical Physics, Chinese Academy of Sciences, China

Advisory Board

Paul Anastas, Yale University, USA

Isabel Arends, TU Delft, The Netherlands

Gregg Beckham, NREL, USA

Asim Bhaumik, Indian Association for the Cultivation of Science, India

Fabrizio Cavani, University of Bologna, Italy

Yonas Chebude, Addis Ababa University, Ethiopia

James Clark, University of York, UK

Avelino Corma, Universidad Politecnica de Valencia, Spain

Robert H Crabtree, Yale University, USA

Paul Dauenhauer, University of Minnesota, USA

Pierre Dixneuf, University of Rennes, France

James Dumesic, University of Wisconsin-Madison, USA

Peter Dunn, Pfizer, UK

Martin Eastgate, Bristol Myers Squibb, USA

Karen Goldberg, University of Washington, USA

Buxing Han, Chinese Academy of Sciences, China

Mark Harmer, SAC Technologies, USA

Milton Hearn, Monash University, Australia

Steve Howdle, Nottingham University, UK

Andrew J. Hunt, Khon Kaen University, Thailand

Graham Hutchings, Cardiff University, UK

Philip Jessop, Queen's University, Canada

C. Oliver Kappe, University of Graz, Austria

Shu Kobayashi, University of Tokyo, Japan

Mihkel Koel, Tallinn University of Technology, Estonia

Burkhard Koenig, University of Regensburg, Germany

Michael Kopach, Eli Lilly and Company, USA

Dhileep Krishnamurthy, Jubilant Ingrevia Limited, India

Walter Leitner, RWTH Aachen University, Germany

Chao-Jun Li, McGill University, Canada

Bruce Lipshutz, University of California, USA

Rafael Luque, University of Cordoba, Spain

Doug MacFarlane, Monash University, Australia

Tomoo Mizugaki, Osaka University, Japan

Regina Palkovits, RWTH Aachen, Germany

Alvise Perosa, Università Ca Foscari, Italy

Martina Peters, Bayer AG, Germany

Martyn Poliakoff, University of Nottingham, UK

Colin Raston, Flinders University, Australia

Roberto Rinaldi, Imperial College London, UK

Robin D. Rogers, McGill University, Canada

Gadi Rothenberg, University of Amsterdam, The Netherlands

Susannah Scott, University of California, USA

Roger Sheldon, Delft University of Technology, The Netherlands

Christian Stevens, Ghent University, Belgium

Natalia Tarasova, Mendeleev University of Chemical Technology, Russia

Rajender Varma, US Environmental Protection Agency, USA

Peter Wasserscheid, Friedrich-Alexander Universität Erlangen-Nürnberg, Germany

Tom Welton, Imperial College London, UK

Kevin C. W. Wu, National Taiwan University, Taiwan

Ganapati D. Yadav, Institute of Chemical Technology, India

Hisao Yoshida, Kyoto University, Japan

Suojiang Zhang, Institute of Process Engineering, Chinese Academy of Sciences, China

Julie Zimmerman, Yale University, USA

Vânia Zuin, Federal University of São Carlos, Brazil

Information for Authors

Full details on how to submit material for publication in Green Chemistry are given in the Instructions for Authors (available from <http://www.rsc.org/authors>). Submissions should be made via the journal's homepage: rsc.li/greenchem

Authors may reproduce/republish portions of their published contribution without seeking permission from the Royal Society of Chemistry, provided that any such republication is accompanied by an acknowledgement in the form: (Original Citation)–Reproduced by permission of the Royal Society of Chemistry.

This journal is © The Royal Society of Chemistry 2023.

Apart from fair dealing for the purposes of research or private study for non-commercial purposes, or criticism or review, as permitted under the Copyright, Designs and Patents Act 1988 and the Copyright and Related Rights Regulation 2003, this publication may only be reproduced, stored or transmitted, in any form or by any means, with the prior permission in writing of the Publishers or in the case of reprographic reproduction in accordance with the terms of licences issued by the Copyright Licensing Agency in the UK. US copyright law is applicable to users in the USA.

