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Подготовка материалов
С. О. Бороздин,
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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

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Е. В. Королев, В. А. Меринов, М. Н. Михайлов, К. Б. Рудяк
ООО «РН-ЦИР»
KorolevEV@rdc.rosneft.ru

Возможные способы декарбонизации нефтегазовой отрасли
с использованием компактных технологий утилизации попутных газов

Ключевой особенностью компактных схем утилизации попутных газов является возможность повышения их углеродной эффективности различными способами. В работе рассмотрены способы подготовки синтез-газа и его компонентов, а также особенности организации компактных технологических схем переработки природного и попутного газа в премиальные синтетические жидкие топлива (GTL), использование которых позволяет значительно снизить углеродный след. Перспективным является получение экологичных авиационных топлив на базе керосина Фишера – Тропша (SAF FT-SPK) одностадийным гидрированием диоксида углерода.

Ключевые слова: диоксид углерода, природный газ, конверсия, углеродная эффективность, синтетическое топливо.

Y. V. Korolyev, V. A. Merinov, M. N. Mikhailov, K. B. Rudyak.
LLC "RN-RD CENTER"

Possible Decarbonization Ways In The Oil And Gas Industry
Using Small-Scale Oilwell Gas Utilization Technologies

A key feature of small-scale oilwell gas utilization technologies is the ability to increase their carbon efficiency in a variety of ways. The paper considers methods for preparing synthesis gas and its components, as well as the organization of small-scale technological schemes for processing natural and oilwell gas into premium synthetic liquid fuels (GTL), the use of which will significantly reduce the carbon footprint. A promising way among them is to produce SAF FT-SPK (Sustainable Aviation Fuel Fischer-Tropsch Synthetic Paraffin Kerosene) by one-stage hydrogenation of carbon dioxide.

Key words: *carbon dioxide, natural gas, reforming, carbon efficiency, synthetic fuel.*

Л. А. Хахин, И. А. Арутюнов, С. Н. Потапова, Д. В. Светиков, С. М. Масоуд
ООО «РН-ЦИР»
MasoudSM@rdc.rosneft.ru

Исследование технологических параметров суспензионного процесса получения этиленпропиленовых каучуков СКЭПТ в присутствии постметаллоценовой каталитической системы

Исследовано влияние параметров суспензионного процесса получения синтетических этиленпропиленовых каучуков СКЭПТ, обеспечивающие получение каучуков с выходом более 10 кг каучука на 1 г ванадия и физико-химическими свойствами, соответствующими наиболее востребованным маркам каучуков СКЭПТ. В качестве мономеров использовали этилен, пропилен, а также этилиденнорборнен или дициклопентадиен. Показано, что проведение суспензионного процесса в присутствии каталитической системы {2,4-ди-трет-бутил-6-[(трет-бутилимино)-метил]фенолят}оксодихлорида ванадия – этилтрихлорацетат – диэтилалюминий хлорида при обеспечивает получение каучуков СКЭПТ с выходом 20 000–23 000 г/г ванадия.

Полученные марки каучуков СКЭПТ могут использоваться в автомобильной и строительной промышленности, в производстве резинотехнических изделий, герметиков, клеев и присадок к технологическим жидкостям.
Ключевые слова: СКЭПТ, СКЭП, каучук, этилен, пропилен, постметаллоценовый катализ, суспензионный процесс.

L. A. Khakhin, I. A. Arutyunov, S. N. Potapova, D. V. Svetikov, S. M. Masoud.
LLC "RN-RD CENTER"
Investigation of Technological Parameters of the Suspension Process for the Production of Ethylene-Propylene Rubbers EP(D)M in the Presence of a Post-Metallocene Catalytic System
The influence of the parameters of the suspension process for the production of synthetic ethylene-propylene rubbers EPDM has been studied: pressure, temperature, ratio of reagents, and ratio of components of post-metallocene catalytic system. The process provides the production of rubbers with a yield of more than 10 kg of rubber per g of vanadium and physicochemical properties corresponding to the most demanded EPDM rubber grades. Ethylene and propylene were used as monomers. ENB or DCPD was used as the third diene monomer. It is shown that carrying out the suspension process in the presence of a catalytic system vanadium {2,4-di-tert-butyl-6-[(tert-butylimino)-methyl]phenolate}oxodichloride-ETCA-DEAC provides the production of EPDM rubbers with a yield of 10,000–23,000 g/g V. The obtained highly demanded grades of EPDM rubbers can be used in the automotive and construction industries, in the production of rubberous products, sealants, adhesives and additives to technological fluids.
Key words: *EPDM, EPM, rubber, ethylene, propylene, post-metallocene catalysis, synthesis, suspension process.*

