Chemistry and Technology of Fuels and Oils

3(601)'2017

Publisher— ICST «TUMA Group» LLC

Редактор
В. С. Дмитриева

Ответственный секретарь
О. В. Любименко

Графика и верстка
В. В. Земсков

Подготовка материалов
С. О. Бороздин

Адрес редакции:
119991, ГСП-1, Москва, В-296, Ленинский просп., 65. РГУ нефти и газа им. И. М. Губкина, редакция «ХТТМ»

Телефон/факс: (499) 507-80-45
e-mail: httm@list.ru

Материалы авторов не возвращаются.

Редакция не несет ответственности за достоверность информации в материалах, в том числе рекламных, предоставленных авторами для публикации.

Формат 60 84 1/8.
Печать офсетная.
Усл. печ. л. 7.
Тираж 1000 экз.

Отпечатано ООО «Стринг»
E-mail: String_25@mail.ru

Contents

Results of E30 bioethanol fuel tests in a full-scale injection engine vis-à-vis standard gasolines

E-mail: ershovma@vniinp.ru

M. A. Ershov, I. F. Khabibullin, E. V. Grigor'eva, V. E. Lazarev, and E. A. Lazarev

The results of tests of a new E30 bioethanol fuel developed at AO VNII NP (JSC All-Russia Scientific Research Institute of Petroleum Products) in a full-scale injection engine are reported. The test results allowed determination of efficiency, fuel economy, and toxicity of exhaust gases for engines running on experimental specimens of bioethanol fuels vis-à-vis automotive gasolines.

Keywords: bioethanol fuel, E30, tests in engine, gasoline, emissions.

Influence of rapeseed oil ester additives on fuel quality index for air jet engines

S. V. Boichenko, K. Leida, A. V. Yakovleva, O. A. Vovk, and Kh. Kuzhevskii

E-mail: pinchuk_anya@ukr.net

This work is devoted to development of an alternative blended aviation fuel containing rapeseed-oil-based biocomponents and to a study of their physicochemical properties. The basic characteristics of a petroleum aviation fuel and three types of biocomponents are studied and analyzed for conformance to standard requirements of a Jet A-1-grade aviation fuel. It is shown that modification of air-jet engine (AJE) fuels with rapeseed oil esters enhances density and viscosity of the fuel, elevates pour point, and broadens fractional composition by virtue of elevation of end-of-boiling temperatures, which is explained by increased energy of interaction between the molecules of the hydrocarbon fuel and the fatty acid esters. It is demonstrated that AJE fuels modified with up to 30 vol. % biocomponents meet the requirements of normative documents on the studied properties and can be used as a source of AJE energy

Keywords: AJE fuel, alternative fuel, biocomponent, rapeseed oil esters, fractional composition, pour point.

Hydrogenation of unsaturated hydrocarbons on Pt and Pd catalysts incapsulated in mesoporous bakelites

M. P. Boronoev, A. B. Kulikov, E. S. Subbotina, L. A. Kulikov, S. V. Egazar'yants, Yu. S. Kardasheva, A. L. Maksimov, and É. A. Karakhanov

E-mail: kar@petrol.chem.msu.ru

Catalysts based on Pt and Pd nanoparticles applied to mesoporous phenol formaldehyde polymer modified by an ionic liquid are synthesized. They are used to implement and study processes of hydrogenation of unsaturated compounds with reference to acyclic and cyclic isoprenoids, such as

isoprene, 2,5-dimethyl-2,4-hexadiene, limonene, a-terpinene, g-terpinene, as well as phenylacetylene, trans-stilbene, and 1,4-diphenyl-1,3- butadiene. It is shown that the synthesized catalysts exhibit high activity in hydrogenation processes and that Pd catalysts are more active than Pt ones. Thus, complete hydrogenation products dominate in isoprenoid hydrogenation reactions on Pd catalysts, whereas monoenes dominate in reactions on Pt catalysts.

Keywords: hydrogenation, palladium, platinum, mesoporous materials, unsaturated compounds.

Modeling and optimization of joint gasoline, ethane, and propane pyrolysis process

A. M. Aliev, Z. A. Mamedov, A. R. Safarov, I. I. Osmanova, and A. M. Guseinova

E-mail: agil_s@mail.ru

Possible variants of gasoline pyrolysis intensification, i.e., implementation of the process with separation and reinjection of the ethane and propane formed into the pyrolysis retort for further conversions, and recirculation of both hydrocarbons simultaneously, i.e., joint gasoline, ethane, and propane pyrolysis, are studied. Yields of target products (ethylene and propylene) in all three cases are compared with yields of hydrocarbons in industrial process without recirculation. The profit an enterprise can get by applying this method is calculated.