Registered charity number: 207890

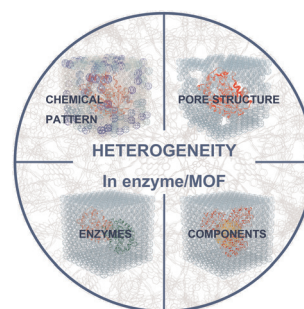


TUTORIAL REVIEWS

4196

Heterogeneity in enzyme/metal–organic framework composites for CO₂ transformation reactions

Ying Shu, Weibin Liang* and Jun Huang*

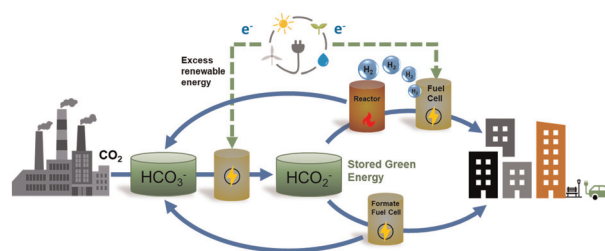


PERSPECTIVE

4222

Using earth abundant materials for long duration energy storage: electro-chemical and thermo-chemical cycling of bicarbonate/formate

Oliver Y. Gutiérrez,* Katarzyna Grubel, Jotheeswari Kothandaraman, Juan A. Lopez-Ruiz, Kriston P. Brooks, Mark E. Bowden and Tom Autrey

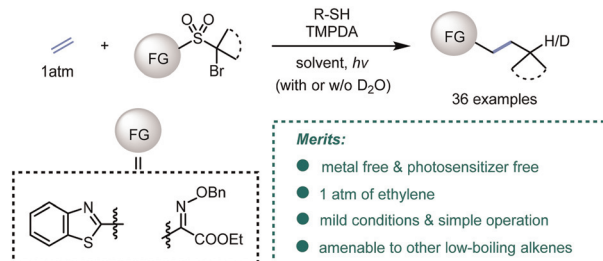


COMMUNICATIONS

4234

Metal-free radical-mediated alkylfunctionalization of ethylene and low-boiling-point alkenes

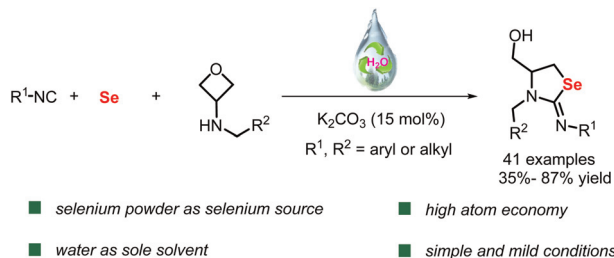
Xu Zhang, Xinxin Wu, Yasu Chen and Chen Zhu*



4239

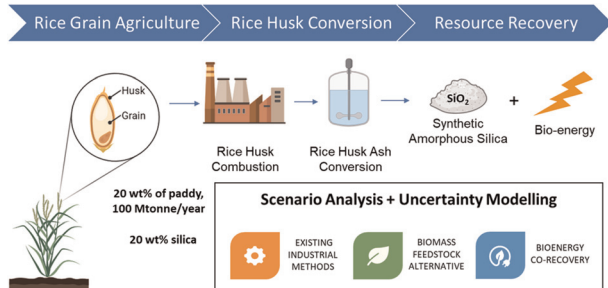
A multicomponent reaction of isocyanides, selenium powder and 3-aminooxetanes in pure water: green and efficient synthesis of 1,3-selenazolines

Huan Liu, Zi-Lin Ye, Zhong-Jian Cai* and Shun-Jun Ji*



PAPERS

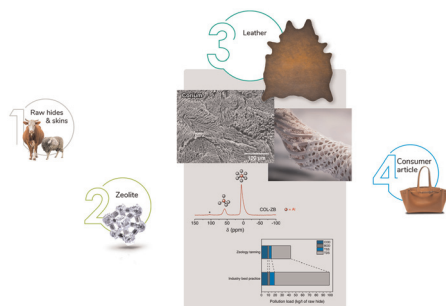
4244



Synthetic amorphous silica: environmental impacts of current industry and the benefit of biomass-derived silica

Ethan Errington, Miao Guo* and Jerry Y. Y. Heng*

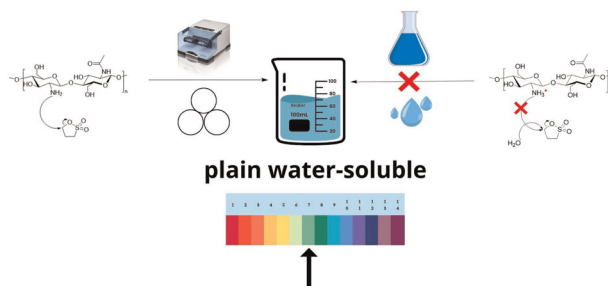
4260



Zeolites as sustainable alternatives to traditional tanning chemistries

William R. Wise, Stefan J. Davis,* Wouter E. Hendriksen, Dirick J. A. von Behr, Sujay Prabakar and Yi Zhang

