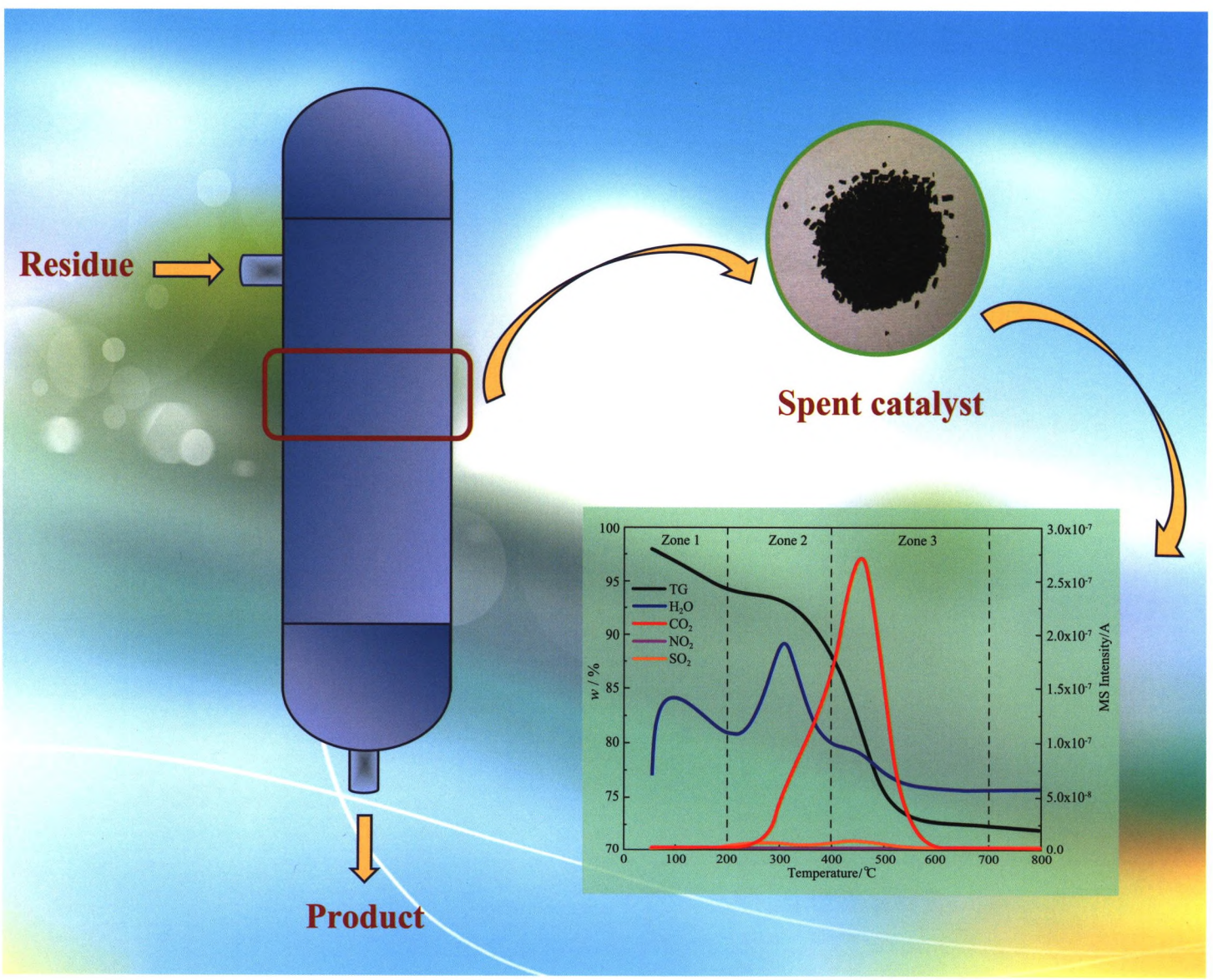
中文核心期刊 Ei核心期刊
本刊被Ei Compendex,CA,AJ,CBST,Scopus等
国际重要检索数据库收录

ISSN 1001-8719
CN 11-2129/TE
CODEN SXSHEY

QK1932445

石油学报(石油加工)

ACTA PETROLEI SINICA
(PETROLEUM PROCESSING SECTION)



ISSN 1001-8719
9 771001 871197 07>

中国石油学会主办
石油化工科学研究院 承办

2019 4 Vol.35

石 油 学 报

（石油加工）

第 35 卷 第 4 期 2019 年 7 月

目 次

研究报告

研究报道

信息

* 封面文章

期刊基本参数：CN11－2129/TE * 1985 * b * A4 * 204 * zh＋en * P * ￥20.00 * 1200 * 25 * 2019－07 **本期责任编辑**：白 雪

特约英文编审：范志明，加拿大不列颠哥伦比亚大学化学及生物工程博士，先后在加拿大自然资源部及加拿大国家研究院工作，现供职 BP 美国公司，研究领域包括重质油加工、石油加工过程中沥青质沉淀及石油化学等。

ACTA PETROLEI SINICA

(PETROLEUM PROCESSING SECTION)