Е. В. Королев, В. А. Меринов, М. Н. Михайлов, К. Б. Рудяк
ООО «РН-ЦИР»
KorolevEV@rdc.rosneft.ru
Обзор применяемых катализаторов и реакторов для дегидроароматизации природного и попутного нефтяного газа
В обзоре рассмотрены применяемые катализаторы и основные способы реализации процесса дегидроароматизации природного и попутного нефтяного газа, а также способы разделения газопродуктовой смеси. Приведено описание мембранных реакторов, реакторов с псевдоожиженным («кипящим») слоем катализатора, с движущимся слоем катализатора, а также с неподвижным слоем катализатора, используемых для осуществления процесса дегидроароматизации природного и попутного нефтяного газа.
Ключевые слова: природный газ, ароматические углеводороды, ароматизация, бензол, толуол, нафталин.

Y. V. Korolyev, V. A. Merinov, M. N. Mikhailov, K. B. Rudyak.
LLC "RN-RD CENTER"
Review of Catalysts and Reactors for Natural and Oilwell Gas Dehydroaromatization

The review discusses catalysts and implementation ways used for natural and oilwell gas dehydroaromatization process, as well as product gas mixture separation methods. Membrane reactors, fluidized catalyst bed, moving catalyst bed and fixed catalyst bed reactors used for dehydroaromatization of natural and oilwell gas are mentioned in the review.
Key words: *natural gas, aromatic hydrocarbons, aromatization, benzene, toluene, naphthalene.*

К. Б. Рудяк, К. Б. Полянский, Н. В. Верещагина, Д. Б. Земцов, Д. М. Панов, Т. М. Юмашева
ООО «РН-ЦИР»
PolyanskiyKB@rdc.rosneft.ru

Депрессорно-диспергирующие присадки к дизельному топливу.
Компоненты, марки, новые технологии и разработки

Рассмотрена ситуация на рынке депрессорно-диспергирующих присадок к дизельному топливу, приведены основные марки, показаны способы получения депрессорного и диспергирующего компонентов. Представлена информация о полифункциональной депрессорно-диспергирующей присадке, разработанной ООО «РН-ЦИР», улучшающей низкотемпературные, противоизносные и электрические свойства дизельных топлив.
Ключевые слова: депрессорно-диспергирующая присадка, депрессор,
диспергатор, дизельное топливо, полифункциональная присадка.

K. B. Rudyak, K. B. Polyanskii, N. V. Vereshchagina, D. B. Zemtsov, D. M. Panov, T. M. Yumasheva.
LLC "RN-RD CENTER"

Depressant and Dispersant Additives for Diesel Fuel.
Components, Brands, New Technologies and Developments

The situation on the market of depressor-dispersing additives for diesel fuel is considered, the main grades are listed, methods for obtaining depressant and dispersant components are shown. Information on multipurpose depressor-dispersing additive designed by LLC "RN-RD Centre", which improves the low-temperature, antiwear and electrical behavior of diesel fuels is presented.
Key words: *depressor-dispersing additive, depressant, dispersant, diesel fuel.*

К. Б. Рудяк, К. Б. Полянский, Н. В. Верещагина, А. А. Сенин, Г. А. Козлова, Т. М. Юмашева
ООО «РН-ЦИР»
PolyanskiyKB@rdc.rosneft.ru

Функциональные присадки к нефти и продуктам нефтепереработки
на основе депрессорных присадок ООО «РН-ЦИР»

Разработана линейка новых депрессорных присадок на основе сополимеров малеинового ангидрида и а-*олефинов, которая может быть использована для улучшения низкотемпературных характеристик нефти и практически полного спектра продуктов ее переработки. Представлены данные по депрессии температуры застывания нефти и нефтепродуктов после введении в них разработанных депрессорных присадок*

Ключевые слова: малеиновый ангидрид, альфа-олефины, депрессорная присадка, низкотемпературные характеристики, дизельное топливо, вакуумный газойль, мазут, масляные фракции, маловязкое судовое топливо.

