

# Green Chemistry

Cutting-edge research for a greener sustainable future

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## IN THIS ISSUE

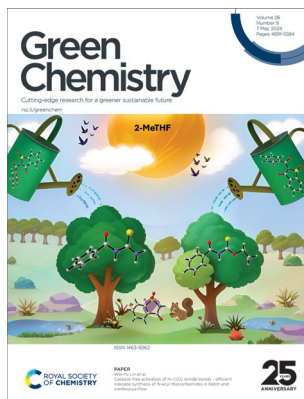
ISSN 1463-9262 CODEN GRCHFJ 26(9) 4891–5584 (2024)



### Cover

See Zhicheng Jiang, Daniel CW Tsang, Bi Shi, et al., pp. 5178–5186.

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### Inside cover

See Wei-Yu Lin et al., pp. 5187–5193.

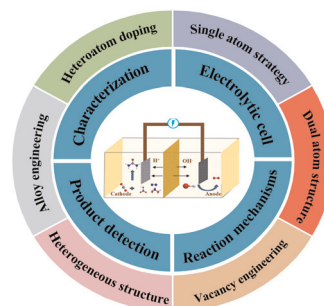
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## CRITICAL REVIEWS

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### Electrocatalytic C–N coupling for urea synthesis: a critical review

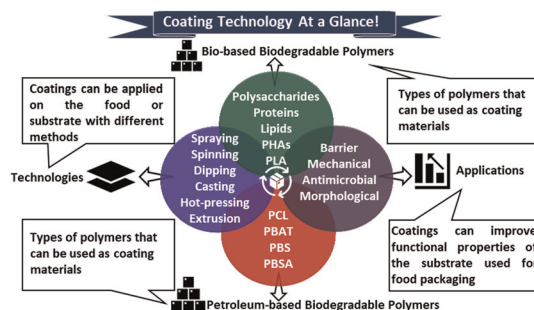
Chuanju Yang, Zhe Li, Junpeng Xu, Yujing Jiang and Wenlei Zhu\*



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### Sustainable biodegradable coatings for food packaging: challenges and opportunities

Fatemeh Jahangiri, Amar K. Mohanty and Manjusri Misra\*



# RSC Sustainability

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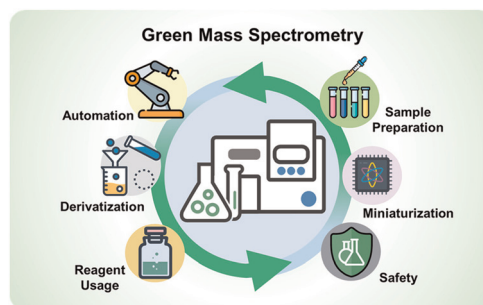
Fundamental questions  
Elemental answers

## TUTORIAL REVIEWS

4975

**Mass spectrometry in the age of green analytical chemistry**

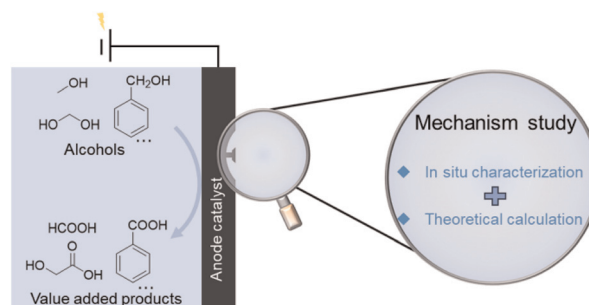
Yuchen Zou, Weiwei Tang and Bin Li\*



4987

**Recent progress in transition metal based catalysts and mechanism analysis for alcohol electrooxidation reactions**

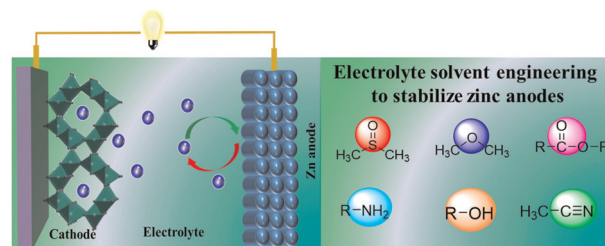
Yuguo Zhao, Emma M. Björk, Yong Yan,\* Peter Schaaf and Dong Wang\*



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**Progress in stabilizing zinc anodes for zinc-ion batteries using electrolyte solvent engineering**

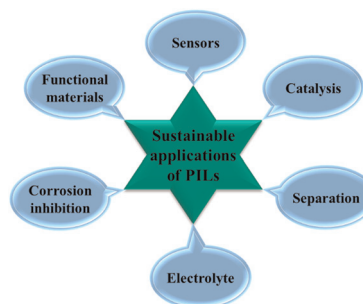
Le Li, Shi Yue, Shaofeng Jia, Conghui Wang, Hengwei Qiu, Yongqiang Ji, Minghui Cao\* and Dan Zhang\*