Vol. 35 No. 4 Jul. 2019

CONTENTS

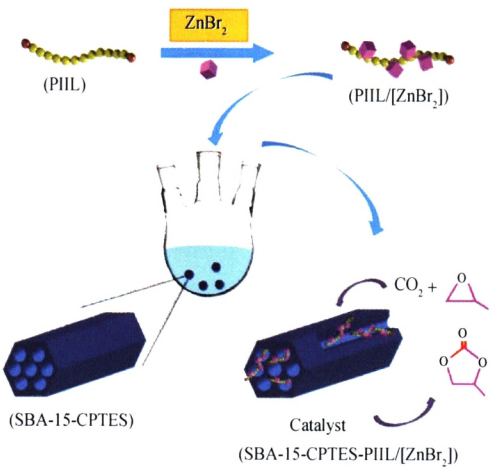
Research Articles

Acta Petrolei Sinica (*Petroleum Processing Section*), 2019, 35(4): 0638-0643 **doi**: 10.3969/j.issn.1001-8719.2019.04.003

Preparation and Properties of Polyether Ionic Liquid Catalyst Immobilized on SBA-15 Modified by Silane

ZHAO Wenkai CHEN Yahui CUI Zhongyi JIN Xianchao
GUO Liying

By reacting three polyether imidazole ionic liquids (PIIL) with $ZnBr_2$, we successfully converted them to three composite PIIL materials, which were further immobilized on silane coupling SBA-15 zeolite to obtain three immobilized catalysts. Then we investigated the properties of immobilized catalysts by appling them to the reaction of CO_2 and propylene oxide (PO) to synthesize propylene carbonate (PC).



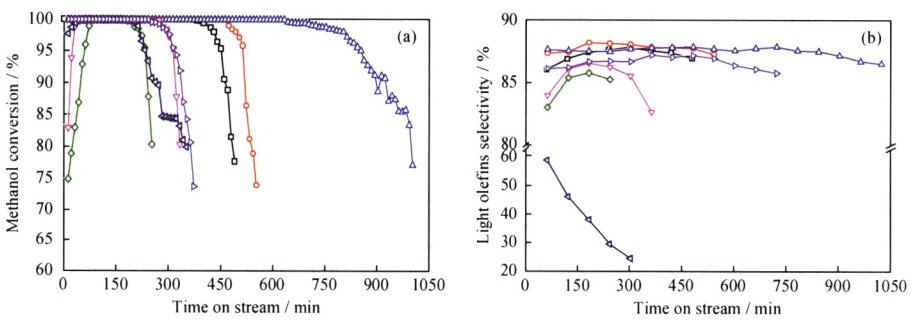
PIIL—Polyether imidazole ionic liquid;
CPTES—3-Chloropropyltriethoxysilane

Acta Petrolei Sinica (*Petroleum Processing Section*), 2019, 35(4): 0644-0652 **doi**: 10.3969/j.issn.1001-8719.2019.04.004

γ-Al_2O_3/SAPO-34 Composite Catalyst and Its Catalytic Performance in MTO Reaction

CHEN Sha LIU Fei LUO Lan CAO Jianxin

The uniformly continuous coating phase and micro-mesoporous structure with synergetic L and B acid sites were successfully obtained in the γ-Al_2O_3/SAPO-34 composite catalyst fabricated via hydrothermal coating strategy. Compared with the physically blending catalyst, the catalytic lifetime of the γ-Al_2O_3/SAPO-34 composite catalyst is extended by 640 min.



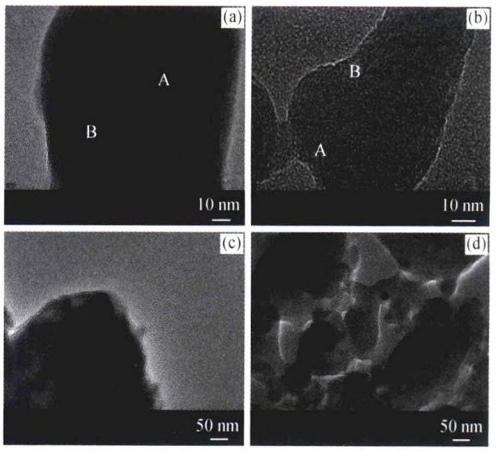
Reaction condition: Atmospheric pressure; Catalyst loading of 1 g; Hydro/Alcohol molar ratio of 2/1; Nitrogen flow rate of 20 mL/min; Feed speed of 2 h^{-1} and reaction temperature of 380 ℃
(a) Methanol conversion; (b) Light olefins selectivity
▫ A/S-25; ○ A/S-33; △ A/S-50; ▽ A/S-67; ◇ A/S-75; ◁ S/A-PM; ▷ SAPO-34

Acta Petrolei Sinica (*Petroleum Processing Section*), 2019, 35(4): 0653-0659 **doi**: 10.3969/j.issn.1001-8719.2019.04.005

Influences of Pt Precursors on the Aromatization Performance of Pt/KL Catalyst

LIU Hang FAN Jingxin ZANG Jiazhong GUO Chunlei HONG Luwei JI Chao

Pt precursors have little effects on the particle size of Pt, surface area and pore volume of the fresh catalysts, while TC-Pt/KL possesses more aromatization active centers and the stronger interaction force between Pt^{2+} and KL molecular sieve. It is beneficial to improve aromatization activity and limit the aggregation and growth of Pt particles.