Keywords: gasoline pyrolysis, ethane pyrolysis, propane pyrolysis, joint pyrolysis, recycling, recycling factor.

Kinetics of dissolution of asphaltoresinous matters in aromatic solvents

D. B. Tagiev, G. I. Kelbaliev, G. Z. Suleimanov, S. R. Rasulov, F. I. Shekiliev, V. I. Kerimli, and G. R. Mustafaeva

E-mail: rasulovsakit@gmail.com

The results of experimental study and kinetic modeling of dissolution of asphaltoresinous matters in aromatic solvents based on mass transfer under isotropic turbulence conditions within a boundary layer are presented. Derivation of a kinetic equation based on equality of diffusional and convective flows on particle surface is described. Kinetic models and dissolution coefficients as a function of temperature are determined.

Keywords: mass transfer, diffusion, convection, asphaltoresinous matters, aromatic solvents, boundary layer.

Dewaxing of heavy diesel fuel in an electric field

N. S. Yakovlev and S. G. Agaev

E-mail: yns007@rambler.ru

Dewaxing of diesel fuel (DF) of heavy fractional composition (HFC) in an electric field using Dodiflow-4971 depressants as activators of the process and higher fatty acids (HFA) is studied. It is shown that dewaxing of DF of HFC allows production of DF with improved low-temperature properties. Yield of dewaxed diesel fuel (DDF) at -15°C reaches 75.8 wt. % and cloud point depression is 17°C; at -5°C, DDF is 77.8 wt. % and cloud point depression is 11°C. It is shown that combination of electric charge of alcohols generated in the crystallization process and the temperature range of thermoelectric effects, in which this charge persists, affects the DF dewaxing indexes. At higher values of these characteristics, dewaxing and quality indexes of DDF are higher. It is shown that effectiveness of HFA as dewaxing activators increases in the following order: tetradecanol <hexadecanol < octadecanol < C19+ HFA fraction < C10-18 HFA fraction.

Keywords: diesel fuel, dewaxing, low-temperature properties, depression additives, higher fatty acids, electric field.

Thermal properties of wax compositions

B. E. Krasavtsev, É. A. Aleksandrova, Zh. T. Khadisova, and B. L. Aleksandrov

E-mail: bor11111@list.ru

Graphical dependencies of temperatures of crystallization start and end and of phase hexagonal-rhombic H→R conversion in solid state on wax compositions of petroleum paraffin P-1 with ceresines (C-65, C-80), wax (ZW-1), and soft paraffin (SP) are proposed. It is shown that the melting point of paraffin-ceresine mixtures obeys additivity rule provided the melting points of the mixed components do not differ by more than 15°C. Paraffin P-1, soft paraffins, and waxes crystallize initially in the H and later also in the R phase and ceresines, only in the R phase.

Keywords: paraffins, ceresines, waxes, paraffin composition, melting point, crystallization, hexagonal-rhombic conversion, meltability diagram, phase state.

Influence of oil pollution on various types of soil

A. F. Tumanyan, N. V. Tyutyuma, A. N. Bondarenko, and N. A. Shcherbakova

E-mail: aftum@mail.ru

Oil pollution impact on physicochemical properties of various types of zonal soils in the arid zone is studied and their self-purification ability is evaluated. Based on bioindication principles concerning crops reaction to oil-contaminated environment, we conducted vegetation experiment, which indicated that crops with varying sensitivities are capable of sprouting and growing on oil-contaminated soils.

Keywords: oil and oil products, zonal soils, oil contaminants.

Use of kinetic inhibitors of gas hydrate formation in oil and gas production processes: current state and prospects of development

A. Yu. Zhukov, M. A. Stolov, and M. A. Varfolomeev

E-mail: mikhail.varfolomeev@kpfu.ru

Kinetic inhibitors of gas hydrate formation in oil and gas production processes are reviewed briefly. A general description of the mechanism of inhibitor action is given. The structural distinctions of both synthetic polymeric inhibitors and natural inhibitors are indicated. Prospects of development of new kinetic inhibitors of hydrate formation are shown.

Keywords: gas hydrates, kinetic inhibitors of hydrate formation, polyamides, antifreeze proteins.

Mechanisms of natural toluene attenuation in BTEX-contaminated groundwater

Rui Zhou, Ying Chang, and Yan Zhao

E-mail: zhour@jlu.edu.cn

Natural attenuation of groundwater occurs by a variety of physical, chemical and/or biological mechanisms, such as dilution, sorption, volatilization, aerobic/anaerobic biodegradation, diffusion, convection, etc. Monoaromatic compounds BTEX (benzene, toluene, ethyl benzene, and xylenes) are common contaminants in groundwater polluted by oil and oil products. In this work, a quantitative evaluation of individual and total contribution of the main mechanisms (sorption, dilution, volatilization, and biodegradation) of natural attenuation of toluene in an aquifer was made using first-order kinetic equations. The contributions of sorption, dilution, volatilization, and biodegradation were 56.83%, 38.05%, 1.78%, and 3.34%, respectively, which shows that the contri-

butions of volatilization and biodegradation were much smaller than those of the other mechanisms. In the initial stage of contamination, sorption played the most important role in natural attenuation of groundwater, followed by dilution, convection, diffusion, and other mechanisms.

