

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(14) 5307–5762 (2023)



Cover

See James A. Dumesic et al., pp. 5416–5427.

Image reproduced by permission of Xin Zhou and Hochan Chang from *Green Chem.*, 2023, **25**, 5416.



Inside cover

See Daihui Zhang, Chenhuan Lai, Yuzhi Xu et al., pp. 5428–5437.

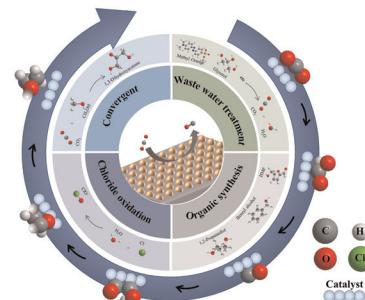
Image reproduced by permission of Daihui Zhang from *Green Chem.*, 2023, **25**, 5428.

CRITICAL REVIEW

5320

The design of alternative anodic reactions paired with electrochemical CO₂ reduction

Honglei Chen, Chenglong Ding, Caitao Kang, Jiahong Zeng, Yao Li, Yanming Li, Yuanli Li, Changli Li* and Jingfu He*

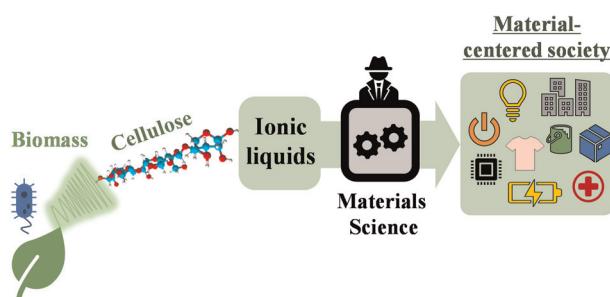


TUTORIAL REVIEW

5338

Cellulose processing in ionic liquids from a materials science perspective: turning a versatile biopolymer into the cornerstone of our sustainable future

László Szabó,* Romain Milotskyi, Gyanendra Sharma and Kenji Takahashi*



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

Members

Professor André Bardow, ETH Zurich, Switzerland
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 Politécnica 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, Kohn Kaen University, UK

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
Dhireep 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

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, Rini Prakash, 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

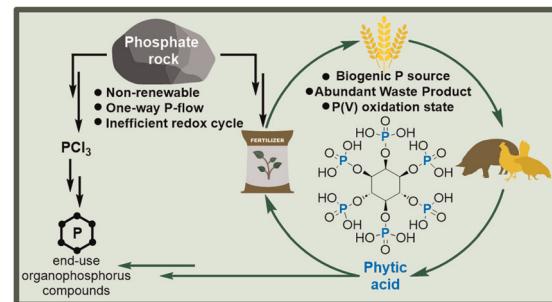


PERSPECTIVE

5390

Phosphorus sustainability: a case for phytic acid as a biorenewable platform

Emma K. Davison,* Jessica C. Neville and Jonathan Sperry*

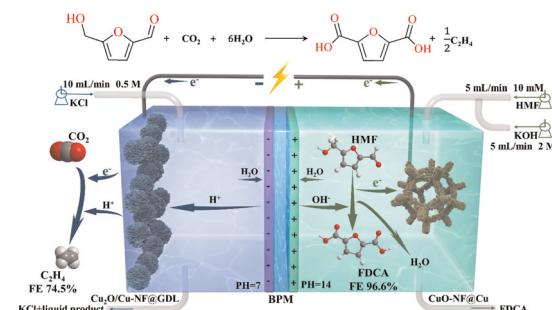


COMMUNICATION

5404

High efficiency coupled electrocatalytic CO_2 reduction to C_2H_4 with 5-hydroxymethylfurfural oxidation over Cu-based nanoflower electrocatalysts

Zonghang Zhang, Shan Liu, Zhao Wu,* Xiaoyan Chen, Jingui Wang, Yuji Gao, Shuai Wang, Furong Tao and Guangqiang Lv*