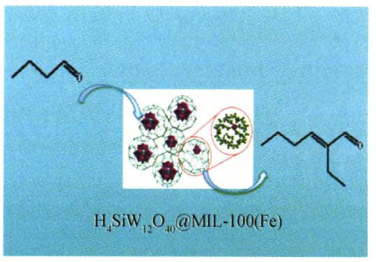
(a) TN-Pt /KL; (b) TC-Pt/KL;
(c) R-TN-Pt /KL; (d) R-TC-Pt/KL

Acta Petrolei Sinica (*Petroleum Processing Section*), 2019, 35(4): 0660-0668 **doi**: 10.3969/j.issn.1001-8719.2019.04.006

Preparation of $H_4SiW_{12}O_{40}$@MIL-100(Fe) and Its Catalytic Performance in the Self-Condensation of *n*-Butyraldehyde

SHI Yamei LI Buwei AN Hualiang ZHAO Xinqiang WANG Yanji

$H_4SiW_{12}O_{40}$@MIL-100(Fe) catalyst prepared by in-situ synthesis method exhibits favorable catalytic performance in *n*-butyraldehyde self-condensation. *n*-Butyraldehyde conversion of 72.9% and 2-ethyl-2-hexenal selectivity of 83.5% are attained. The catalyst could be reused for four times through treatment with absolute ethanol, which suggests good reusability.

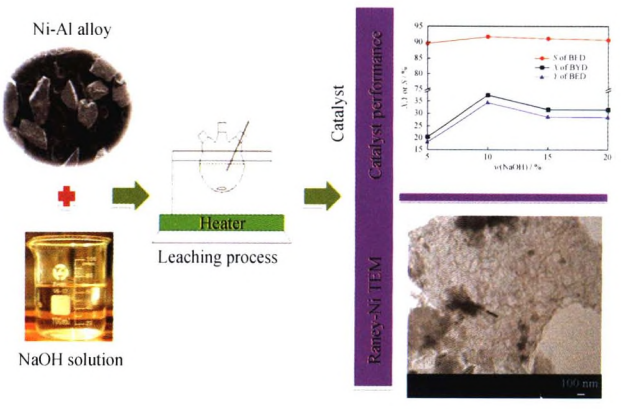


Acta Petrolei Sinica (*Petroleum Processing Section*), 2019, 35(4): 0669-0675 **doi**: 10.3969/j.issn.1001-8719.2019.04.007

Influence of Alkali Concentration on the Structure and Catalytic Performance of Raney-Ni Catalyst in 1,4-Butynediol Hydrogenation

ZHANG Ruiyu MO Wenlong MA Fengyun ZHONG Mei LIU Jingmei WU Hongli

Effects of alkali concentration on the structure and catalytic performance of Raney-Ni catalysts was investigated. RN 10% presents the smallest Ni grain size, the largest specific surface area and of residual Ni_2Al_3 phase as the "structural promoter", which shows excellent hydrogenation performance, with BYD conversion of 37.46%, BED selectivity and yield of 91.73% and 34.36%, respectively.

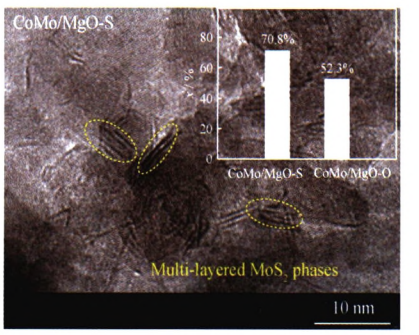


Acta Petrolei Sinica (*Petroleum Processing Section*), 2019, 35(4): 0676-0684 **doi**: 10.3969/j.issn.1001-8719.2019.04.008

Preparation of CoMo/MgO Catalyst and Its Catalytic Performance in the Hydrodesulfurization of 4,6-DMDBT

ZHENG Shifu ZHANG Lei HE Mingyang

The CoMo/MgO-S catalyst prepared with $(NH_4)_2MoS_4$ precursor is of more multi-layered MoS_2 active phases, and exhibits higher hydrogenation activity than CoMo/MgO-O prepared using $(NH_4)_6Mo_7O_{24}$, because the lowest bond energy of Mo-S-Mg is larger than that of Mo-O-Mg. Thus, the CoMo/MgO-S exhibits higher catalytic activity in the hydrodesulfurization of 4,6-DMDBT than CoMo/MgO-O.

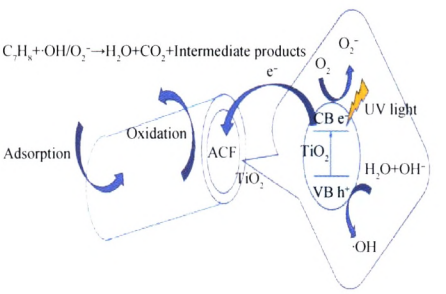


Acta Petrolei Sinica (*Petroleum Processing Section*), 2019, 35(4): 0685-0695 **doi**: 10.3969/j.issn.1001-8719.2019.04.009

Coupling Adsorption With Photocatalysis for the Removal of Toluene With TiO_2/ACF Composites

DAI Yexin LI Yuwei QI Xuejin LI Meng XUE Ming LIU Fang ZHAO Chaocheng WANG Yongqiang

The dynamic removal of toluene under UV excitation was investigated in a self-made reactor. The results show that the TiO_2/ACF composite film has a synergistic adsorption and photocatalytic effect.