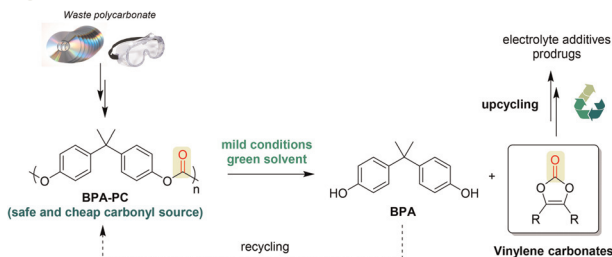
4271



Green mechanochemical synthesis of water-soluble *N*-sulfonated chitosan

Casper Van Poucke,* Aurèle Vandeputte, Sven Mangelinckx and Christian V. Stevens

4282



Chemical upcycling of poly(bisphenol A carbonate) to vinylene carbonates through organocatalysis

Killian Onida, Mohamad Fayad, Sébastien Norsic, Olivier Boyron and Nicolas Duguet*

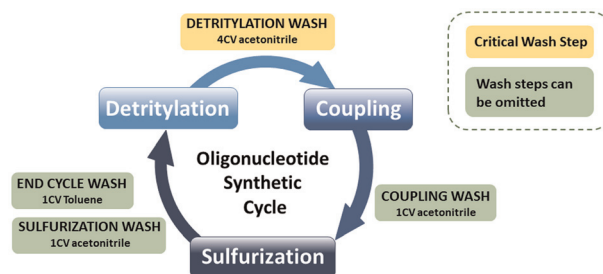


PAPERS

4292

Omission of column washing operations in the solid phase synthesis of oligonucleotides

Li Xiao,* Thomas Pickel, Zifan Li, Dominic Luciano, Jing Yang, David Cho, Sophia Mac, Xianglin Shi, George Bou-Assaf, Firoz Antia and Yannick Fillon



4302

Electrochemical single-step *N*-acylation and *S*-cyclization synthesis of thiazolimide *via* radical process

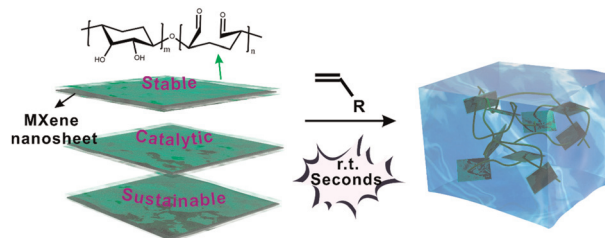
Yao Li, Jun Zhang, Mengyao She, Lang Liu, Zheng Yang, Ping Liu,* Shengyong Zhang and Jianli Li*



4309

Long-term stable and catalytic 2D MXene nanosheets wrapped with dialdehyde xylan for ultrafast gelation

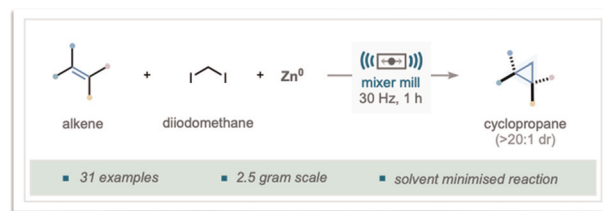
Nan Li, Lupeng Shao, Qiang Xia, Shujun Tan, Shuwen Zhao, XuPeng Li, Zhenhua Su, Xiang Hao* and Feng Peng*



4319

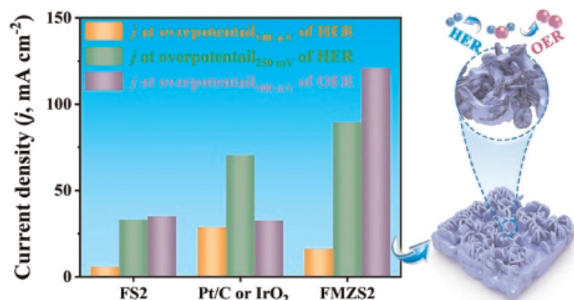
Mechanochemical Simmons–Smith cyclopropanation *via* ball-milling-enabled activation of zinc(0)