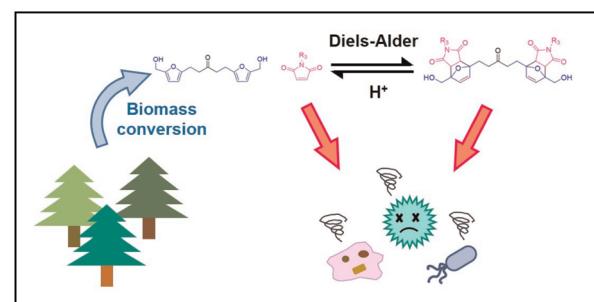


PAPERS

5416

Controlling the toxicity of biomass-derived difunctional molecules as potential pharmaceutical ingredients for specific activity toward microorganisms and mammalian cells

Hochan Chang, Douglas H. Chang, Alexios G. Stamoulis, George W. Huber, David M. Lynn, Sean P. Palecek and James A. Dumesic*



5428

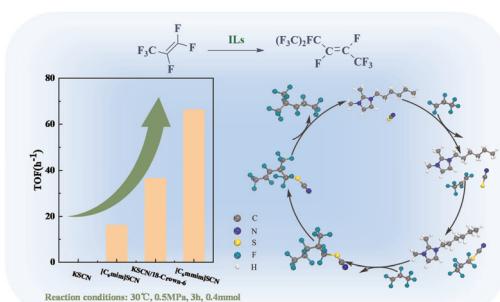
Facile design of renewable lignin copolymers by photoinitiated RAFT polymerization as Pickering emulsion stabilizers

Jingyi Liu, Xiaoyu Shi, Lin Ma, Daihui Zhang,* Chenhuan Lai,* Chunpeng Wang, Mi Li, Arthur J. Ragauskas, Fuxiang Chu and Yuzhi Xu*



PAPERS

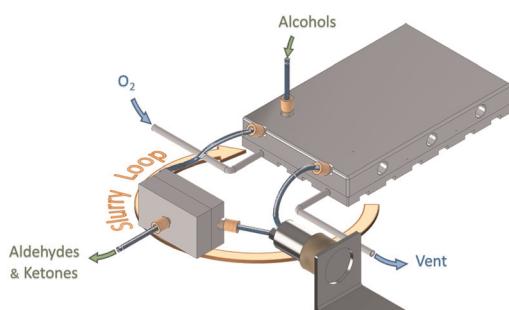
5438



Efficient dimerization of perfluoroolefin with strong nucleophilic ionic liquid catalysts by adjusting the interaction of anions and cations

Shiqi Huang, Xianglei Meng,* Yanzhao Gao, Minmin Liu, Junjie Zhang, Yu Zhou, Yuting Song* and Yanyan Diao*

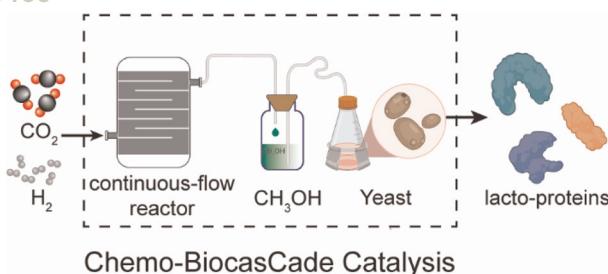
5449



Aerobic oxidation of alcohols using a slurry loop membrane reactor

Baldassarre Venezia and Asterios Gavrilidis*

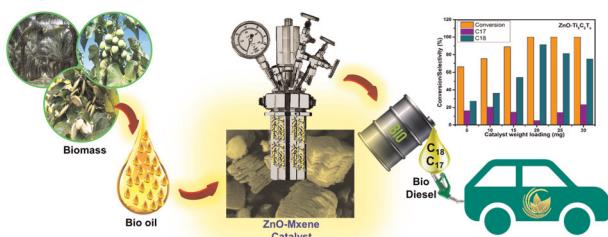
5460



Cascaded *de novo* biosynthesis of lacto-proteins from CO₂ by engineered *Pichia pastoris*

Xueqin Lv, Shixiu Cui, Jie Chen, Lingrui Wang, Yanfeng Liu, Jianghua Li, Guocheng Du, Xiaohao Liu,* Jian Chen, Rodrigo Ledesma-Amaro and Long Liu*