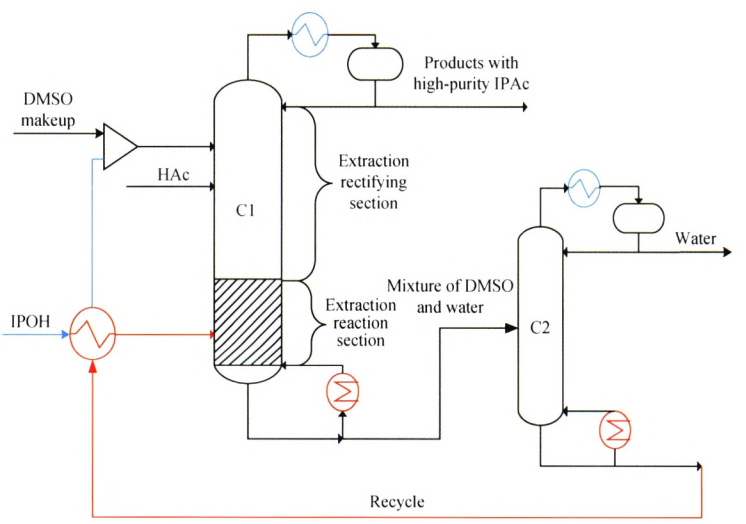


Acta Petrolei Sinica (*Petroleum Processing Section*), 2019, 35(4): 0696-0707 **doi**: 10.3969/j.issn.1001-8719.2019.04.010

Intensification and Dynamic Control of a Reactive Distillation Process for the Synthesis of Isopropyl Acetate

YAN Sen LI Haiying XU Pengfei ZHANG Qingrui

A novel reactive and extractive distillation process was proposed and used for the synthesis of IPAc, in which the molar fraction of IPAc reaches 99.5%. Two control schemes are presented and both of them handle the disturbances effectively and keep the process running smoothly.



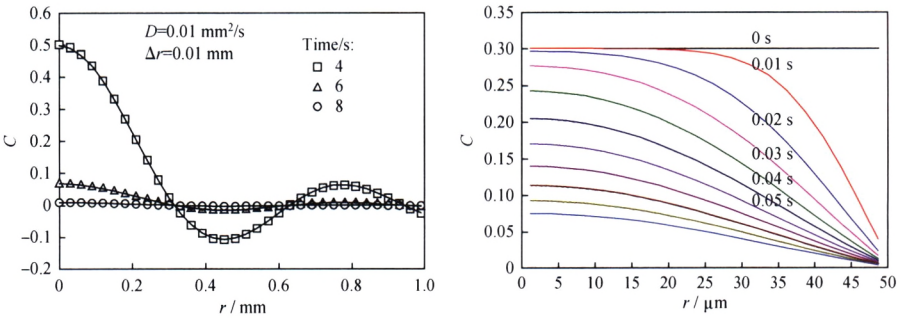
C1—The reactive and extractive distillation column; C2—The entrainer recovery column; E1—The heat exchanger
DMSO—Dimethyl sulfoxide; HAc—Acetic acid; IPAc—Isopropyl acetate; IPOH—Isopropyl alcohol

Acta Petrolei Sinica (*Petroleum Processing Section*), 2019, 35(4): 0708-0713 **doi**: 10.3969/j.issn.1001-8719.2019.04.011

Mass and Heat Transfer Model in Droplets During Spray Drying Process

ZHANG Tongwang ZHANG Yi ZHU Bingtian LIU Lingtao HAN Ying HE Guangxiang CHEN Haiying

A mass and heat transfer model of aqueous droplets during the spray drying process is established, and an efficient numerical method to solve such model is presented.

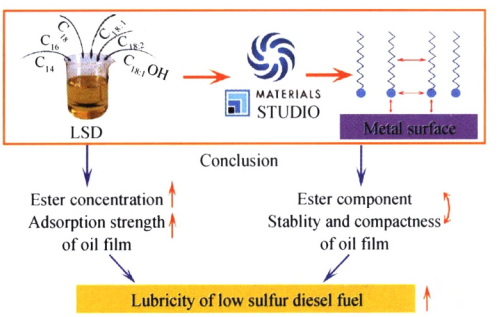


Acta Petrolei Sinica (*Petroleum Processing Section*), 2019, 35(4): 0714-0720 **doi**: 10.3969/j.issn.1001-8719.2019.04.012

Adsorption of Esters Contained Fuel on the Fe Surface: A Molecular Dynamics Study

CHEN Tiaotiao MEI Deqing REN Wuyue WANG Hengquan YUAN Yinnan GUO Rui

Adsorption behavior of esters contained low sulfur diesel fuel on Fe surface were investigated by molecular dynamics simulations. Results show that both the increase of ester fraction and the change of ester composition are effective ways to improve the lubrication properties of low sulfur diesel.

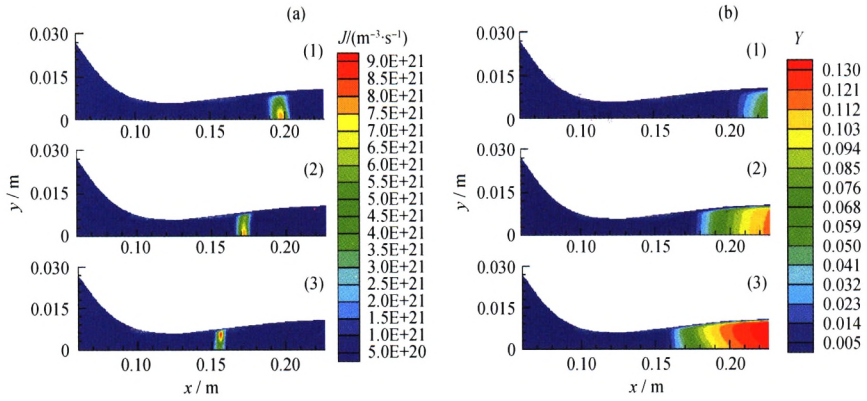


Acta Petrolei Sinica (*Petroleum Processing Section*), 2019, 35(4): 0721-0729 **doi**: 10.3969/j.issn.1001-8719.2019.04.013

Supersonic Condensation Characteristics of Hydrogen Sulfide in Natural Gas

CAO Xuewen WANG Chunzhi SUN Wenjuan MOU Linsheng

The superoinc condensation characteristics of hydrogen sulfide in a Laval nozzle was numerically simulated by the Eulerian-Eulerian dual-phase model and the condensation theory. The effects of inlet pressures, temperatures and back pressures on the condensation process were analyzed.