Lorenzo Pontini, Jamie A. Leitch* and Duncan L. Browne*



PAPERS

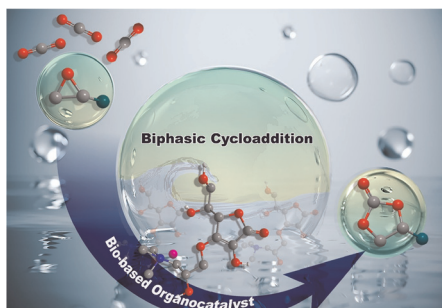
4326



Compositionally modulated FeMn bimetallic skeletons for highly efficient overall water splitting

Licheng Huang, Ruiqi Yao, Zili Li, Jiabin He, Yingqi Li,* Hongxiang Zong,* Shuang Han,* Jianshe Lian, Yang-Guang Li and Xiangdong Ding

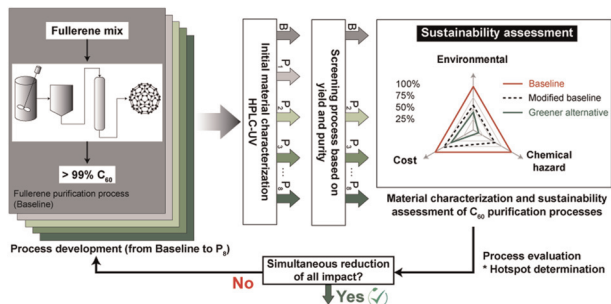
4336



Cycloaddition of CO₂ to epoxides "around water": a strategy to apply and recycle efficient water-soluble bio-based organocatalysts in biphasic media

Tharinee Theerathanagorn, Anna Vidal-López, Aleix Comas-Vives, Albert Poater* and Valerio D'Elia*

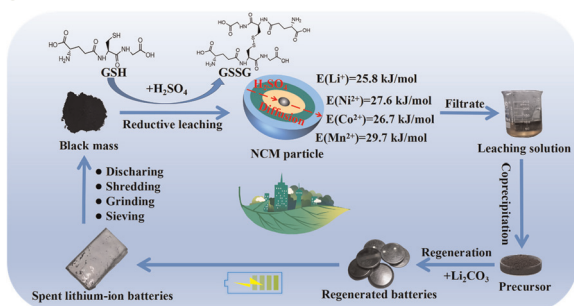
4350



Environmental, cost, and chemical hazards of using alternative green solvents for fullerene (C₆₀) purification

Seyed M. Heidari, Eunsang Lee, Ben Cecil and Annick Anctil*

4362



A green strategy for recycling cathode materials from spent lithium-ion batteries using glutathione

Kunhong Gu, Xingyuan Gu, Yongwei Wang, Wenqing Qin and Junwei Han*

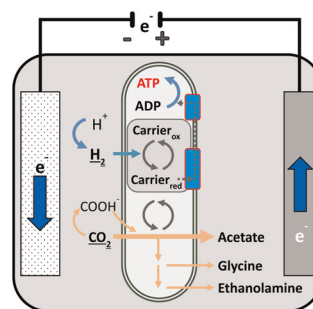


PAPERS

4375

Microbial electrosynthesis with *Clostridium ljungdahlii* benefits from hydrogen electron mediation and permits a greater variety of products

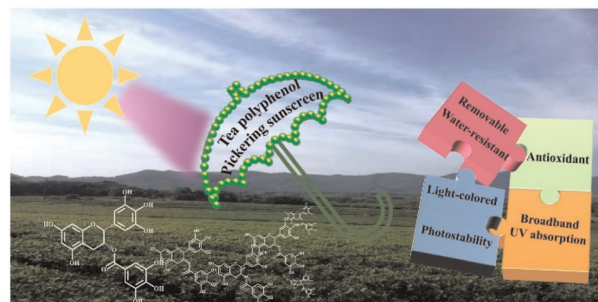
Santiago T. Boto, Bettina Bardl, Falk Harnisch and Miriam A. Rosenbaum*



4387

Polyphenolic condensation assembly enabled biocompatible, antioxidative, and light-colored tea sunscreen formulations with broadband UV protection