5470



On the reduction of CO₂ footprint via selective hydrodeoxygenation by ZnO-Ti₃C₂T_x catalyst under solvent-free conditions

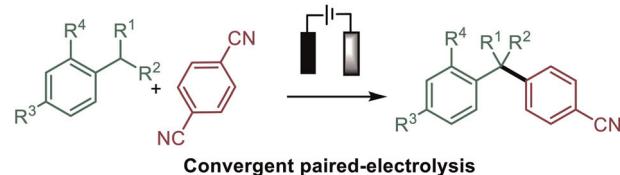
Bhagirath Saini, R. Krishnapriya, Meena Yadav, Rahul Singhal and Rakesh K. Sharma*

PAPERS

5483

Benzylic C–H arylation with dicyanoarenes *via* convergent paired electrolysis

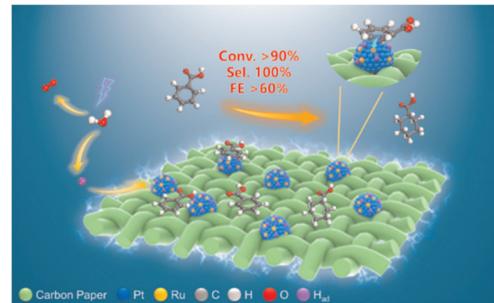
Shanyu Tang and Guillaume Vincent*



5489

Electrocatalysis as an efficient alternative to thermal catalysis over PtRu bimetallic catalysts for hydrogenation of benzoic acid derivatives

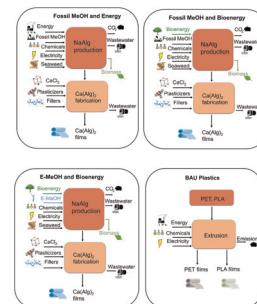
Yan Du, Xiao Chen,* Weilin Shen, Huibin Liu, Min Fang, Jinxuan Liu and Changhai Liang*



5501

The environmental impact and economic feasibility assessment of composite calcium alginate bioplastics derived from *Sargassum*

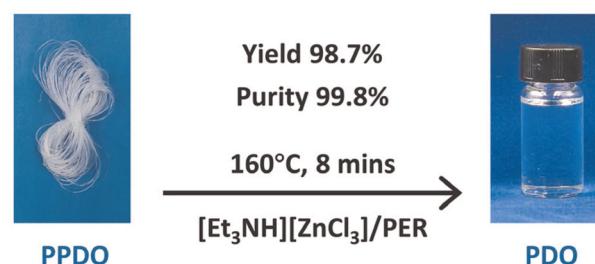
Akeem Mohammed, Keeran Ward,* Koon-Yang Lee* and Valerie Dupont



5517

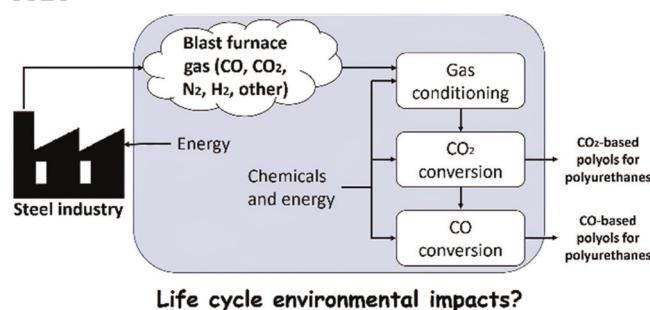
Ultrafast and selective recycling of poly(*p*-dioxanone) to monomers by using Brønsted–Lewis acidic ionic liquids as solvents/catalysts