5022

**Poly(ionic liquid)s: an emerging platform for green chemistry**

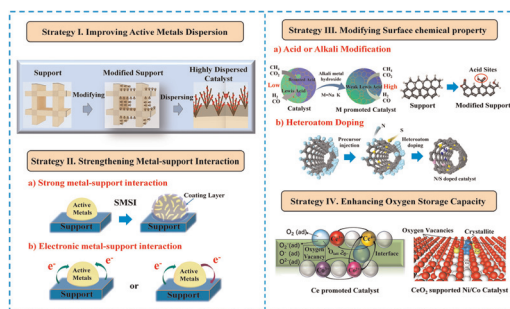
Maiyong Zhu\* and Yu Yang





## TUTORIAL REVIEWS

5103

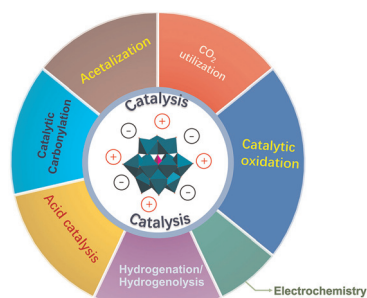


## Recent advances in the design of high-performance cobalt-based catalysts for dry reforming of methane

Yinghui Sun,\* Yanbin Zhang, Xifei Yin, Chenghu Zhang, Ying Li and Jie Bai\*

## PERSPECTIVE

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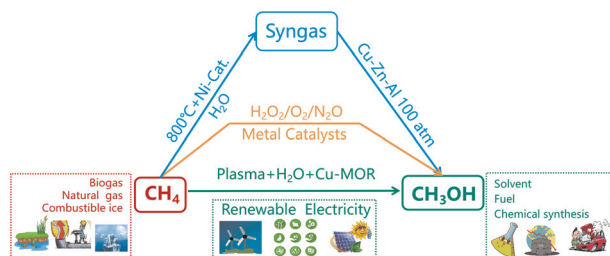


## Ionic liquid-stabilized metal oxoclusters: from design to catalytic application

Yunxiang Qiao, Enting Shi, Xinjia Wei and Zhenshan Hou\*

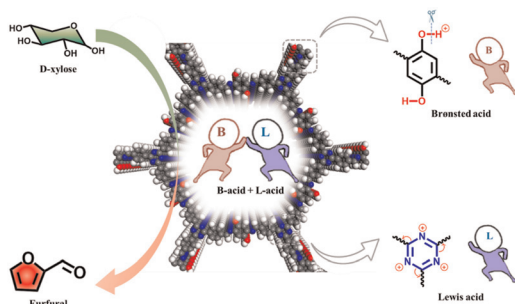
## COMMUNICATIONS

5150

Plasma-catalytic one-step steam reforming of CH<sub>4</sub> to CH<sub>3</sub>OH and H<sub>2</sub> promoted by oligomerized [Cu–O–Cu] species on zeolites

Wei Fang, Ximiao Wang, Shangkun Li, Yingzi Hao, Yuping Yang, Wenping Zhao, Rui Liu, Dongxing Li, Chuang Li, Xiaoxia Gao, Li Wang, Hongchen Guo and Yanhui Yi\*

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## One-pot furfural production from sustainable biomass-derived sugars using a functionalized covalent organic framework as a heterogeneous catalyst

Peng Gan, Kai Zhang,\* Zhihao Li, Chengxiang Zhang, Guihua Yang,\* Lei Zhang, Baobin Wang and Jiachuan Chen\*



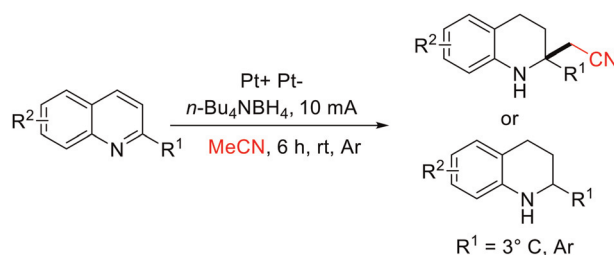


## COMMUNICATIONS

5160

### Synthesis of tetrahydroquinoline derivatives via electrochemical hydrocyanomethylation or hydrogenation of quinolines with MeCN

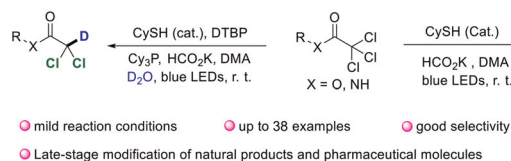
Jie Xia, Dahan Wang,\* Ruitong Yang, Yujie Deng and Guo-Jun Deng\*



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### Photocatalytic organosulfur reagent-promoted selective mono-(deutero)hydrodechlorination