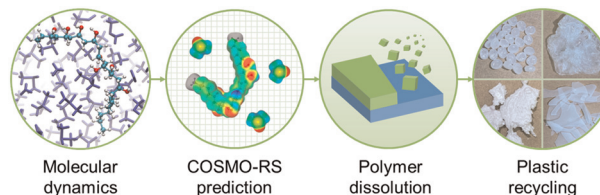
Qiulan Tong, Yue Xiao, Zeng Yi, Xiangyu Chen, Xian Jiang* and Xudong Li*



4402

Large-scale computational polymer solubility predictions and applications to dissolution-based plastic recycling

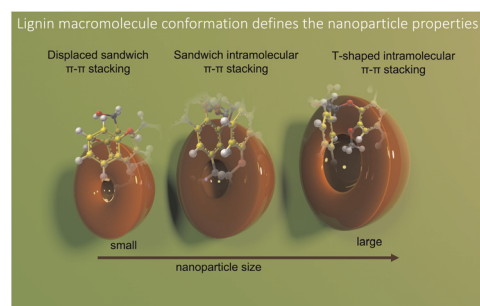
Panzheng Zhou, Jiuling Yu, Kevin L. Sánchez-Rivera, George W. Huber and Reid C. Van Lehn*



4415

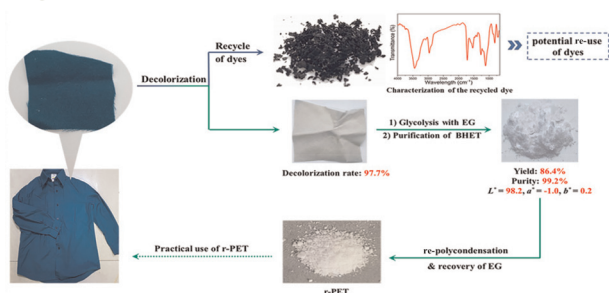
Molecular understanding of the morphology and properties of lignin nanoparticles: unravelling the potential for tailored applications

Ievgen V. Pylypchuk, Maria Karlsson, Pär A. Lindén, Mikael E. Lindström, Thomas Elder, Olena Sevastyanova* and Martin Lawoko*



PAPERS

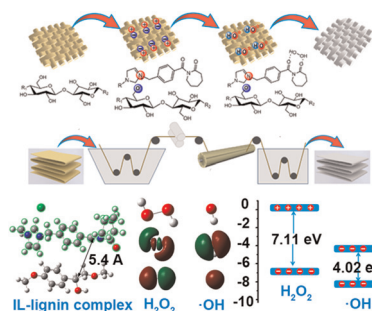
4429



Closed-loop utilization of polyester in the textile industry

Zhuo Chen, Haiyu Sun, Weiqing Kong, Long Chen* and Weiwei Zuo*

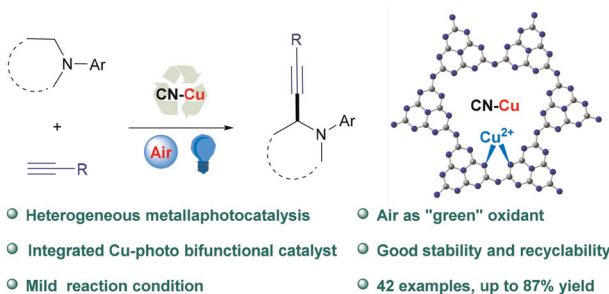
4438



Efficient catalysis of H_2O_2 with ionic liquid molecules to generate hydroxyl radicals and application in green chemistry cotton processes

Kongliang Xie, Xiang Zhuang, Xiang Luo, Zeye Jing, Xiyu Song,* Aiqin Hou and Aiqin Gao*

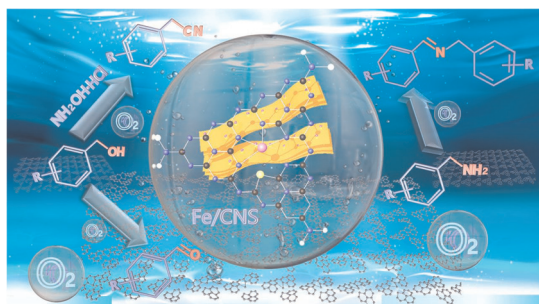
4446



Copper-doped carbon nitride as a practical heterogeneous metallaphotocatalyst for aerobic oxidative cross-coupling of tertiary amines with terminal alkynes