Keywords: BTEX, benzene, toluene, ethyl benzene, xylenes, groundwater, natural attenuation, volatilization, biodegradation, sorption, dilution.

A new mathematical model for predicting capillary pressure

Yang Jian-ping, Liu Zhi-bin, Chen Li-qun, and Huang Yong-ning

E-mail: shuxingyun@163.com

Difficulties and variations arise often while measuring capillary pressure in laboratory experiments. In addition, laboratory testing of capillary pressure is time consuming and expensive. To avoid this problem, it is necessary to develop a mathematical model for calculating capillary pressure. One of the representative capillary pressure curve types is the hyperbola. The best-known examples of hyperbolic models for capillary pressure determination are the Thomeer and Donaldson models. However, these models have certain deficiencies. A new and intuitive capillary pressure model with fewer parameters was derived and verified in this study. Least-squares regression is proposed for use in determining the value of the shape factor f in the new capillary pressure model. Using the new capillary pressure model, relative permeability can be calculated easily.

Keywords: capillary pressure, mathematical model, relative permeability.

Research on laws for potential distribution in three-dimensional space for oil exploitation adopting SAGD technology and compound well group

Chao Liang, Chusheng Wang, Qiji Sun, and Chenglin He

E-mail: sunqiji@nepu.edu.cn

The seepage law for heavy oils exploited by employing SAGD (steam assisted gravity drainage) technology and a well group compounded by single horizontal wells and multiple vertical wells differs from the law for conventional oil exploitation. A mathematical model of distribution of potential field of horizontal and vertical wells, based on the principle of potential superposition in a three-dimensional space, has been used to determine the function of the potential developed as per the referred seepage scheme. The effect of three-dimensional seepage and the boundary conditions that ensure fluid motion under the action of gravity forces alone were determined. The SAGD technologies with and without involvement of gravity forces are compared and the effect

of gravity field on the pressure gradient of the reservoir is analyzed. Based on the obtained data, a theoretical model is proposed for the study and prediction of heavy oil productivity and seepage mechanisms in a compound well group.

Keywords: compound well group, SAGD, oil exploitation by steam injection, seepage law, potential function, gravity drive.

Study of flow characteristics of ASP solution based on numerical simulation in jet nozzle channel

Bin Huang, Wei Zhang, Cheng Fu, Pengxin Feng, and Ying Wang

E-mail: fu_cheng111@163.com

With increasing depth of oilfield development, sublayers are becoming the main object of alkali-surfactant-polymer (ASP) flooding. Compared with major layers, sublayers differ in permeability, which may cause clogging of low-permeability layers when ASP solution containing polymer of the same molecular weight is injected into these layers. To solve this problem, injection allocators are widely used in oilfields. In this work, the jet nozzle channel was modeled using FLUENT 6.3 software. The ASP solution flowing through the jet nozzle channel in the injection allocator was simulated using a mathematical model based on Navier-Stokes equation and renormalization group (RNG) turbulence and power-law fluid models. The influences of nozzle diameter on the distribution of pressure difference, velocity, average strain rate, turbulence power, and apparent viscosity of the flow were analyzed. It was found that with increase of nozzle diameter the pressure difference and velocity of the flow decrease before and after passage through the nozzle, whereas the average strain rate increases gradually. The simulation results can provide theoretical guidance for optimal design of the nozzle.

Keywords: ASP flooding, polymer flooding, sublayers, jet nozzle, numerical simulation, injection allocator.

Deep rock fabric characteristics and optimization of drilling fluid composition for deeper zone of Longmenshan fault

Zhijun Li, Sheng Wang, Liyi Chen, Yang Wu, Jinyong Zhu, and Jiamin Hu

E-mail: 158588951@qq.com

The main objective of this study was to improve borehole wall stability in deep drilling into the Lonmenshan fault zone by developing a drilling fluid with ultra-fine inert materials. The mineral composition and microstructure of rock samples from deeper zones of the fault were analyzed by

X-ray diffraction and scanning electron microscopy. It was found that the rock has a loose fabric and is microporous and highly permeable. The main clay minerals in the rock are illite and chlorite, which are prone to hydrate and swell. Under high pressures, their hydration and swelling capacity increases, which may cause instability of boreholes. Based on the obtained mineral composition and surface microstructure data and analysis of the mechanism of additive action, the following was found to be the optimum composition of the drilling fluid that helped rapid drilling into the fault zone: water + 5% sodium bentonite + 0.3% Na2COe + 5% sodium bentonite in the form of hollow glass microspheres (HGM) + 2% polysaccharide polymer + 3% carboxymethyl cellulose.