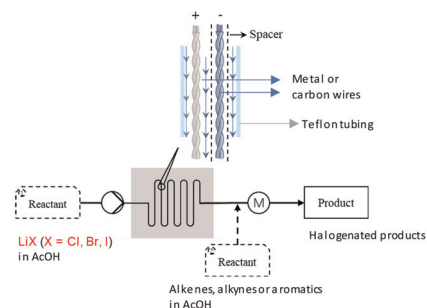
Junlei Wang,\* Guocheng Gao, Jiadong Cheng, Jintao Li, Xiaoshuang Chen, Xuemei Chen, Daohai Zhang, Hongqing Li,\* Xiaohua Cai and Binbin Huang\*



5173

### A continuous flow electrochemical reactor using readily available metal wires and carbon fibers as electrodes: environmentally benign halogenations of alkenes, alkynes, and aromatics

Yinqing Xie, Long Lin and Bo Xu\*

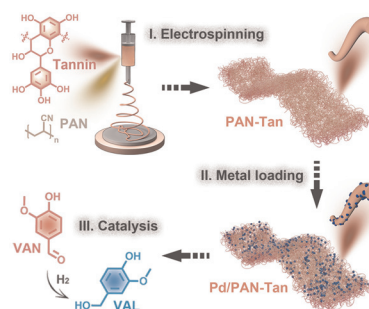


## PAPERS

5178

### Composite fiber as a multifunctional catalyst support for the upgradation of lignin-based chemicals

Zuzhi Li, Ya Ma, Xingjie Guo, Yang Cao, Qian Jiang, Mi Gao, Xudong Liu, Daniel C. W. Tsang,\* Zhicheng Jiang\* and Bi Shi



**Recycle of saccharin**

PhCOCl + Et<sub>3</sub>N

NH<sub>4</sub>SCN

KSCN

ROH

Advantages:

- benign (sweetener)
- sustainable
- cheap (<0.10\$/g)
- bench-stable solid
- tunable reactivity
- widely-available (>50,000 ton/year)

★ Bench-stable reagents    ★ Chemical recycling    ★ Simple / scalable protocols

★ Batch and continuous-flow    ★ N-C bond cleavage    ★ Sustainable / divergent synthesis

★ Broad scope    ★ Environmentally friendly    ★ Low E-factor

## Karthick Govindan, Nian-Qi Chen and Wei-Yu Lin\*

Qiangui Yan, Timothy Ketelboeter, Wenjun Fan,  
Caixia Wan\* and Zhiyong Cai\*

Qiangui Yan, Timothy Ketelboeter, Wenjun Fan,  
Caixia Wan\* and Zhiyong Cai\*

The diagram illustrates the metabolic pathway for the production of Ambroxol in *Yarrowia lipolytica*. The process begins with Glucose, which is converted to Acetyl-CoA. Acetyl-CoA enters the mevalonate pathway, where it is converted to IPP (Isopentenyl pyrophosphate). IPP is then converted to DMAPP (Dimethylallyl pyrophosphate), which is further converted to FPP (Farnesyl pyrophosphate). FPP is converted to GGPP (Geranylgeranyl pyrophosphate). GGPP is then converted to GGOH (Geranylgeraniol) and LOH (Linalool). The chemical structures of GGOH and LOH are shown. The pathway is labeled with the enzyme Yarrowia lipolytica. The final product, Ambroxol, is shown as a chemical structure and a bottle of the fragrance. The yield of Ambroxol is 12.9 g/L.

Mei-Li Sun, Yuting Han, Xiao Yu, Kaifeng Wang, Lu Lin,  
Rodrigo Ledesma-Amaro and Xiao-Jun Ji\*

Mei-Li Sun, Yuting Han, Xiao Yu, Kaifeng Wang, Lu Lin,  
Rodrigo Ledesma-Amaro and Xiao-Jun Ji\*

**C. sativa Futura 75**

steam distillation waste

extraction in bioEtOH

**cannabidiol (CBD)**  
10.1 mg/g yield

chemo-enzymatic oxidation

**cannabielsoin (CBE)**  
31-47% isol. yield

Daniele Fiorito, Davide Tessaro, Fabio Sangalli,  
Celeste Nobbio, Mario Nebuloni, Matteo Vezzini,  
Elisabetta Brenna and Fabio Parmeggiani\*

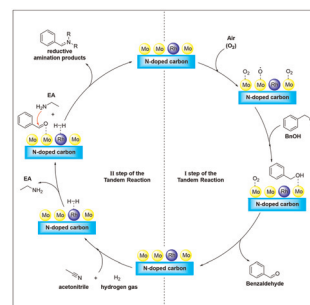
Daniele Fiorito, Davide Tessaro, Fabio Sangalli,  
Celeste Nobbio, Mario Nebuloni, Matteo Vezzini,  
Elisabetta Brenna and Fabio Parmeggiani\*

## PAPERS

5221

# Orthogonal assisted tandem reactions for the upgrading of bio-based aromatic alcohols using chitin derived mono and bimetallic catalysts

Francesco Zorzetto, Daniel Ballesteros-Plata, Alvise Perosa, Enrique Rodríguez-Castellón, Maurizio Selva\* and Daily Rodríguez-Padrón\*



5239

# Interactions of multiple metrics and environmental indicators to assess processes, detect environmental hotspots, and guide future development