Yilian Bai, Qian Yang, Yurong Tang,* Xiao Dan, Wentao Wang* and Yunfei Cai*

4453



Enzyme-mimicking single atoms enable selectivity control in visible-light-driven oxidation/ammoxidation to afford bio-based nitriles

Ye Meng, Jinshu Huang, Jie Li, Yumei Jian, Song Yang* and Hu Li*

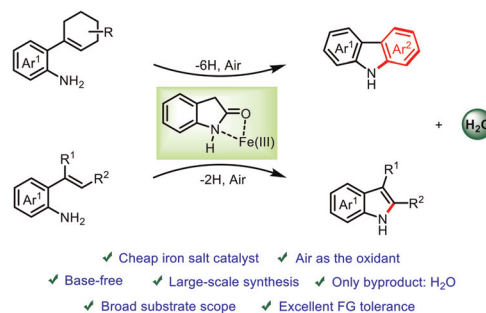


PAPERS

4463

Iron-catalyzed intramolecular C–H amination for the synthesis of N–H carbazoles and indoles

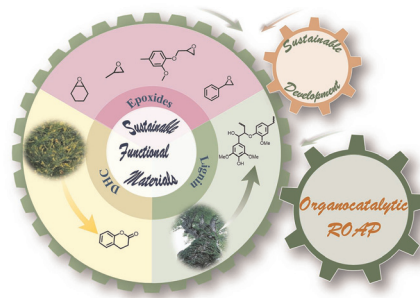
Zheng-Lin Wang, Yun-Hao Zhang, Jun-Yu Huang, Jian Zhou, Ya-Qin Yu, Dexin Feng* and Da-Zhen Xu*



4469

Lignin-grafting alternative copolymer of 3,4-dihydrocoumarin and epoxides as an active and flexible ingredient in sunscreen

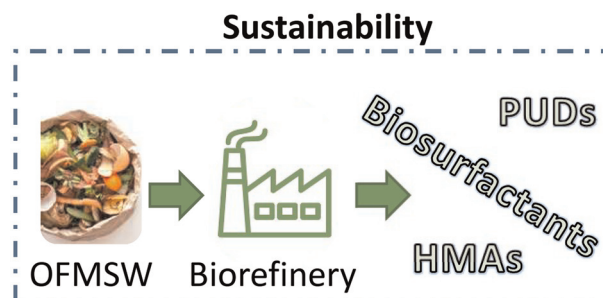
Pengcheng Liu, Yuanlong Guo, Gu Guo, Lei Dai, Gang Hu and Haibo Xie*



4482

Techno-economic evaluation and life cycle assessment for sustainable alternative biorefinery concepts using the organic fraction of municipal solid waste

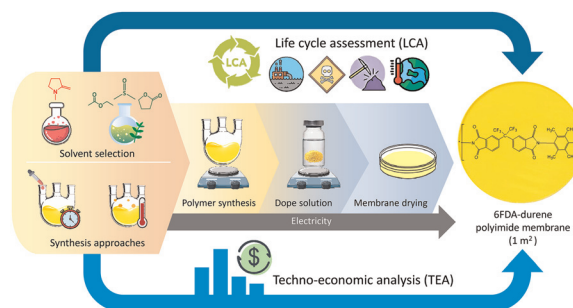
Sofia-Maria Ioannidou, José Pablo López-Gómez, Joachim Venus, Miguel Angel Valera, Vera Eßmann, Irantzu Alegria-Dallo, Ioannis K. Kookos, Apostolis Koutinas* and Dimitrios Ladakis*



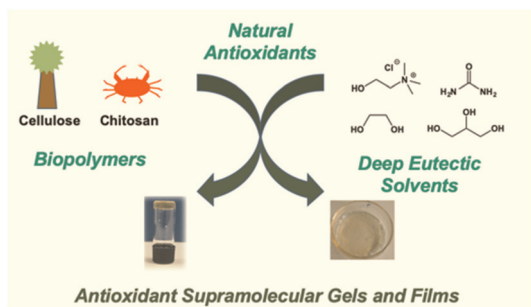
4501

Are green solvents truly green? Integrating life cycle assessment and techno-economic analysis for sustainable membrane fabrication

