



化工进展

Chemical Industry and Engineering Progress

Vol.42 No.10

2023年10月

中国化工学会会刊 ISSN 1000-6613 CN 11-1954/TQ CODEN HUJIEK

化工进展

第四十二卷

第十期

二〇二三年十月

**安特威**
助您安心享受美好生活

助您安心享受美好生活



安特威硬密封球阀 不会卡涩的硬密封球阀！

硬密封球阀

- 自主研发硬质合金涂层，VI级密封，超长寿命；
- 十年如一日的研究，彻底解决卡涩问题；
- 全流程可视化智能制造，批量生产质量可靠，大量成功应用案例；



广告

ISSN 1000-6613



9 771000 661232



主办



中国化工学会



化学工业出版社有限公司



目次

特约评述

- 数字孪生智能乙烯工厂工业互联网平台的设计与构建王子宗, 索寒生, 赵学良, 闫雅琨(5029)
光伏电池封装胶膜材料发展现状与前景分析黄格省, 师晓玉, 丁文娟, 王春娇, 慕彦君, 侯雨璇(5037)

化工过程与装备

- 气固流化床化学反应数值模拟中颗粒尺度模型研究进展邱沫凡, 蒋琳, 刘荣正, 刘兵, 唐亚平, 刘马林(5047)
基于机器学习的煤层气组成预测及液化过程的实时优化曾思颖, 杨敏博, 冯霄(5059)
氨基酸和DTAC对CO₂水合分离动力学影响康宇, 苟泽念(5067)
波纹板对湿空气冷凝传热特性影响的实验研究纪国剑, 尹琦瑞, 陆蓓蓓, 黄鹏圆, 周晓庆, 顾金铭(5076)
非均匀高热通量内置纽带冷却通道阻力特性分析朱戈, 毕勤成, 田书建, 颜建国(5083)
沸石堆积高度对反应器蓄放热性能的影响高士超, 王树刚, 胡沛裕, 赵一铭, 王继红, 孙毅, 蒋爽(5092)
低温下硅油基纳米磁流体沉降稳定性与黏度特性朱启晨, 吴张永, 王志强, 蒋佳骏, 李翔(5101)
笼式调节阀的冲蚀磨损与空蚀乔元, 仇畅, 钱锦远, 干瑞彬, 徐春明, 金志江(5111)

能源加工与技术

- s II 型水合物储氢研究进展岳子瀚, 龙臻, 周雪冰, 臧小亚, 梁德青(5121)
纤维状钙钛矿太阳能电池研究进展韩丽, 李望良, 李艳香, 安高军, 鲁长波(5135)

工业催化

- 催化脱除钢铁副产煤气中COS和H₂S的研究进展袁礼, 王学谦, 李翔, 王郎郎, 马懿星, 宁平, 熊亦然(5147)
镓改性HZSM-5催化低碳烷烃芳构化研究进展吴毅恒, 张耀远, 吴芹, 史大昕, 陈康成, 黎汉生(5162)
磷酸修饰二氧化硅负载钨催化剂用于木质素衍生物高效水相低温加氢脱氧
.....杨程瑞雪, 黄琪媛, 冉建速, 崔耘通, 王健健(5179)
石蜡基原油直接催化裂解制低碳烯烃新型炼化工艺的开发刘美佳, 王刚, 张忠东, 何盛宝, 高金森(5191)
固定床渣油加氢脱残炭催化剂的再生表征及性能评价
.....崔瑞利, 程涛, 宋俊男, 牛贵峰, 刘圆元, 张涛, 赵愉生, 王路海(5200)
MWW分子筛上异丁烯齐聚反应探索霍文涛, 刘稳, 于强, 安杰, 朱向学, 秦玉才, 李秀杰(5205)
固体超强酸SO₄²⁻/ZrO₂催化生物基丁二酸盐直接酯化尹科科, 王玉高, 谷豹, 申峻(5213)
Au-Pd/MnO₂催化剂的制备及其苯甲醇氧化性能郭晓宇, 李冬晨, 赵炜, 杜朕屹, 李晓良(5223)