Keywords: Longmenshan fault, drilling fluid, X-ray diffraction, scanning electron microscopy, ultrafine inert materials, clay minerals.

Design and field test of nitrogen circulation drilling system

Jun Li, Shunji Yang, Hui Zhang, Gonghui Liu, and Tengfei Sun

E-mail: Lijun446@vip.163.com

In recent decades, the merit of enhancing drilling rate by wellbore gas scavenging has been described comprehensively in many papers. This method began to be used widely and successfully in field conditions. In comparison with air and natural gas, due to its inertness and non-inflammability, gaseous nitrogen has become the most preferred fluid for drilling. The biggest shortcoming of using nitrogen gas as drilling fluid is high cost of its production. If the nitrogen gas circulated out of the wellbore can be recycled by some ground-based equipment and injected into the wellbore again, nitrogen gas drilling may become more viable. In this work, we developed a new nitrogen gas circulation drilling technology and carried out systematic study of the proposed project, namely, technological process, development of separation equipment, control system, etc. To verify the feasibility of this technology system, a comprehensive on-site experiment was designed and implemented for testing the prototype system.

Keywords: nitrogen gas circulation drilling, wellbore scavenging, system design, on-site test.

Impact of alkyl methacrylate-maleic anhydride-methacrylamide terpolymers as cold flow improver on crystallization behavior of diesel fuel

Jilu Chen, Tianliang Li, and Sheng Han

E-mail: Hansheng654321@sina.com

Alkyl methacrylate-maleic anhydride-methacrylamide terpolymers (MR1-MA-MCNR2) are one of the most widely used cold flow improvers (CFI). In order to develop more efficient MR1-MA-

MCNR2, it is necessary to study the crystallization behavior of diesel fuel after it is infused with MR1-MA-MCNR2. We synthesized MC14-MA-MCNR2 by reacting tetradecyl methacrylate (MC14), maleic anhydride (MA), and methacrylamide (MCNR2). The diesel fuel was filtered in situ before and after adding MC14-MA-MCNR2 at its cold filter plugging point (CFPP) in a manual CFPP apparatus. The influence of the amount of polymer additive on the fluidity of the system was studied. The results showed that the solid point (SP) at first falls gradually to -34°C and then rises sharply to -17°C with increase of the additive. The CFPP changed from -2°C to -5°C with increase of the additive and remained steady thereafter. The crystallization behavior of the diesel was studied by DSC, XRD and TEM analysis. The enthalpy ΔH of the system decreased initially with addition of CFI to the base diesel and then began to increase with further addition of CFI, which shows that the liquid-solid phase transition of the diesel is delayed and the crystallization start temperature is lower than that of the base diesel. The X-ray diffraction pattern of the CFI showed two distinct peaks at 2θ angle of 21.32 ° and 23.817 °, which indicate presence of complex crystals with a long-range order. The TEM photos showed that addition of CFI to the diesel leads to uneven crystal size and bonding of crystals. The difference in crystal size and bonding of crystals occurred due to insufficiency of crystallization centers in the diesel. The CFI performs is this case by eutectic mechanism.

Keywords: alkyl methacrylate, maleic anhydride, methacrylamide, terpolymers, cold flow improver, diesel fuel, filter plugging point, crystallization behavior.

Experimental study of mechanism of methane adsorption in coal under impact of electrostatic field

Chengwu Li, Po Hu, Dongji Lei, and Yingfeng Sun

E-mail: fslcw2000@163.com

The influence of electrostatic field on methane adsorption in coal was studied by putting two kinds of coal samples - samples from a normal coal seam and samples from a tectonically deformed coal seam - in a constant electrostatic field under various conditions. The values of Langmuir adsorption constants ‘a’ and ‘b’ of the coal samples were measured and the mechanism of methane adsorption under the impact of electrostatic field was analyzed. It was found that electrostatic field enhances gas adsorption and that tectonically deformed coal has a higher ‘a’ value than normal coal. The ‘a’ value basically remains unchanged after exposure to electrostatic field, while ‘b’ value tends to increase. The specific surface free energy g of the coal-gas adsorption system was estimated. The results showed that g value increases with increase in electrostatic field intensity.

Electrostatic field was found to enhance entropy S and reduce Gibbs free energy G of coals. Methane adsorption capacity of coals increases with increase in electrostatic field intensity (with the exception of some abnormal coals).
Keywords: electrostatic field, methane adsorption in coal, adsorption constant, entropy, surface free energy.