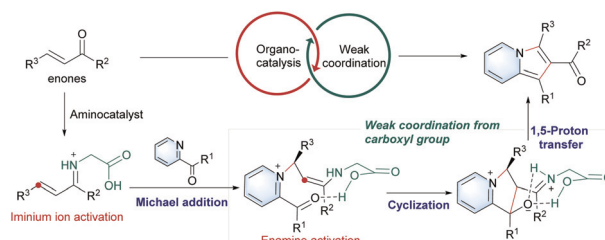
Michael U. Luescher\* and Fabrice Gallou



5253

# Weak-coordination-auxiliary aminocatalysis enables directed [3 + 2] cyclization for 2-acylindolizines

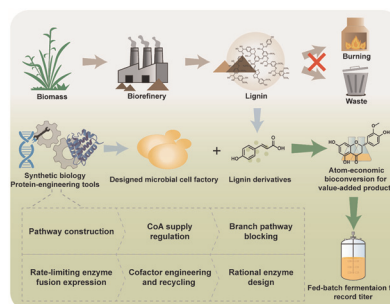
Kui Zeng, Neeraj Kumar Pandit, João C. A. Oliveira, Sebastian Dechert, Lutz Ackermann\* and Kai Zhang\*



5260

# Pathway and enzyme engineering for the bioconversion of lignin derivatives into homoeriodictyol in *Saccharomyces cerevisiae*

Si-Yu Zhu, Shi-Chang Liu, Chuan-Xi Zhang, Xin Xin, Zhi-Hua Liu, Lu-Jia Zhang, Bing-Zhi Li\* and Ying-Jin Yuan





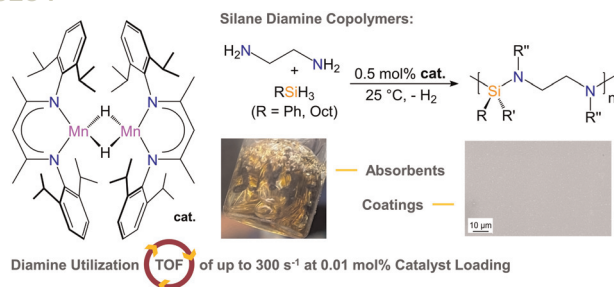
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### Comparative environmental assessment of zeolites synthesized from chemicals and natural minerals

Xiaoling Chen, Guoxi Xiao, Tiesen Li,\* Chan Wang, Qingyan Cui, Xiaojun Bao and Yuanyuan Yue\*

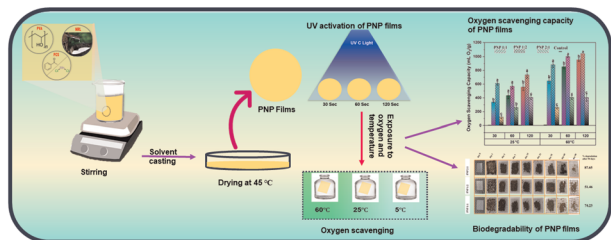
5284



### Silane diamine copolymers: efficient synthesis, solvent absorption capacity, and limitations as coatings

Thao T. Nguyen, Anuja Sharma, Tam Le Phuong Nguyen, Michael A. Trimble, Dong-Kyun Seo and Ryan J. Trovitch\*

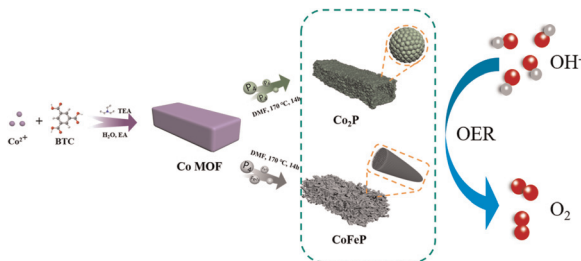
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### Ultra-violet light-driven green oxygen scavenging composite made of PVA/NRL for active packaging: an alternative to metallic oxygen scavengers

Dakuri Ramakanth, Konala Akhila, Bittu Prudhvi Kumar, Kirtiraj K. Gaikwad\* and Pradip K. Maji\*

5308



### Iron-doped cobalt phosphide nanowires prepared via one-step solvothermal phosphidization of metal–organic frameworks for the oxygen evolution reactions

Jianbo Tong,\* Yichuang Xing, Xuechun Xiao, Yuan Liu, Zhikai Hu, Zeyi Wang, Yanling Hu, Bowen Xin, Shuling Liu, He Wang\* and Chao Wang\*

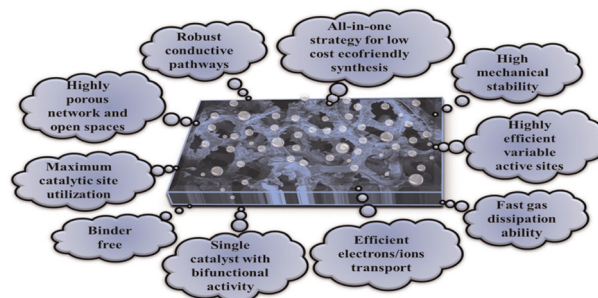


## PAPERS

5326

### *In situ* hierarchical self-assembly of NiFeHCF nanoparticles on nickel foam: highly active and ultra-stable bifunctional electrocatalysts for water splitting and their environmental assessment towards green energy