材料科学与技术

- 聚酰亚胺薄膜在氢气分离中的研究进展蔡铭威, 王知, 卢小闯, 庄俊伟, 吴嘉豪, 张诗洋, 闵永刚(5232)

面向精密流体分离的MXene基膜材料研究进展	李亚男, 年佩, 徐楠, 罗海玉, 魏逸彬(5249)
柔性可穿戴压阻式压力传感器研究进展	徐娜, 王国栋, 陶亚楠(5259)
电沉积法制备氢氧化物/氧化物超级电容器电极的研究进展	王晓亮, 于振秋, 常雷明, 赵浩男, 宋晓琦, 高靖淞, 张一波, 黄传辉, 刘忆, 杨绍斌(5272)
有机硅、有机氟低表面能防污涂料研究进展	关永昕, 周强, 陈立义, 李慧, 刘小楠(5286)
非金属元素掺杂石墨相氮化碳光催化材料的研究进展	宋亚丽, 李紫燕, 杨彩荣, 黄龙, 张宏忠(5299)
磁性纤维电磁波吸收剂研究进展	叶好, 胡平, 王策, 刘勇(5310)
金属-有机框架材料结构设计及其对合成染料的吸附性能	许春树, 姚庆达, 梁永贤, 周华龙(5322)
共价有机框架(COFs)在锂离子电池中的应用	马文杰, 姚卫棠(5339)
超疏水海绵的简易制备及其高效油/水分离性能	路涛, 胡嘉怡, 徐成, 胡鑫琳, 郭庆阳, 李朦(5353)
响应面优化温敏水凝胶汲取剂的制备及性能	仇洁, 王旭东, 杨逸飞, 任玥, 陈立成(5363)
环糊精原位改性MoS ₂ 管式陶瓷复合膜的制备及性能	王妍, 秦振平, 刘越, 张文海, 郭红霞(5373)
基于 α -Al ₂ O ₃ 载体管的新型MXene膜异丙醇脱水性能	张国春, 周志辉, 吴红丹(5381)

生物与医药化工

pH响应性磁性介孔纳米载药系统的制备	刘慧慧, 史笑飞, 王倩男, 刘锦博, 张静(5390)
--------------------	------------------------------

精细化工

基于超临界CO ₂ 萃取再生废润滑油	杨鑫, 许红, 胡卫勋, 刘泓佐, 龙泉芝, 朱立业(5399)
含氟聚氨酯二甲基丙烯酸酯为芯材的微胶囊制备及自修复性能	辛华, 彭琪, 李阳帆, 张岩, 陈悦, 李新琦(5406)
气体硫黄还原磷石膏制酸新工艺预还原数值模拟	范旭阳, 陈延信, 赵博, 张蕾蕾(5414)
磷Ⅱ型无水石膏制备及活性联合激发基础研究	毕强, 梅毅, 夏举佩(5427)
双子型咪唑啉季铵盐缓蚀剂的制备及缓蚀机理	阳清正, 张太亮, 刘从胜, 白毅, 程鑫, 郑存川(5436)