T_{in} = 273 K

(a) Nucleation rate (J); (b) Liquid phase mass fraction (Y)

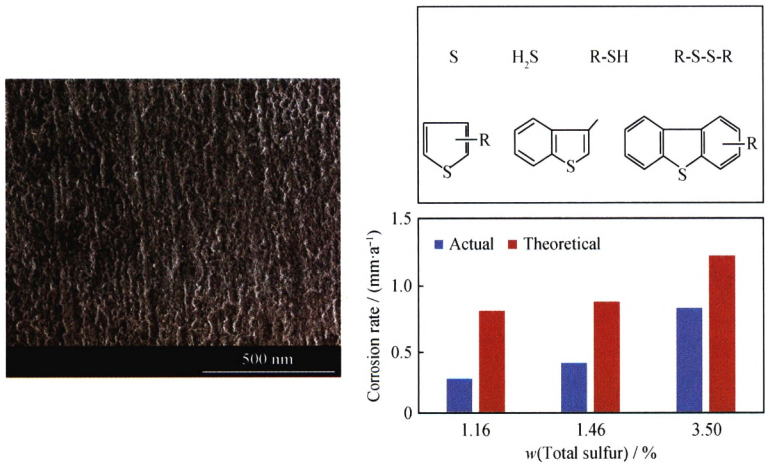
p_{in}/MPa: (1) 3; (2) 4; (3) 5

Acta Petrolei Sinica (*Petroleum Processing Section*), 2019, 35(4): 0730-0735 **doi**: 10.3969/j.issn.1001-8719.2019.04.014

Carbon Steel Corrosion in High-Sulfur Crude Distillates

NIU Luna ZHANG Chao LAN Zhenggui HAN Lei QU Dingrong

Total active sulfur content, composition and distribution of sulfur compounds in high-sulfur heavy distillates were determined by potentiometric titration and mass spectrometry methods. Corrosion behavior of typical carbon steels in the distillates was studied under conditions. It is concluded that the proportion of active sulfur in total sulfur is less than 1%. Experimental corrosion rates are significantly than McConomy theoretical corrosion rates.

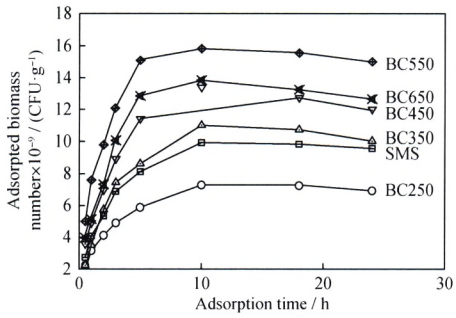


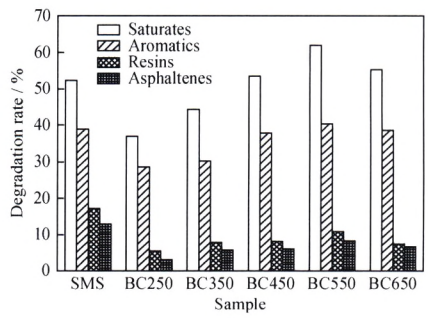
Acta Petrolei Sinica (*Petroleum Processing Section*), 2019, 35(4): 0736-0743 **doi**: 10.3969/j.issn.1001-8719.2019.04.015

Adsorption and Degradation of Petroleum Hydrocarbon With Biochars and Microorganisms

ZHANG Bofan XU Wenfei WANG Jiahua XIONG Xin HAN Zhuo ZHANG Xiuxia ZHANG Zhao LIU Huie GU Yingying

Effect of spent mushroom substrate and biochars (250—650 ℃) on adsorption rate of *Ochrobactrum sp.* Q1 and the degradation rate of different components of oil by immobilized microorganisms were analyzed. Experimental results showed that the 550 ℃-biochar (BC550) has the best adsorption effect (1.582×10^{10} CFU/g) on microorganism. It was also found that BC550 immobilized bacteria have better degradation rate of different components in the oil than other biochar groups prepared at other different pyrolysis temperatures.





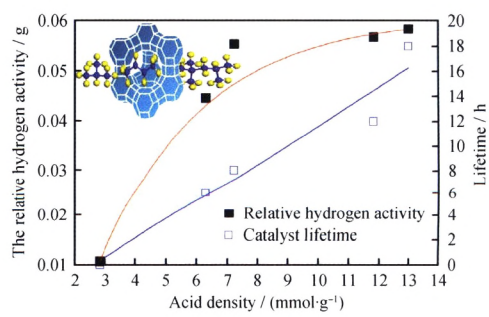
Research Notes

Acta Petrolei Sinica (*Petroleum Processing Section*), 2019, 35(4): 0744-0750 **doi**: 10.3969/j.issn.1001-8719.2019.04.016

Effects of Acid Density on the Catalytic Performance of HY Zeolite in the Isobutene-Butene Alkylation Reaction

HOU Yacong ZHANG Chengxi LI Yongxiang

The acid sites in HY zeolites provide active sites for alkylation reactions. Having a higher acid density means a higher relative hydrogen activity and longer catalyst lifetime, which is beneficial for achieving high selectivity of target products.