Wei Zhang, Guo-Qiang Tian,* Gang Wu, Si-Chong Chen* and Yu-Zhong Wang



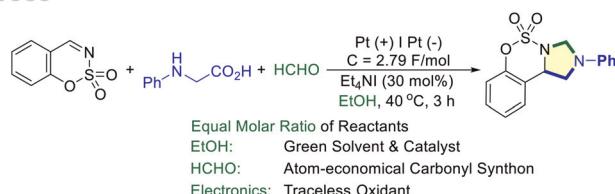
PAPERS

5526

**Ex-ante life cycle assessment of polyols using carbon captured from industrial process gas**

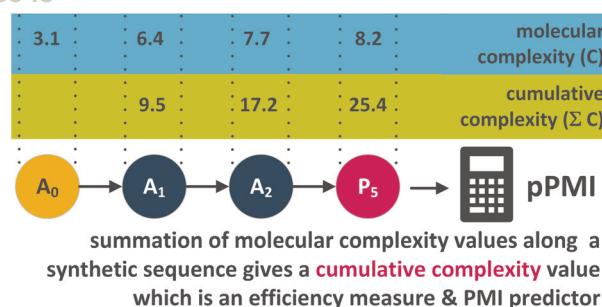
Natalya Tsoy,* Bernhard Steubing and Jeroen B. Guinée

5539

**EtOH-catalyzed electrosynthesis of imidazolidine-fused sulfamides from *N*-sulfonyl ketimines, *N*-arylglycines and formaldehyde**

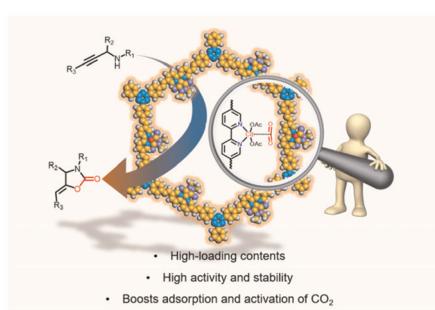
Yu-Han Lu, Si-Yu Mu, Hong-Xia Li, Jun Jiang, Chao Wu, Min-Hang Zhou, Wen-Tao Ouyang and Wei-Min He*

5543

**Cumulative complexity meta-metrics as an efficiency measure and predictor of process mass intensity (PMI) during synthetic route design**

Lucrezia Angelini, Charlotte E. Coomber, Gareth P. Howell,* George Karageorgis and Brian A. Taylor

5557

**Covalent organic frameworks embedding single cadmium sites for efficient carboxylative cyclization of CO2 with propargylic amines**

Yize Zhang, Hangshuai Li, Xingyue He, Aiqing Wang,* Guoyi Bai* and Xingwang Lan*

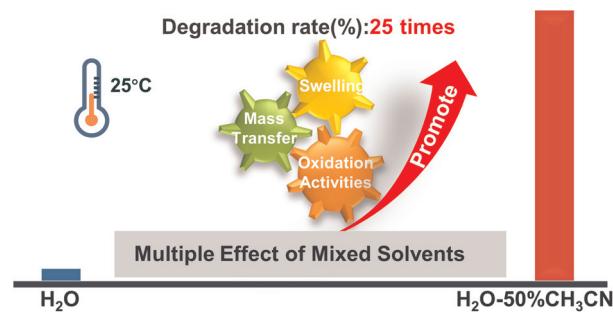


PAPERS

5566

Multiple promotion effect of mixed solvents on the oxidative degradation of thermosetting polymers

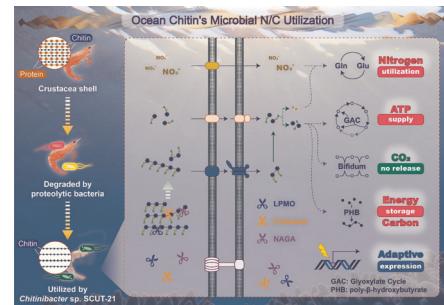
Yuwei Long, Zhishan Su, Lan Bai, Xu Zhao, Wenli An, Xuehui Liu, Shimei Xu* and Yu-Zhong Wang*



5575

The chitin utilization mechanisms of a new *Chitinibacter* sp. isolate SCUT-21

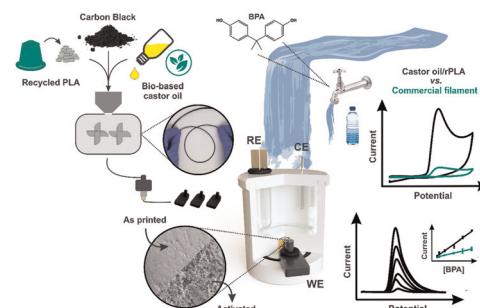
Zhen-Dong Yang, Ming-Shu Zhang, De-Lin Lu, Zhi-Wei Li, He-Hua Mao, Lei Wu, Jia-Rui Zhang, Jing-Tao Ni, Jun-Jin Deng* and Xiao-Chun Luo*