资源与环境化工

生物炭对水环境中微塑料的去除研究进展	苏景振, 詹健(5445)
生物炭回收水中氮磷营养物质的研究进展与挑战	王书燕, 张新波, 彭安萍, 刘阳, HUU HAO NGO, 郭文珊, 温海涛(5459)
染料废水处理用纳滤膜制备及改性研究进展	杨凯璐, 陈明星, 王新亚, 张威, 肖长发(5470)
碳量子点修饰半导体复合光催化剂降解水中有机污染物	章萍萍, 丁书海, 高晶晶, 赵敏, 俞海祥, 刘玥宏, 谷麟(5487)
煤粉耦合生物质气协同降低NO _x 和CO ₂ 的排放技术	范宝田, 严祯荣, 苏厚德, 刘岑凡, 宋玉娟(5501)
硫酸盐还原活性污泥矿化固定酸性矿山废水中的镉	王大为, 毕春梦, 秦永丽, 蒋永荣, 谢华宾, 毛宇昆, 苗雪岩(5509)
不同径流冲刷作用下多孔炉渣沥青混合料重金属的浸出特性	李晶晶, 赵曜, 徐泮驰, 李康建(5520)
改性煤矸石基沸石对水中腐殖酸的吸附性能	朱义浩, 赵白航, 王淳, 张雨晴, 杨海山(5531)
电路探针测量污泥液膜厚度方法验证及应用	潘思睿, 邓文义, 苏亚欣(5538)
Bi ₂ S ₃ /TiO ₂ 纳米锥光阳极的制备及其光电催化降解土霉素	张会霞, 周立山, 张程蕾, 钱光磊, 谢陈鑫, 朱令之(5548)
新型磁性树脂的合成及其在水中去除Cu(Ⅱ)的性能	张英杰, 陆加越, 王方刚(5558)
空气取水用活性炭纤维复合吸附剂的研究	王胜楠, 郑旭(5567)
强碱性阴离子树脂对铀的循环吸附-淋洗性能及动力学分析	刘玉龙, 胡南, 陈祥标, 陈森才, 曾冰勇, 丁德馨(5574)

责任编辑: 余雪娇

英文顾问: 郭梅芳, 金仁村, 李保庆, 龙秉文, 王运东



Contents

Invited review

- Design and construction of industrial internet platform for digital twin intelligent ethylene plant**
.....WANG Zizong, SUO Hansheng, ZHAO Xueliang, YAN Yakun (5029)
- Development status and prospect analysis of photovoltaic cell packaging adhesive film materials**
.....HUANG Gesheng, SHI Xiaoyu, DING Wenjuan, WANG Chunjiao, MU Yanjun, HOU Yuxuan (5037)

Chemical processes and equipment

- Research progress of particle-scale model in chemical reaction numerical simulation of gas-solid fluidized bed**
.....QIU Mofan, JIANG Lin, LIU Rongzheng, LIU Bing, TANG Yaping, LIU Malin (5047)
- Machine learning-based prediction of coalbed methane composition and real-time optimization of liquefaction process**
.....ZENG Siying, YANG Minbo, FENG Xiao (5059)
- Kinetics studies of carbon gas hydrate separation in the presence of amino acids and DTAC**
.....KANG Yu, GOU Zenian (5067)
- Experimental research on the effect of corrugated plates on the condensation heat transfer characteristics of humid air**
.....JI Guojian, YIN Qirui, LU Beibei, HUANG Pengyuan, ZHOU Xiaoqing, GU Jinming (5076)
- Analysis of pressure drop characteristics of the cooling channel with twisted tape insert under high and non-uniform heat fluxes**
.....ZHU Ge, BI Qincheng, TIAN Shujian, YAN Jianguo (5083)
- Effect of zeolite packing height on thermal energy storage-release performance of reactor**
.....GAO Shichao, WANG Shugang, HU Peiyu, ZHAO Yiming, WANG Jihong, SUN Yi, JIANG Shuang (5092)
- Sedimentation stability and viscosity properties of silicone oil-based magnetic nanofluid at low temperature**
.....ZHU Qichen, WU Zhangyong, WANG Zhiqiang, JIANG Jiajun, LI Xiang (5101)
- Analysis of erosion and cavitation wear in the cage-typed control valve**
.....QIAO Yuan, QIU Chang, QIAN Jinyuan, GAN Ruibin, XU Chunming, JIN Zhijiang (5111)

Energy processes and technology

- State of the art on hydrogen storage of s II clathrate hydrate**
.....YUE Zihan, LONG Zhen, ZHOU Xuebing, ZANG Xiaoya, LIANG Deqing (5121)
- Research progress of fibrous perovskite solar cells**HAN Li, LI Wangliang, LI Yanxiang, AN Gaojun, LU Changbo (5135)