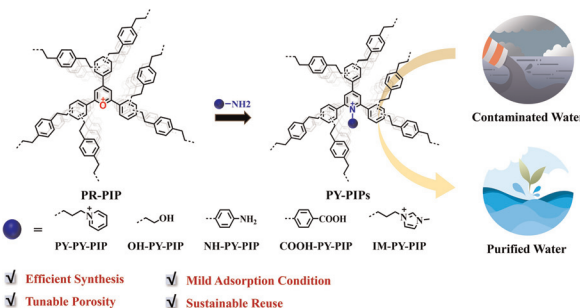
Arunagiri Gayathri, Venkatachalam Ashok, Muthukumar Sangamithirai, Jayaraman Jayabharathi and Venugopal Thanikachalam\*



5339

### Construction of a tunable pyrylium based porous ionic polymer network for efficient waterborne pollutant treatment

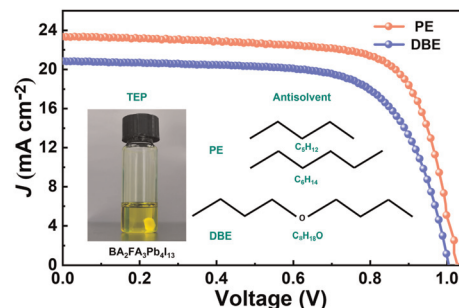
Xueye Zhu, Jiayu Han, Zhiwei Chen, Zheng Shi, Jiamin Zhang and Siyu Guo\*



5347

### Antisolvent effects in green solvent engineering of FA-based quasi-2D Ruddlesden–Popper perovskite films for efficient solar cells

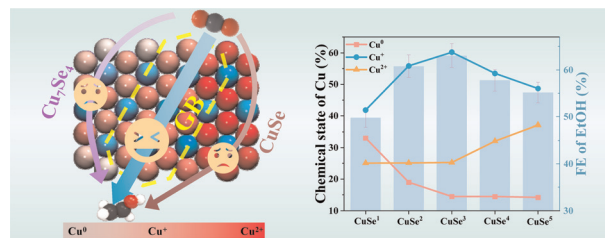
Guoshuai Zhang, Jun Tang, Chenming Wang, Xianyao Wu, Jie Chen, Xi Wang, Kai Wang, Xixiang Zhu, Haomiao Yu and Jinpeng Li\*



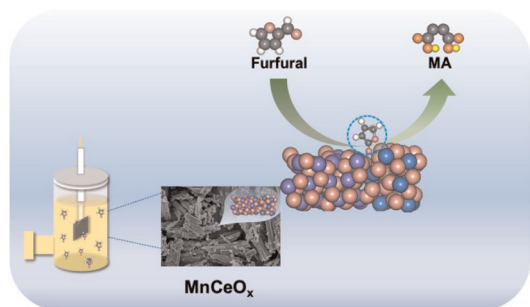
5356

### Grain boundaries assisting the generation of abundant Cu<sup>+</sup> for highly selective electroreduction of CO<sub>2</sub> to ethanol

Xinze Bi, Yuezhu Zhao, Yifan Yan, Hongzhi Wang\* and Mingbo Wu\*



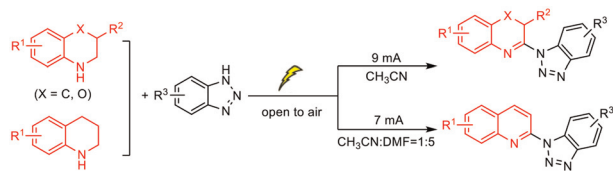
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### Highly efficient electrocatalytic oxidation of furfural to maleic acid over MOF-derived $\text{MnCeO}_x$

Xue Yuan, Xin Huang,\* Meimin Hu, Jinjia Liu,\*  
Wenhao Guo, Yuchen Hao, Zhenting Li, Kai Zhang and  
Buxing Han\*

5371

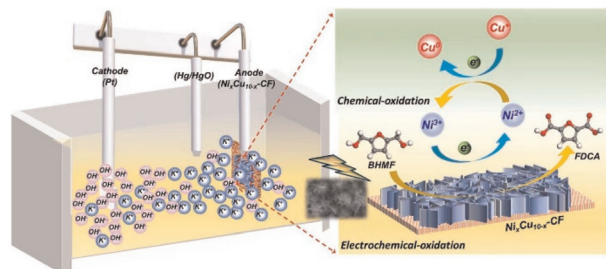


- mild and green conditions
- insensitive to air
- atomic economy
- suitable for structurally diverse benzotriazoles
- broad functional group tolerance
- diversity of products