Seang Uyin Hong, Yida Wang, Leong Sing Soh and Wai Fen Yong*



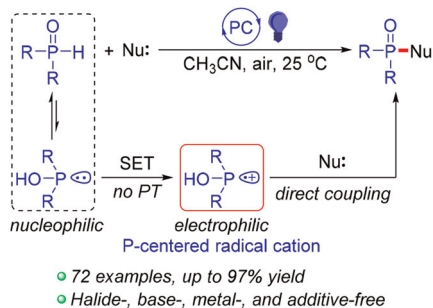
4513



Polysaccharide-based supramolecular bicomponent eutectogels as sustainable antioxidant materials

Salvatore Marullo, Floriana Petta, Giulia Infurna, Nadka T. Dintcheva and Francesca D'Anna*

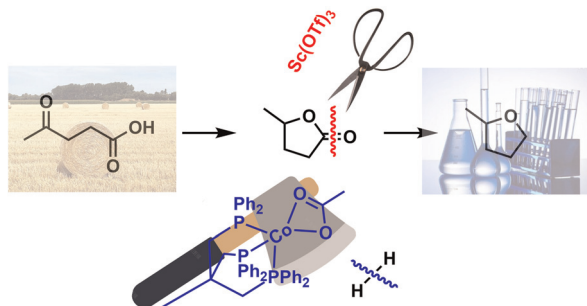
4528



Visible light photocatalytic phosphorylation of heteroatom nucleophiles triggered by phosphorus-centered radical cations

Yuanting Huang, Jinyu Tang, Xi Zhao, Yanping Huo, Yang Gao, Xianwei Li and Qian Chen*

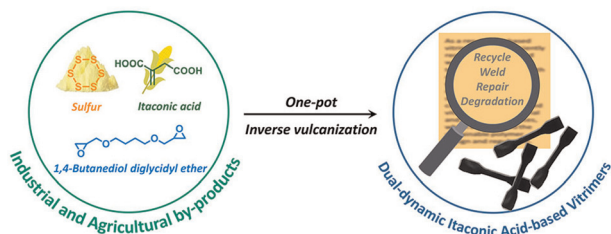
4536



Catalytic hydrodeoxygenation of neat levulinic acid into 2-methyltetrahydrofuran using a cobalt phosphine complex and Sc(OTf)₃ co-catalytic system

Lijin Gan and Jin Deng*

4544



Comprehensive itaconic acid-based vitrimers via one-pot inverse vulcanization

Zhongkai Guo, Xuewei Jiao, Kailun Wei, Jianqiao Wu* and Jun Hu*

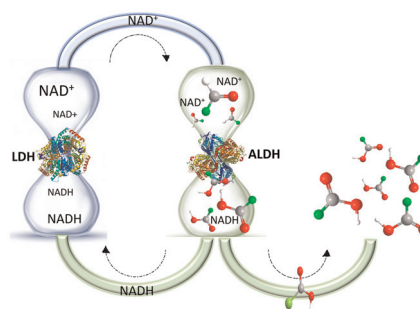


PAPERS

4553

Coupled immobilized bi-enzymatic flow reactor employing cofactor regeneration of NAD^+ using a thermophilic aldehyde dehydrogenase and lactate dehydrogenase

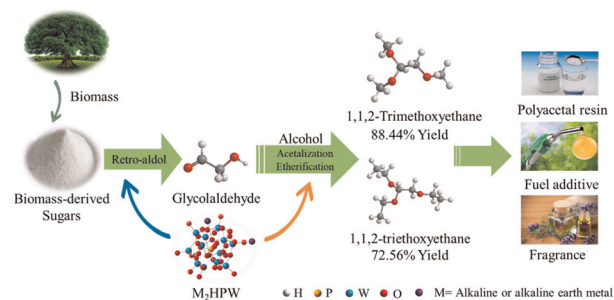
Kim Shortall, Simin Arshi, Simon Bendl, Xinxin Xiao, Serguei Belochapkin, Denise Demurtas, Tewfik Soulimane and Edmond Magner*



4565

Conversion of biomass-derived sugars to 1,1,2-trialkoxylethane via a [2 + 4] retro-aldol reaction over alkaline and alkaline earth metal salts of phosphotungstic acid

Tihang Liu, Jiangang Wang, Hongyou Cui* and Jinghua Wang*



CORRECTION

4577

Correction: Continuous flow solvent free organic synthesis involving solids (reactants/products) using a screw reactor

Brijesh M. Sharma, Ranjit S. Atapalkar and Amol A. Kulkarni*