Industrial catalysis

- Research advances on catalytic removal COS and H₂S from by-product gas in iron and steel industry**
.....YUAN Li, WANG Xueqian, LI Xiang, WANG Langlang, MA Yixing, NING ping, XIONG Yiran (5147)
- Research progress of gallium modified HZSM-5 catalysts for aromatization of light alkanes**
.....WU Yiheng, ZHANG Yaoyuan, WU Qin, SHI Daxin, CHEN Kangcheng, LI Hansheng (5162)
- Palladium nanoparticles supported by phosphoric acid-modified SiO₂ as efficient catalysts for low-temperature hydrodeoxygenation of vanillin in water**
.....YANG Chengruixue, HUANG Qiyuan, RAN Jiansu, CUI Yuntong, WANG Jianjian (5179)
- Development of a new refining process for direct catalytic cracking of paraffin based crude oil to produce light olefins**
.....LIU Meijia, WANG Gang, ZHANG Zhongdong, HE Shengbao, GAO Jinsen (5191)
- Regeneration characterization and performance evaluation of the fixed-bed residue hydrotreating catalyst for microcarbon reduction**
.....CUI Ruili, CHENG Tao, SONG Junnan, NIU Guifeng, LIU Yuanyuan, ZHANG Tao, ZHAO Yusheng, WANG Luhai (5200)
- Oligomerization of isobutene over MWW zeolite based catalysts**
.....HUO Wentao, LIU Wen, YU Qiang, AN Jie, ZHU Xiangxue, QIN Yucui, LI Xiujie (5205)
- Direction esterification of bio-based succinate catalyzed by solid super acid SO₄²⁻/ZrO₂**
.....YIN Keke, WANG Yugao, GU Bao, SHEN Jun (5213)
- Preparation of Au-Pd/MnO₂ catalyst and its catalytic performance for benzyl alcohol oxidation**
.....GUO Xiaoyu, LI Dongchen, ZHAO Wei, DU Zhenyi, LI Xiaoliang (5223)

Materials science and technology

- Polyimide membranes for hydrogen separation: A review**
.....CAI Mingwei, WANG Zhi, LU Xiaochuang, ZHUANG Junwei, WU Jiahao, ZHANG Shiyang, MIN Yonggang (5232)
- Research progress of MXene-based membrane materials for precision fluid separation**
.....LI Ya'nan, NIAN Pei, XU Nan, LUO Haiyu, WEI Yibin (5249)
- Flexible wearable piezoresistive pressure sensors**XU Na, WANG Guodong, TAO Yanan (5259)
- Research progress in the preparation of hydroxide/oxide supercapacitor electrodes by electrodeposition**
.....WANG Xiaoliang, YU Zhenqiu, CHANG Leiming, ZHAO Haonan, SONG Xiaoqi, GAO Jingsong, ZHANG Yibo, HUANG Chuanhui, LIU Yi, YANG Shaobin (5272)

- Research progress of organic silicon and organic fluorine low surface energy antifouling coatingsGUAN Yongxin, ZHOU Qiang, CHEN Liyi, LI Hui, LIU Xiaonan (5286)
- Research progress of non-metallic element doped graphitic carbon nitride photocatalytic materialsSONG Yali, LI Ziyang, YANG Cairong, HUANG Long, ZHANG Hongzhong (5299)
- Advances in research on magnetic fibrous electromagnetic wave absorbersYE Hao, HU Ping, WANG Ce, LIU Yong (5310)
- Structural design of metal-organic framework materials and its adsorption performance on synthetic dyesXU Chunshu, YAO Qingda, LIANG Yongxian, ZHOU Hualong (5322)
- Application of covalent organic frameworks (COFs) in lithium-ion batteriesMA Wenjie, YAO Weitang (5339)
- Facile synthesis of superhydrophobic sponge for efficient separation of oil/water mixtureLU Tao, HU Jiayi, XU Cheng, HU Xinlin, GUO Qingyang, LI Meng (5353)
- Response surface optimization of preparation and performance of thermo-responsive hydrogels as draw agentZHANG Jie, WANG Xudong, YANG Yifei, REN Yue, CHEN Licheng (5363)
- Preparation and properties of β -cyclodextrin *in-situ* modified MoS₂ tubular ceramic composite membraneWANG Yan, QIN Zhenping, LIU Yue, ZHANG Wenhui, GUO Hongxia (5373)
- Isopropanol dehydration performance of a novel MXene membrane based on a α -Al₂O₃ carrier tubeZHANG Guochun, ZHOU Zhihui, WU Hongdan (5381)