### Electrochemical oxidative cross-coupling of tetrahydroquinolines and azoles

Dan Yang, Yu-Fang Tan, Ya-Nan Zhao, Jin-Feng Lv,  
Zhi Guan\* and Yan-Hong He\*

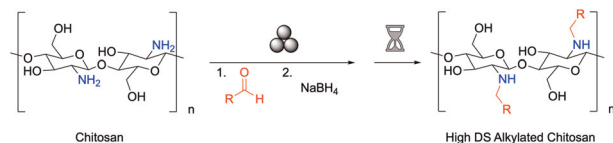
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### Interaction between copper and nickel species for electrooxidation of 2,5-bis(hydroxymethyl)furan

Peiyuan Liu, Liyuan Huai, Bin Zhu, Yang Zhong,  
Jian Zhang\* and Chunlin Chen\*

5386



- No dissolution
- No heating
- Wide scope
- PMI 36

### Mechanochemical and aging-based reductive amination with chitosan and aldehydes affords high degree of substitution functional biopolymers

Galen Yang, Sophie Régner, Noah Huin, Tracy Liu,  
Edmond Lam\* and Audrey Moores\*



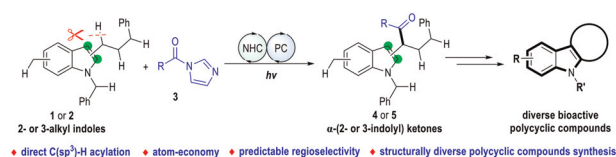


## PAPERS

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### N-heterocyclic carbene and photocatalyst-catalyzed rapid access to indole ketones via radical C(sp<sup>3</sup>)-H acylation

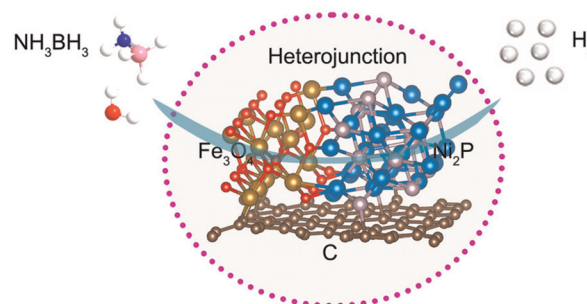
Guihua Nie, Ting Tu, Tianhui Liao, Donghan Liu, Wenjun Ye and Shi-Chao Ren\*



5409

### In situ formed nickel phosphide/iron oxide heterojunction for accelerating hydrogen generation

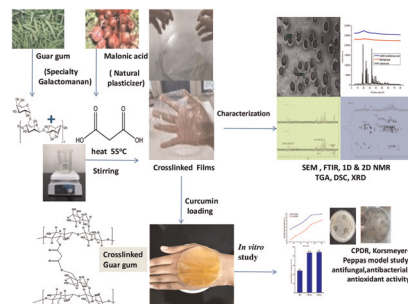
Wenjing Xu,\* Wei Li, Wei Chen, Mei Liu, Xianji Guo and Baojun Li\*



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### Galactomannan crosslinking with a green plasticizer malonic acid and its biomedical applications

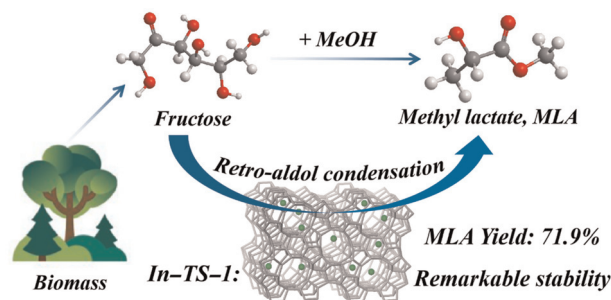
Jyoti Rajput, Vineet Kumar,\* Kalpana Chauhan, Vipin Parkash and Sushil Bhattarai



5433

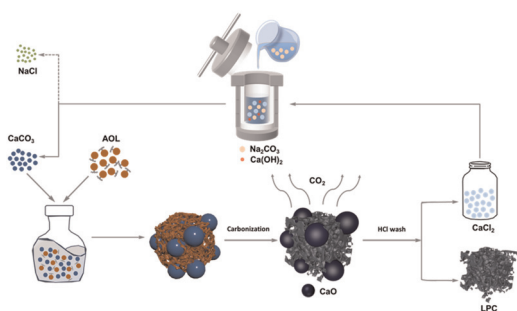
### An encapsulation strategy to design an In-TS-1 zeolite enabling high activity and stability toward the efficient production of methyl lactate from fructose

Yuxi Jiang, Xilei Lyu,\* Chao Chen, Aotian Ren, Wenqi Qin, Hao Chen\* and Xiuyang Lu\*