5591

Utilising bio-based plasticiser castor oil and recycled PLA for the production of conductive additive manufacturing feedstock and detection of bisphenol A

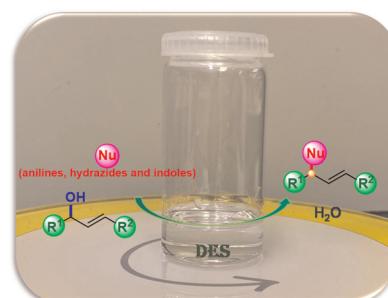
Robert D. Crapnell, Iana V. S. Arantes, Matthew J. Whittingham, Evelyn Sigley, Cristiane Kalinke, Bruno C. Janegitz, Juliano A. Bonacin, Thiago R. L. C. Paixão and Craig E. Banks*



5601

Alkylation of amines with allylic alcohols and deep eutectic solvents as metal-free and green promoters

Stephany Zárate-Roldán, M. Concepción Gimeno* and Raquel P. Herrera*



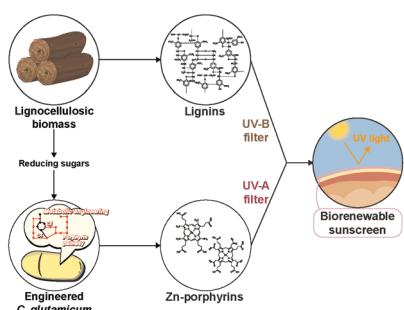
PAPERS

5613


Temperature-responsive Zn-based catalysts for efficient catalytic conversion of biomass-derived carbohydrates to ethyl lactate

Jiangang Wang, Jinghua Wang, Yifan Liu, Tihang Liu, Zhaobin Pang, Hongyou Cui,* Yuan Zhang and Feng Song

5626


Biobased sunscreen fabrication using Zn-porphyrins from engineered *Corynebacterium glutamicum*

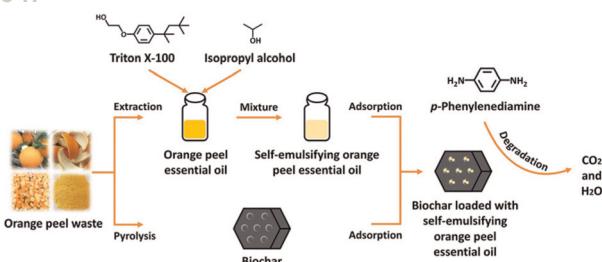
Young Jin Ko, Jeong-Joo Oh and Sung Ok Han*

5634


Sequential extraction of hemicelluloses by subcritical water improves saccharification of hybrid aspen wood grown in greenhouse and field conditions

Pramod Sivan, Emilia Heinonen, Madhavi Latha Gandla, Amparo Jiménez-Quero, Hüsamettin Deniz Özeren, Leif J. Jönsson, Ewa J. Mellerowicz and Francisco Vilaplana*

5647


Reactive oxygen species induced by plant essential oil for effective degradation of *p*-phenylenediamine

Huixian Xu, Yanjun Li, Qin Li, Dandan Yang, Ting Li, Saimeng Jin,* Liandi Zhou,* Qihui Zhang* and James H. Clark

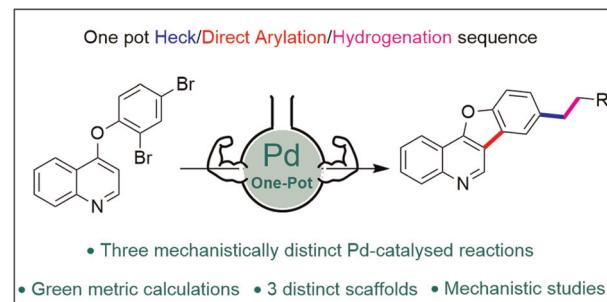


PAPERS

5654

A phosphine free, inorganic base free, one-pot tandem Mizoroki–Heck olefination/direct arylation/hydrogenation sequence, to give multicyclic alkylated heteroarenes