K. B. Rudyak, K. B. Polyanskii, N. V. Vereshchagina, A. A. Senin, G. A. Kozlova, T. M. Yumasheva,
LLC "RN-RD CENTER"

Functional Additives for Oil And Petrochemichal Products
Based on Depressor Additives of LLC "RN-RD CENTRE"

A range of new pour point additives based on copolymers of maleic anhydride and alpha-olefins has been designed, that can be used to improve the low-temperature behavior of oil and almost all its derivatives. The data on the depression of the pour point temperature of oil and petrochemical products after doping them with the designed pour point depressants are submitted.

Key words: *depressant, maleic anhydride, alpha-olefins, copolymers, petrochemichal products.*

Г. А. Корнеева, О. Г. Карчевская, Т. Е. Крон, Д. В. Марочкин, Ю. Г. Носков
ООО «РН-ЦИР»
KarchevskayaOG@rdc.rosneft.ru

Свойства и получение триарилфосфатных огнестойких масел

Рассмотрены физико-химические свойства и способы получения огнестойких масел на основе триарилфосфатов. Описан разработанный в ООО «РН-ЦИР» процесс получения трет-бутилированного огнестойкого масла и обсуждаются перспективы его применения для возобновления производства огнестойких масел и гидравлических жидкостей на базе отечественного сырья.

Ключевые слова: огнестойкие масла, триарилфосфаты, триксиленилфосфат, *трет*-бутилированные триарилфосфаты.

G. A. Korneeva, O. G. Karchevskaya, T. E. Kron, D. V. Marochkin, Yu. G. Noskov.
LLC "RN-RD CENTER"

Properties and Preparation of Triaryl Phosphate Fire-Resistant Oils

The physicochemical properties and production fire-resistant oils based on triaryl phosphates are considered. The method for obtaining butylated fire-resistant oil developed in RD-RN Center is described. The application of this method for resuming the production of fire-resistant oils and hydraulic fluids based on raw materials available in the Russian Federation is discussed.

Key words: *fire-resistant oil, triaryl phosphates, trixylyl phosphate, butylated triaryl phosphates.*

О. Г. Карчевская[1], Т. Е. Крон[1], Г. А. Корнеева[1], Ю. Г. Носков[1], Л. В. Иванова[2]
[1]ООО «РН-ЦИР»,
[2]РГУ нефти и газа (НИУ) имени И. М. Губкина
KarchevskayaOG@rdc.rosneft.ru

Регенерация отработанных огнестойких масел на основе триарилфосфатов

Предложен способ регенерации огнестойких масел на основе триарилфосфатов, основанный на термической обработке безводным нейтрализующим агентом с последующей ректификацией реакционной смеси. В результате такой обработки отработанные триарилфосфатные масла очищаются от комплекса продуктов старения (кислот, фенолов, продуктов уплотнения, металлов износа, привнесенных шламов, воды). Способ обеспечивает высокие выходы регенерированных масел с качеством, отвечающим нормативным требованиям к огнестойким триарилфосфатным маслам для повторного использования.

Ключевые слова: триарилфосфаты, отработанное огнестойкое масло, регенерация.