## PAPERS

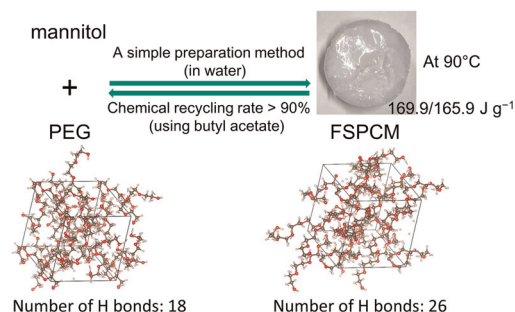
5441



### Sustainable lignin-derived hierarchical mesoporous carbon synthesized by a renewable nano-calcium carbonate hard template method and its utilization in zinc ion hybrid supercapacitors

Jiahao Zhu, Tao Huang, Manjia Lu, Xueqing Qiu\* and Wenli Zhang\*

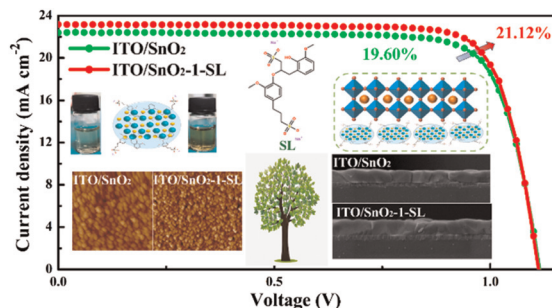
5452



### A form-stable phase change material based on intermolecular hydrogen bonding with a high chemical recycling rate

Xinyi Shen, Yulin Liu, Na Li, Haiyan Ju,\* Xiaowei Fu, Liang Jiang, Yao Xiao,\* Ping He\* and Jingxin Lei\*

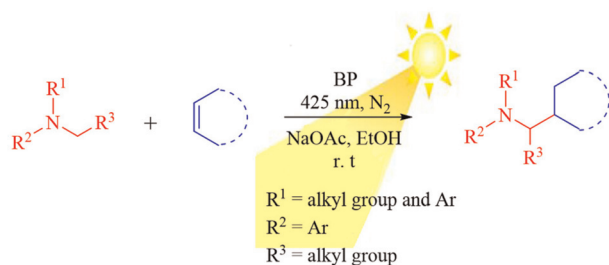
5460



### Performance enhancement of perovskite solar cells by doping non-toxic multifunctional natural sodium lignosulfonate into SnO<sub>2</sub>

Zezhuan Jiang, Fuling Li, Huaqing Yan, Rathes Kannan R, Lijia Chen, Ping Li\* and Qunliang Song\*

5471



### Photocatalytic $\alpha$ -aminoalkyl radical addition of amines mediated by benzophenone under visible light

Jinke Chen, Qi Lian, Xinru Jiang, Juan Zhang, Xiang Luo,\* Jiansong Fang\* and Wentao Wei\*

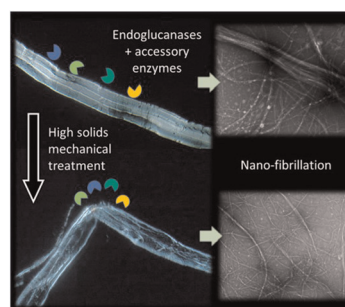


## PAPERS

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### Production of lignin containing cellulose nanofibrils (CNF) after enzymatic treatment of curl-induced, unbleached kraft pulps

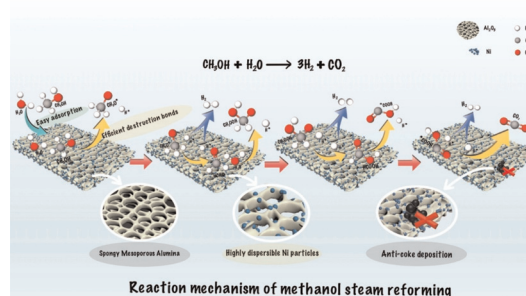
Jie Wu, Yintian Dong, Xia Sun, Peipei Wang, Jiaying Zhu, Yeling Zhu, Feng Jiang and Jack Saddler\*



5485

### Enhancement of hydrogen production via methanol steam reforming using a Ni-based catalyst supported by spongy mesoporous alumina

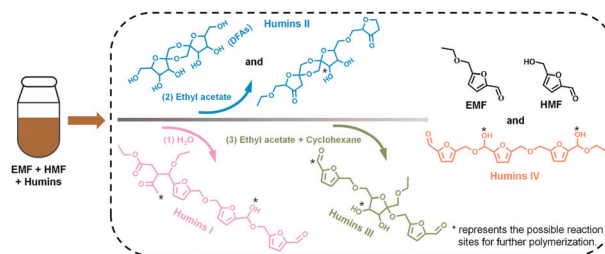
Bin Hu, Riyang Shu,\* Zhipeng Tian, Chao Wang, Ying Chen and Ying Xu\*



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### Sequential extraction and separation of soluble humins from fructose conversion for structural and evolutionary understanding