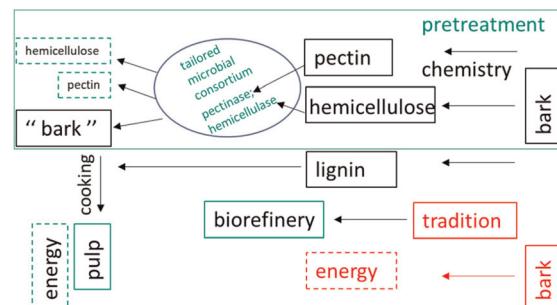
Roberta A. Kehoe, Mark E. Light, David J. Jones and Gerard P. McGlacken*



5661

Structural features of lignin–hemicellulose–pectin (LHP) orchestrate a tailored enzyme cocktail for potential applications in bark biorefineries

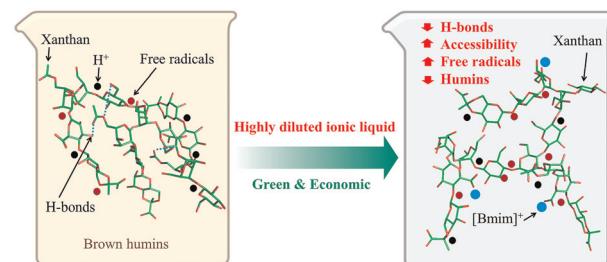
Jinze Dou,* Jincheng Wang, Sami Hietala, Dmitry V. Evtuguin, Tapani Vuorinen* and Jian Zhao



5679

Diluted aqueous ionic liquid assists the acidic oxidative hydrolysis of water-soluble recalcitrant polysaccharide xanthan through structural deterioration

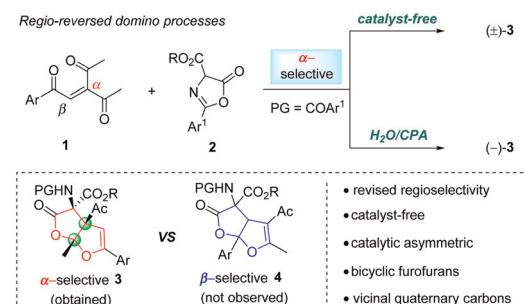
Weiming Liu, Liwei Zhang, Miao Li, Qian Wang, Jinyun Gu, Xiaoyi Chen, Xiaoyu Guo, Zhimin Yu, Xianzhen Li, Shang Wang* and Fan Yang*



5692

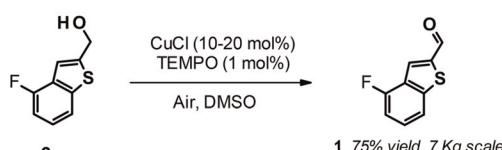
Catalyst-free racemic and $\text{H}_2\text{O}/\text{CPA}$ -catalyzed asymmetric regio-reversed domino processes of triketone enones with azlactones

Yun-Dong Fu, Xiang Gao, Shi-Kun Jia, Xiao Xiao, Min-Can Wang, Lihua Huang* and Guang-Jian Mei*



PAPERS

5698

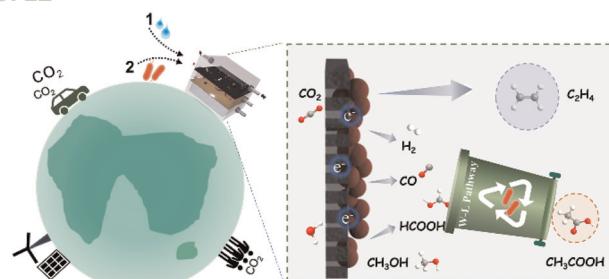
2nd generation process

- Eco-friendly catalytic system ■ Air as terminal oxidant ■ Simple, safe Protocol
- Pilot scale implementation ■ Green metrics improvement (PMI, RME, EMY)