O. G. Karchevskaya[1]*, T. E. Kron*[1]*, G. A. Korneeva*[1]*, Yu. G. Noskov*[1]*, L. V. Ivanova*[2]

[1]LLC "RN-RD CENTER,

[2] Gubkin Russian State University of Oil and Gas (National Research University)

Fire-Resistant Triaryl Phosphate Fluids Regeneration

The method for the regeneration of used fire-resistant oils based on treating oils with an anhydrous neutralizing agent at heating, followed by rectification has been developed. As a result of such treatment, used triaryl phosphate oils are purified from a complex of aging products (acids, phenols, sealing products, wear metals, introduced sludge, water). The method provides high yields of regenerated oils with quality that meets the regulatory requirements for fire-resistant triaryl phosphate oils for reuse.

Key words: *triaryl phosphates, fire-resistant oil, regeneration.*

Л. А. Хахин*[1]*, И. А. Арутюнов*[1]*, В. Л. Заворотный*[2]*, С. Н. Потапова*[1]*,

***Д. В. Светиков*[1]*, Е. В. Королев*[1]*, А. В. Кулик*[1]**

[1]ООО «РН-ЦИР»,

[2]РГУ нефти и газа (НИУ) имени И. М. Губкина,

PotapovaSN@rn-rdc.ru

Перспективы применения синтетических углеводородных основ — дисперсионных сред буровых промывочных жидкостей на неводной основе

Исследована возможность использования легкой (побочной) фракции процесса получения синтетических высокоиндексных низкозастывающих полиальфаолефиновых базовых масел на основе октена-1 в составе экологически безопасных технологических жидкостей на неводной основе, применяемых при бурении скважин в самых сложных горно-геологических условиях, в том числе при морском бурении. Показано, что димерная фракция октена-1 по своим показателям соответствует требованиям, предъявляемым к дисперсионным средам буровых растворов.

Ключевые слова: полиальфаолефины, синтетические углеводороды, дисперсионная среда, буровые растворы.

L. A. Khakhin[1]*, I. A. Arutyunov*[1]*, V. L. Zavorotny*[2]*, S. N. Potapova*[1]*, D. V. Svetikov*[1]*, E. V. Korolev*[1]*, A. V. Kulik*[1]

[1]LLC "RN-RD CENTER,

[2] Gubkin Russian State University of Oil and Gas (National Research University)

Application Prospects of Synthetic Hydrocarbon Bases –

Dispersion Mediums of Non-Aqueous Drilling Fluids

The possibility of using a light (by-product) fraction of the process of producing synthetic high viscosity index, low pour point polyalphaolefin base oils based on octene-1 as part of environmentally safe non-aqueous process fluids used in drilling wells in the most difficult mining and geological conditions, including offshore drilling, is investigated. It is shown that the dimeric fraction of octene-1 meets the requirements for the dispersion media of drilling fluids.

Key words: *polyalphaolefins, synthetic hydrocarbons, dispersion phase, drilling fluids.*

А. Х. Купцов, Е. В. Жмаева, А. В. Кулик, К. Б. Рудяк

ООО «РН-ЦИР»

KuptsovAK@rdc.rosneft.ru

Эффективный метод полного контроля процессов производства поли-□-олефиновых масел — лазерная спектроскопия комбинационного рассеяния

Разработанные подходы к увеличению селективности анализа методом лазерной спектроскопии комбинационного рассеяния, применение хемометрики и патентованного алгоритма самонастройки калибровочных моделей при экономичности и быстроте метода показали возможность информационно равнозначного онлайн контроля всех технологических стадий производства поли- -олефиновых масел и других продуктов через сеть оптоволоконных зондов. Олигомеры -олефинов C_6, C_8 и C_{10}, получаемые по разработанной в РН-ЦИР технологии гетерогенного хром-оксидного катализа, как показано по спектрам комбинационного рассеяния, отличаются от получаемых гомогенным синтезом аналогов разнообразием структур ненасыщенных групп, а также большей шириной и вариативностью молекулярно-массового распределения, что позволяет регулировать широкий ассортимент продуктов низкой и высокой молекулярной массы. Особый случай — нетипично высокая чувствительность спектров комбинационного рассеяния к длине цепи — позволяет в процессе синтеза прогнозировать и корректировать в реальном времени молекулярную массу олигомеров и другие целевые показатели, замещая одним методом парк традиционного аналитического оборудования.