Biochemical and pharmaceutical engineering

- Preparation of pH responsive magnetic mesoporous nanoparticle drug loading systemLIU Huihui, SHI Xiaofei, WANG Qiannan, LIU Jinbo, ZHANG Jing (5390)

Fine chemicals

- Regeneration of waste lubricant oil by supercritical carbon dioxide extractionYANG Xin, XU Hong, HU Weixun, LIU Hongzuo, LONG Quanzhi, ZHU Liye (5399)
- Preparation and self-repairing performance of microcapsules with fluoropolyurethane dimethacrylate as the coreXIN Hua, PENG Qi, LI Yangfan, ZHANG Yan, CHEN Yue, LI Xinqi (5406)
- Numerical simulation of pre-reduction for a new process of acid production from phosphogypsum by gas sulfur reductionFAN Xuyang, CHEN Yanxin, ZHAO Bo, ZHANG Leilei (5414)
- Basic research on preparation and activity combined excitation of anhydrite- II phosphogypsumBI Qiang, MEI Yi, XIA Jupei (5427)
- Preparation and inhibition mechanism of gemini imidazoline quaternary ammonium salt inhibitorYANG Qingzheng, ZHANG Tailiang, LIU Congsheng, BAI Yi, CHENG Xin, ZHENG Cunchuan (5436)

Resources and environmental engineering

- Research progress of microplastic removal from water environment by biocharSU Jingzhen, ZHAN Jian (5445)
- Research progress and challenges in recovery of nitrogen and phosphorus nutrients from water by biocharWANG Shuyan, ZHANG Xinbo, PENG Anping, LIU Yang, NGO HUU HAO, GUO Wenshan, WEN Haitao (5459)
- Research progress of preparation and modification of nanofiltration membrane for dye wastewater treatmentYANG Kailu, CHEN Mingxing, WANG Xinya, ZHANG Wei, XIAO Changfa (5470)
- Carbon quantum dots modified semiconductor composite photocatalysts for degradation of organic pollutants in waterZHANG Pingping, DING Shuhai, GAO Jingjing, ZHAO Min, YU Haixiang, LIU Yuehong, GU Lin (5487)
- Synergistic reduction of NO_x and CO₂ emissions by coupling pulverized coal with biomass gasFAN Baotian, YAN Zhenrong, SU Houde, LIU Cenfan, SONG Yujian (5501)
- Sulfate-reducing activated sludge for immobilization of cadmium in acid mine drainage by mineralizationWANG Dawei, BI Chunmeng, QIN Yongli, JIANG Yongrong, XIE Huabin, MAO Yukun, MIAO Xueyan (5509)
- Heavy metal leaching characteristics of porous asphalt mixture containing MSWI-BAA under different stormwater runoff flow ratesLI Jingjing, ZHAO Yao, XU Fengchi, LI Kangjian (5520)
- Humic acid adsorption removal by modified coal gangue-based zeoliteZHU Yihao, ZHAO Baihang, WANG Chun, ZHANG Yuqing, YANG Haishan (5531)
- Verification and application of circuit probe method for measuring the liquid film thickness of sewage sludgePAN Sirui, DENG Wenyi, SU Yaxin (5538)
- Preparation of Bi₂S₃/TiO₂ nancone photoanode and their photoelectrocatalysis degradation of hygromycinZHANG Huixia, ZHOU Lishan, ZHANG Chenglei, QIAN Guanglei, XIE Chenxin, ZHU Lingzhi (5548)
- Synthesis of a new MCER and its performance in removing Cu(II) from waterZHANG Yingjie, LU Jiayue, WANG Fanggang (5558)
- Research on activated carbon fiber based composite adsorbents for atmospheric water harvestingWANG Shengnan, ZHENG Xu (5567)
- Circulating adsorption-desorption properties and kinetic analysis of uranium by strong basic anion resinsLIU Yulong, HU Nan, CHEN Xiangbiao, CHEN Sencai, ZENG Bingyong, DING Dexin (5574)