Development and pilot scale implementation of safe aerobic Cu/TEMPO oxidation in a batch reactor

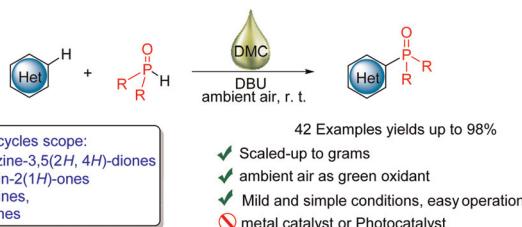
Sylvain Lemaitre, Anne-Lise Romain, François Bariere, Anthony Craquelin, Chloé Copin* and Alexandre Jean*

5712

A novel tandem reactor design based on nano-Cu electrocatalysts and microbial biocatalysts for converting CO₂ into ethylene and acetate

Juan Liu, Xiaoxiao Guo, Zhao yuan Lyu, Rong-Bin Song, Pengyu Zhou, Shichao Ding, Yang Zhou, Li-Ping Jiang, Yuehe Lin* and Wenlei Zhu*

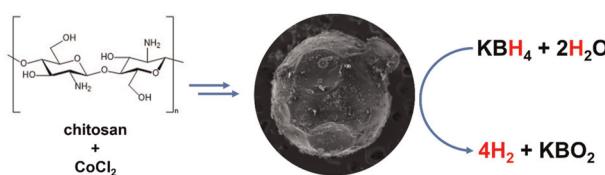
5721



Metal-free direct C–H phosphonation of N-heterocycles with diphenylphosphine oxides under mild conditions

Zhao-Nan Cai, Ya-Ping Han, Yuecheng Zhang, Hong-Yu Zhang,* Jiquan Zhao* and Shang-Dong Yang

5727



From shrimp balls to hydrogen bubbles: borohydride hydrolysis catalysed by flexible cobalt chitosan spheres

Frances Pope, Jeffrey Jonk, Millie Fowler, Petrus C. M. Laan, Norbert J. Geels, Larissa Drangai, Vitaly Gitis and Gadi Rothenberg*

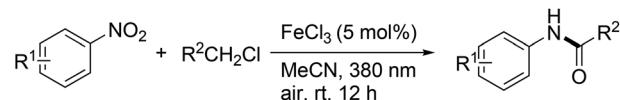


PAPERS

5735

Visible-light-induced iron-catalyzed synthesis of *N*-aryl amides from nitroarenes and chloroalkanes

Qun-Liang Zhang, Wenxin Liu, Yirong Zhou* and Fang-Lin Zhang*

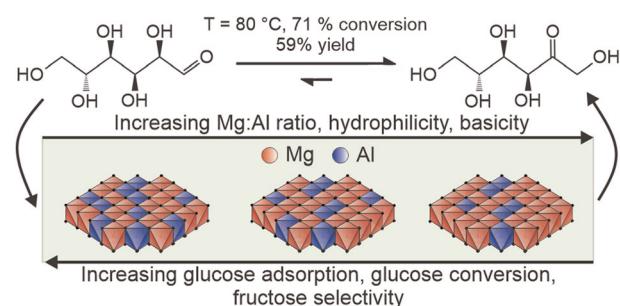


- reductant and photocatalyst free
- high step economy
- nontoxic sustainable iron catalyst
- mild conditions
- good functional group tolerance
- simple manipulation

5741

Structure–activity relationships of LDH catalysts for the glucose-to-fructose isomerisation in ethanol

Krisztina Karádi, Thanh-Truc Nguyen, Adél Anna Ádám, Kornélia Baán, András Sápi, Ákos Kukovecz, Zoltán Kónya, Pál Sipos,* István Pálunkó and Gábor Varga*



COMMENT

5756

Comment on "Catalyst- and additive-free sunlight-induced autoxidation of aldehydes to carboxylic acids" by H. Shi, J. Li, T. Wang, M. Rudolph and A. S. K. Hashmi, *Green Chem.*, 2022, 24, 5835

Alain Favre-Réguillon* and Laurent Vanoye