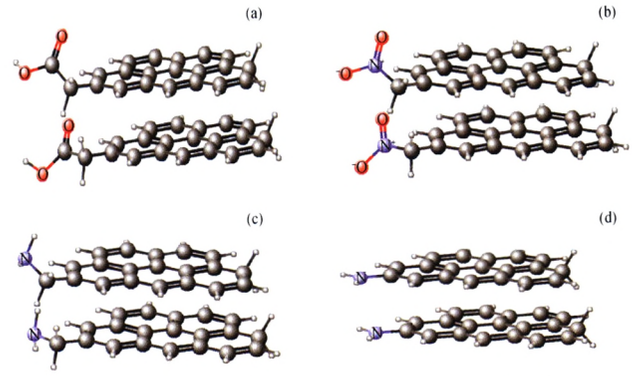


Acta Petrolei Sinica (*Petroleum Processing Section*), 2019, 35(4): 0751-0758 **doi**: 10.3969/j.issn.1001-8719.2019.04.017

Theoretical Study on π-π Interactions in Asphaltene Molecular Aggregates

REN Qiang LONG Jun DAI Zhenyu
ZHOU Han

Quantum mechanical and molecular dynamics methods were used to study the π-π interactions in asphaltene molecular aggregates. The results show that the π-π interactions between asphaltene molecules increases with the increase of molecular aromatic rings' number, and the heteroatoms significantly increase the π-π interaction energies between the asphaltene molecules.



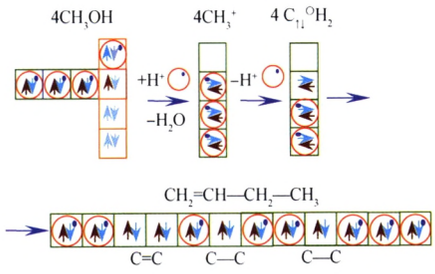
(a) Side chains with electron-withdrawing groups (—COOH);
(b) Side chains with electron-withdrawing groups ($—NO_2$);
(c) Side chains with electron donating groups ($—NH_2$);
(d) Aromatic hydrocarbons directly linked to $—NH_2$ groups (electron-donating groups)

Acta Petrolei Sinica (*Petroleum Processing Section*), 2019, 35(4): 0759-0765 **doi**: 10.3969/j.issn.1001-8719.2019.04.018

Study on Reaction Mechanism of Methanol to Butene

HE Zhenfu

B-acid center can release an H^+ to attack the C—O bond in the methanol molecule, and C—O bond is cleaved to form the methyl carboncation (CH_3^+), in which the carbon atom outer layer has an empty orbit. After releasing H^+, the B-acid center loses its activity. B-acid center can obtain H^+ from CH_3^+ to recover its activity, then CH_3^+ losses H^+ and transforms a new intermediate H-form, whose structural formula is $C_{\uparrow\downarrow}{}^{\circ}H_2$. H-form has a pair of lone pair of electrons (e^-) and one empty orbit. The four $C_{\uparrow\downarrow}{}^{\circ}H_2$ units can form different butene molecule structures, such as 1-butene, 2-butene and isobutylene.

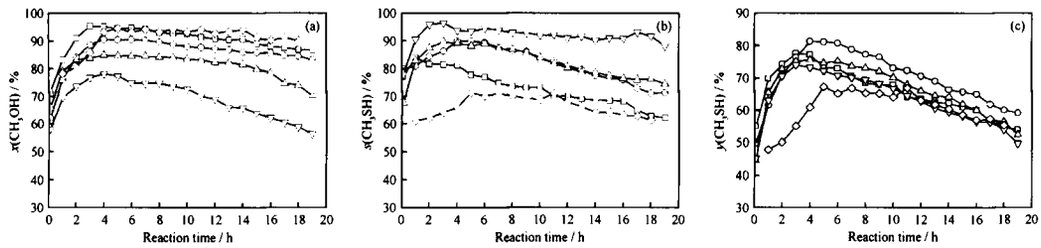


Acta Petrolei Sinica (*Petroleum Processing Section*), 2019, 35(4): 0766-0774 **doi**: 10.3969/j.issn.1001-8719.2019.04.019

Effects of the Mass Ratio of ZSM-5/MgO on the Physicochemical Properties and Catalytic Performance in the Synthesis of Methanethiol

LIU Piao LIU Fei YANG Kaixu CAO Jianxin

As ZSM-5/MgO mass ratio of 1/3, the homogeneously continuous coating phase and hierarchical structure with large amount of acidic and alkaline sites were successfully obtained by using liquid-phase precipitation coating route. Compared with ZSM-5 molecular sieve, the reaction lifetime of the composite catalyst is extended for 7 h and the yield of methanethiol is increased 13.97 percentage.



p=1.0 MPa; m(Catalyst)=2.0 g; T=370 ℃; $n(H_2S)/n(CH_3OH)$=2/1; $q_v(H_2S)$=4.9 mL/min; $q_v(N_2)$=80 mL/min