Ключевые слова: спектроскопия комбинационного рассеяния, самонастраиваемая модель, контроль процессов, □-олефины, олигомеризация, синтетические масла.

A. Kh. Kuptsov, E. V. Zhmaeva, A. V. Kulik, K. B. Rudyak.

LLC "RN-RD CENTER"

Effective Method for Full Cycle Control of Technological Processes

of Poly-a-Olefines Production – Laser Raman Spectroscopy

The developed approaches to increasing the selectivity of analysis by laser Raman spectroscopy, the use of chemometrics and a proprietary algorithm for self-tuning calibration models with the efficiency and speed of the method have shown a rare and excellent opportunity for information equivalent on-line control of all technological stages of the production of poly-□-olefin oils and other products through a network of fiber-optic probes. The oligomers of □-olefins C_6, C_8 and C_{10} obtained by the technology of heterogeneous chromium-oxide catalysis

developed at RN-RDC, as shown by the Raman spectra, differ from analogues obtained by homogeneous synthesis by a variety of structures of unsaturated groups, as well as by a greater width and variability of molecular mass distribution, which makes it possible to regulate a wide range assortment of low and high molecular weight products. A special case – the atypically high sensitivity of Raman spectra to the length of the chain – make it possible in the synthesis process to predict and adjust in real time the molecular weight of oligomers and other target properties, and replacing a fleet of traditional analytical equipment with one method.

Key words: *laser raman spectroscopy, self-tuning model, process control, □-olefins, oligomerization, synthetic base oil stocks.*

В. Ю. Гейгер, Е. Г. Петрова, В. В. Фадеев, С. В. Заглядова
ООО «РН-ЦИР»
PetrovaEG@rdc.rosneft.ru

Технология приготовления сферического носителя для катализатора непрерывного риформинга

В работе представлена технология масляного формования сферического оксида алюминия, модифицированного оксидом олова, который применяется для синтеза катализаторов риформинга с непрерывной регенерацией катализатора.

Ключевые слова: оксид алюминия, носитель катализатора, масляное формование, катализатор непрерывного риформинга.

V. Yu. Geiger, E. G. Petrova, V. V. Fadeev, S. V. Zaglyadova.
LLC "RN-RD CENTER"

The Spherical Alumina Preparation Technology for a Continuous Catalytic Reforming Catalyst

The paper presents the technology of spherical alumina production by oil-drop method developed at RN-RDC, LLC. Alumina is modified by tin oxide and is used for the synthesis of reforming catalysts with continuous catalyst regeneration.

Key words: *alumina, catalyst carrier, oil drop method, continuous reforming catalyst.*

Б. В. Шнейдер, С. В. Орлов, О. Ю. Пушкина, Е. В. Жмаева
ООО «РН-ЦИР»
ZhmaevaEV@rdc.rosneft.ru

Способы пробоподготовки катализаторов процессов нефтепереработки для определения их элементного состава методами атомной спектроскопии

Рассмотрены способы химической пробоподготовки (высокотемпературное сплавление, автоклавное разложение и кислотное растворение в открытых системах) катализаторов процессов нефтепереработки для определения элементного состава методом атомно-эмиссионной спектроскопии с индуктивно связанной плазмой АЭС-ИСП. Изучено влияние HNO_3, H_3PO_4, H_2SO_4, H_2O_2, Li_2B4O_7, необходимых для переведения

катализаторов в раствор, на величину аналитического сигнала для ряда элементов. Установлены закономерности и особенности различных способов пробоподготовки и их влияние на полноту перехода тех или иных элементов в раствор.

Ключевые слова: катализаторы процессов нефтепереработки, пробоподготовка, элементный состав, атомная спектроскопия.