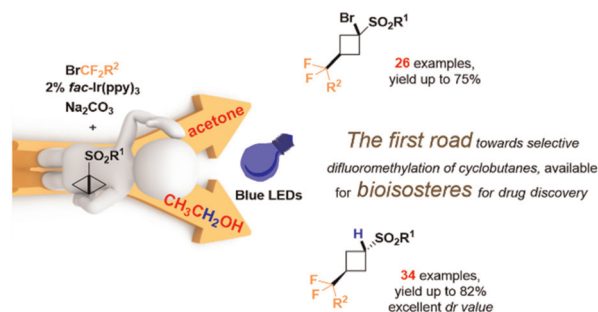
Hui Li, Yexin Hu, Ping Hu, Linzhen Li, Di Wu, Zhidan Xue, Changwei Hu and Liangfang Zhu\*



5512

### Photochemical selective difluoroalkylation reactions of bicyclobutanes: direct sustainable pathways to functionalized bioisosteres for drug discovery

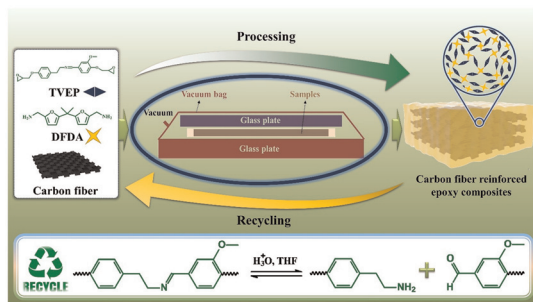
Yunxin Duan, Yerong Xu, Yunzhe Li, Lin Mao, Jianquan Feng, Ruyue Zhang, Weifang Tang, Tao Lu,\* Yadong Chen\* and Jie Feng\*





## PAPERS

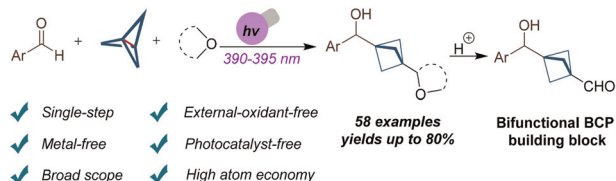
5519



### High biomass content, anti-flammable and degradable epoxy thermosets by curing a tyramine-derived epoxy monomer with a furan-derived diamine for non-destructively recyclable carbon fiber composite application

Hao-Xin Niu, Tian-Mo Yang, Xin Wang,\* Ping Zhang, Wenwen Guo, Lei Song and Yuan Hu\*

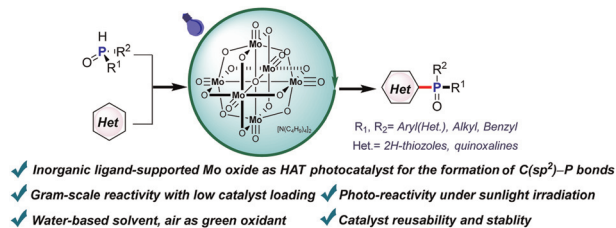
5531



### Metal- and photocatalyst-free three-component strategy to prepare benzylalcohol-, aldehyde-substituted BCP building blocks

Fei Li, Huijuan Liao, Jianyang Dong, Weikang Xiong, Yonggang Yan, Gang Li and Dong Xue\*

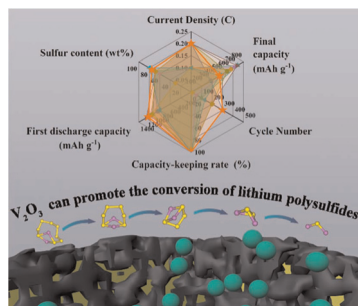
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### Inorganic ligand-supported Mo oxide as a hydrogen atom transfer photocatalyst for direct $\text{C}(\text{sp}^2)\text{-H}$ phosphorylation

Zeqi Jiang,\* Shuangfei Jiang, Jin Gao, Junmei Xia, Hongwei Yu, Lixin Ma, Xi Chen, Bo Chen, Xinghua Zhang\* and Wenchao Zhu\*

5546



### Conductive $\text{V}_2\text{O}_3$ electrocatalyst on carbon hollow spheres to accelerate polysulfide conversion for long-cycle and high-rate lithium sulfur batteries

Jiangnan Zhang, Mingjun Xiao,\* Tingting Liu, Yanshuang Meng, Fuliang Zhu\* and Zhaoyang Fan\*



## PAPERS

5556

# Preparation of chemically recyclable bio-based semi-aromatic polyamides using continuous flow technology under mild conditions

Yirong Feng, Xiaowei Li, Tingting Ma, Yuguang Li, Dong Ji, Hong Qin, Zheng Fang, Wei He\* and Kai Guo\*



5564

# Carbonic anhydrase assisted acidogenic fermentation of forest residues for low carbon hydrogen and volatile fatty acid production: enhanced *in situ* CO<sub>2</sub> reduction and microbiological analysis

Omprakash Sarkar,\* Io Antonopoulou,\* Charilaos Xiros, Ylva Bruce, Sarra Souadkia, Ulrika Rova, Paul Christakopoulos and Leonidas Matsakas\*