(a) $x(CH_3OH)$; (b) $s(CH_3SH)$; (c) $y(CH_3SH)$

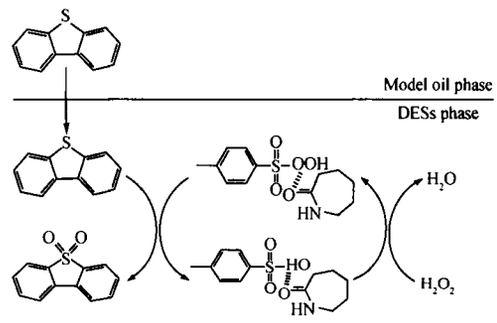
ZSM-5/MgO composite catalyst, m(ZSM-5)/m(MgO): □ 1/2; ○ 1/3; △ 1/4; ▽ 1/5; ◇ ZSM-5

Acta Petrolei Sinica (*Petroleum Processing Section*), 2019, 35(4): 0775-0782 **doi**: 10.3969/j.issn.1001-8719.2019.04.020

Preparation of $C_6H_{11}NO$/2TsOH Type Deep Eutectic Solvent and Its Catalytic Performance in Oxidative Desulfurization

WANG Xinbo LI Xiuping ZHAO Rongxiang

$C_6H_{11}NO$/2TsOH was synthesized with caprolactam and *p*-toluenesulfonic acid as raw materials. $C_6H_{11}NO$/2TsOH as the extractant and catalyst, H_2O_2 as the oxidant, the remove of sulfide in the model oil by catalytic oxidation was carried out. The desulfurization rate of DBT, 4, 6-DMDBT and BT attach 97.32%, 86.60% and 77.80%, respectively, under the optimum experimental conditions.

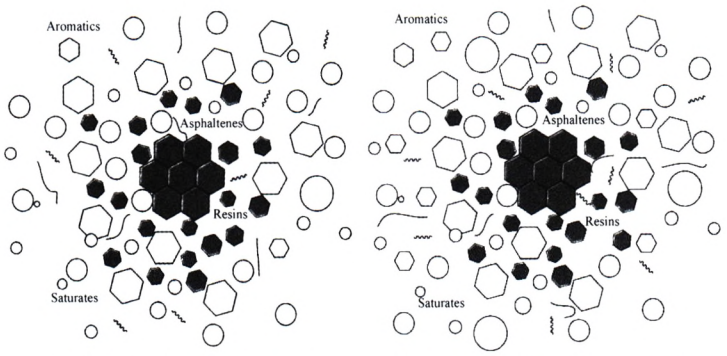


Acta Petrolei Sinica (*Petroleum Processing Section*), 2019, 35(4): 0783-0789 **doi**: 10.3969/j.issn.1001-8719.2019.04.021

Effect of Hydrodynamic Cavitation on the Properties of Saudi Heavy Crude Oil

CHEN Hui HAN Haibo LI Kang LEI Jie CHEN Jianmin CUI Shuqi LIU Xuedong

Hydrodynamic cavitation process can produce extreme physical conditions such as local high temperature, high pressure, high jet flow and strong shear stress. Applying hydrodynamic cavitation device to upgrade heavy crude oil is proposed in this study. Mechanisms of hydrodynamic cavitation upgrading heavy oil mainly include free radical reactions and colloid loosening. The physical-chemical properties and process ability of heavy oil can be improved through proper cavitation treatment.



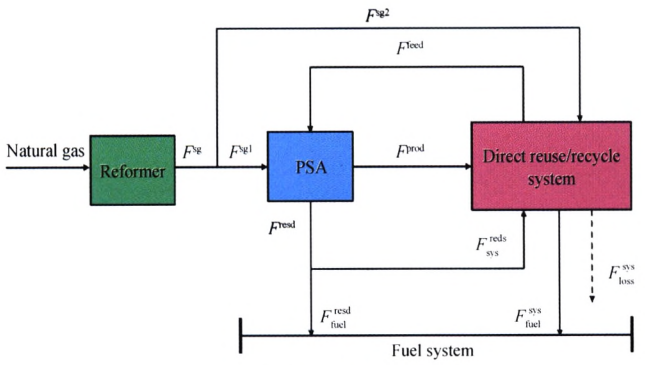
Crude oil model before cavitation treatment　　Crude oil model after cavitation treatment

Acta Petrolei Sinica (*Petroleum Processing Section*), 2019, 35(4): 0790-0797 **doi**: 10.3969/j.issn.1001-8719.2019.04.022

Hydrogen System Optimization in the Integrated Hydrogen Production and Purification Unit

LIU Jian ZHU Meiqian DENG Chun FENG Xiao

Detail mass balance analysis of hydrogen system was conducted, and two purification reuse scenarios were introduced. The optimal flowrates of hydrogen utility, shifted gas and natural gas were determined by using the improved problem table method.



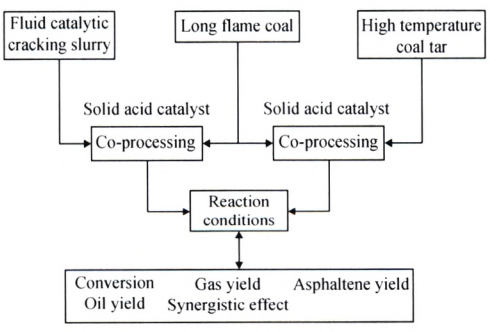
PSA—Pressure swing adsorption; F— Flow rate

Acta Petrolei Sinica (*Petroleum Processing Section*), 2019, 35(4): 0798-0806 **doi**: 10.3969/j.issn.1001-8719.2019.04.023

Co-Hydrogenation Performance of Heavy Oil With Long Flame Coal

HU Fating LI Junfang MAO Xuefeng

Co-hydrogenation experiments of high temperature coal tar and FCC slurry with Xinjiang long flame coal were carried out. The effects of co-processing conditions on the feed oil conversion, oil yield, gas yield and asphaltene yield were comprehensively analyzed. The optimized reaction conditions were obtained.