Executive Editor: YU Xuejiao

English Consultant: GUO Meifang, JIN Rencun, LI Baoqing, LONG Bingwen, WANG Yundong

广 告 索 引

封面：苏州安特威阀门有限公司

封二：一念传感科技（深圳）有限公司

封三：北京世纪森朗实验仪器有限公司

封四：精馏技术国家工程研究中心（天津大学）

彩插1：中船双瑞（洛阳）特种装备股份有限公司

彩插2、3：北京泽华化学工程有限公司

彩插4、5：中国石油化工股份有限公司

大连石油化工研究院

彩插6：北京北化工程技术有限公司

彩插7：重庆江增船舶重工有限公司

彩插8：天津市新天进科技开发有限公司

彩插9：北京航天石化技术装备工程有限公司

彩插10：中国矿业大学碳中和研究院CCUS研究所

彩插11：上海市离心机械研究所有限公司

彩插12：青岛科大隆腾科技发展有限公司

彩插13：中石化南京化工研究院有限公司

内插1：华烁科技股份有限公司

内插2：南通富莱克流体装备有限公司

内插3：上海申银机械（集团）有限公司



化 工 进 展

HUAGONG JINZHAN

（月刊，1981年创刊）

第42卷第10期（总第385期）

2023年10月出版

© 版权所有

Chemical Industry and Engineering Progress

(Monthly, Started in 1981)

Vol.42 No.10 (total No.385)

October 2023

© All Rights Reserved

主 管	中国科学技术协会	Superintended by	China Association for Science and Technology
主 办	中国化工学会 化学工业出版社有限公司	Sponsored by	The Chemical Industry and Engineering Society of China; Chemical Industry Press Co., Ltd.
出 版	化学工业出版社有限公司 (北京市东城区青年湖南街13号, 邮编100011)	Publisher	Chemical Industry Press Co., Ltd. (No.13 Qingnianhu South Street, Dongcheng District, Beijing 100011, China)
印 刷	北京科信印刷有限公司	Printed by	Beijing Kexin Printing Co., Ltd.
编 辑	《化工进展》编辑部	Editor	Editorial Department of Chemical Industry and Engineering Progress
主 编	谭天伟	Editor in Chief	TAN Tianwei
编辑部主任	黄丽娟	Managing Editor	HUANG Lijuan
编辑部电话	010-64519466/9499/9500/9501/9502	Telephone	+86-10-64519466/9499/9500/9501/9502
电子信箱	hgjz@263.net	E-mail	hgjz@263.net
网 址	www.hgjz.com.cn	Website	http://www.hgjz.com.cn
国内发行	中国邮政集团公司北京市报刊发行局	Domestic Distributed by	Local Post Offices
国外发行	中国国际图书贸易集团有限公司	Abroad Distributed by	China International Book Trading Corporation (P.O. Box 399, Beijing 100044, China)
广告发布登记号	京东市监广登字20170106号		

ISSN 1000-6613

CN 11-1954/TQ

国内邮发代号 82-311

国外发行代号 M3231

国内定价 180元

CODEN HUJIEK