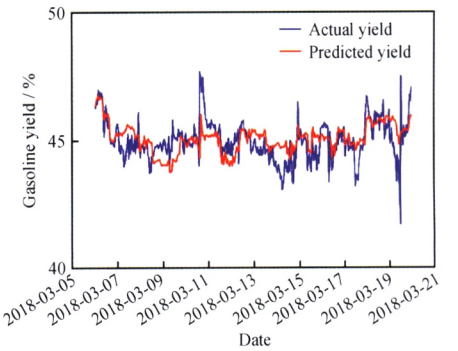


Acta Petrolei Sinica (*Petroleum Processing Section*), 2019, 35(4): 0807-0817 **doi**: 10.3969/j.issn.1001-8719.2019.04.024

Construction and Analysis of Gasoline Yield Prediction Model for FCC Unit Based on Artificial Intelligence Algorithm

YANG Fan ZHOU Min DAI Chaonan CAO Jun

A model based on GBDT algorithm is developed to predict the product yield on catalytic cracking unit by analyzing key factors from the industrial data. The prediction results show a high accuracy and stability compared to the industrial gasoline yield, which is of great significance to optimize the operation conditions and enhance economic performance.

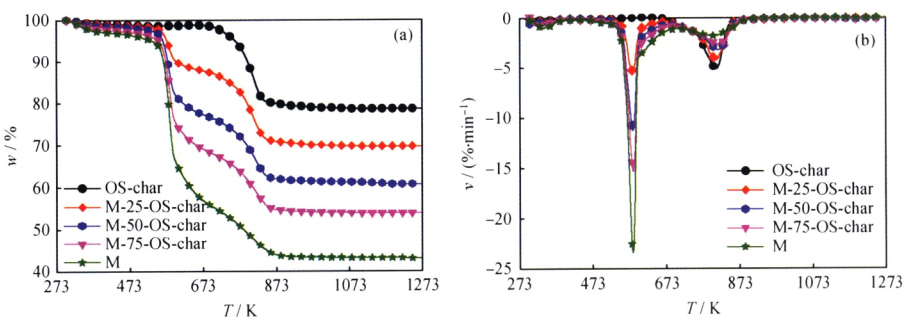


Acta Petrolei Sinica (*Petroleum Processing Section*), 2019, 35(4): 0818-0824 **doi**: 10.3969/j.issn.1001-8719.2019.04.025

Experimental Study on Co-Combustion of Oil Sludge Pyrolysis Char Blended With Microalgae Residues

WANG Zhentong GONG Zhiqiang WANG Zhenbo FANG Peiwen MENG Fanzhi HAN Dong

Compared with OS char, microalgae residue has a higher heating value and volatile contents, while OS char has more fixed carbon content. Microalgae residue addition could enhance the mass loss rate and improve combustion characteristics of OS char. This finding provides fundamental support for clean and effective oil sludge treatment.



(a) TG profiles; (b) DTG profiles

β=20 K/min

石油学报(石油加工)

SHIYOU XUEBAO (SHIYOU JIAGONG)

主 编 汪燮卿

双 月 刊

(1985 年 3 月创刊)

第 35 卷 第 4 期 2019 年 7 月 25 日

ACTA PETROLEI SINICA

(PETROLEUM PROCESSING SECTION)

Editor in Chief Wang Xieqing

Bimonthly

(Started in March 1985)

Vol. 35 No. 4 Jul. 25, 2019

主 管:中国科学技术协会

主 办:中国石油学会

编辑、出版:《石油学报(石油加工)》编辑部

地址:北京市海淀区学院路 18 号

邮编:100083

电话:010-62310752, 010-82368282

网址:www. syxbsyjg. com

E-mail:syxb8282. ripp@sinopec. com,

syxb8282@163. com

副 主 编:胡晓春

印 刷:北京科信印刷有限公司

发 行:

国 内:北京市报刊发行局

国 外:中国国际图书贸易总公司

(中国国际书店)

北京市 399 信箱

国内订阅处:全国各地邮局

报刊登记证:(BJ)第 1404 号

Responsible Institution: China Association for Science and Technology

Sponsored by: China Petroleum Society

Edited and Published by: Editorial Office of Acta Petrolei Sinica

(Petroleum Processing Section)

Add: No. 18 Xueyuan Road, Haidian District, Beijing 100083, China

Tel: +86-010-62310752, +86-010-82368282

Http://www. syxbsyjg. com

E-mail: syxb8282. ripp@sinopec. com,

syxb8282@163. com

Deputy Editor in Chief: Hu Xiaochun

Printed by: Beijing Kexin Printing Co., Ltd.

Distributed by:

Domestic: The Bureau of Periodical Distribution, Post Office of Beijing

Abroad: China International Book Trading Corporation (Guoji Shudian), P. O. Box 399, Beijing

(Code No. BM845)

Subscripted by: Local Post Offices in China

Periodical Registration: (BJ) No. 1404

ISSN 1001-8719

CN 11-2129/TE

国内邮发代号:82-332

国外发行代号:BM845

定价:20.00 元/期

120.00 元/年