B. V. Schneider, S. V. Orlov, O. Yu Pushkina, E. V. Zhmaeva.
LLC "RN-RD CENTER"

Approaches of Sample Preparation of Catalysts for Oil Refining Processes to Determine Their Elemental Composition by Atomic Spectroscopy Methods

Chemical sample preparation methods (such as high temperature fusion, autoclave decomposition and acid dissolution in open systems) of catalysts for oil refining processes to determine their elemental composition by using Inductively coupled plasma atomic emission spectroscopy were considered. The influence of HNO_3, H_3PO_4, H_2SO_4, H_2O_2, $Li_2B_4O_7$ necessary for the conversion of the catalysts into an solution on the value of the analytical signal for the some elements was studied. Regularities and features of various methods of sample preparation and their influence on the completeness of the transition of certain elements into solution are established.

Key words: *catalysts for oil refining processes, sample preparation, elemental composition, atomic spectroscopy.*

Н. В. Карпов[1], Н. Н. Вахромов[1], Э. В. Дутлов[1], Е. А. Шарин[2], М. А. Бубнов[1], И. В. Гудкевич[1], С. С. Ковальчук[1], А. Л. Максимов[3], В. В. Фадеев[4], К. Б. Рудяк[4], А. А. Романов[5], Д. В. Борисанов[1]
[1]ПАО «Славнефть-ЯНОС»,
[2]ФАУ «25 ГосНИИ химмотологии Минобороны РФ»,
[3]Институт нефтехимического синтеза им. А. В. Топчиева РАН,
[4]ООО «РН-ЦИР»,
[5]ГОУ ЯО «Лицей № 86», г. Ярославль
BorisanovDV@yanos.slavneft.ru

Дизельное топливо для применения в условиях Арктики и субтропиков

В работе рассмотрена возможность получения всесезонного дизельного топлива, эффективное использование которого возможно как в условиях Арктики, так и в условиях субтропического климата. Полученное топливо обладает цетановым числом на уровне требований к летним дизельным топливам уровня Евро 5, температурой вспышки не ниже 62°С и температурой застывания не выше минус 55°С без вовлечения депрессорно-диспергирующей присадки. Проведенные исследования показали, что ни одна из узких фракций, выделенных из нефти, характерной для НПЗ центральной части России, не обладает требуемыми свойствами даже с учетом ввода промоторов воспламенения. Улучшение низкотемпературных свойств за счет крекинга н-алканов в процессе каталитической депарафинизации приводит к существенному снижению цетанового числа, поэтому в работе рассмотрено применение процесса изодепарафинизации дизельного топлива на платиновом катализаторе. Этот процесс позволяет существенно улучшать низкотемпературные свойства депарафинизата при умеренном снижении его цетанового числа. Определены оптимальные условия проведения процесса изодепарафинизации, подобранно

оптимальное сырье для установки. По разработанной технологии на ПАО «Славнефть-ЯНОС» была выпущена первая в мире промышленная партия унифицированного всесезонного дизельного топлива.

Ключевые слова: дизельное топливо, температура помутнения, температура застывания, температура вспышки, унифицированное дизельное топливо.

N. V. Karpov[1], N. N. Vakhromov[1], E. V. Dutlov[1], E. A. Sharin[2], M. A. Bubnov[1], I. V. Gudkevich[1], S. S. Koval'chuk[1], A. L. Maksimov[3], V. V. Fadeev[4], K. B. Rudyak[4], A. A. Romanov[5], D. V. Borisanov[1].

[1] PJSC "Slavneft-YANOS"

[2] The 25th State Research Institute of chemmotology of the Ministry of Defence of the Russian Federation

[3] A.V.Topchiev Institute of Petrochemical Synthesis, RAS (TIPS RAS)

[4] LLC "United Research and Development Centre" (RN-RDC, LLC),

[5] State educational institution "Lyceum No. 86"

Diesel Fuel for Use both in Arctic and in Subtropical Regions

This paper reviews the possibility to obtain all-season diesel fuel, the effective use of which is possible both in the Arctic and in the subtropical climate. The resulting fuel has a cetane number at the level of requirements for summer diesel fuels of Euro 5 standard, a flash point in accordance with not less than 62°C and a pour point not higher than minus 55°C without the involvement of a depressant-dispersant additive. The conducted research has shown that none of the narrow fractions isolated from oil typical for refineries in the central part of the Russian Federation, has the required properties, even taking into account the introduction of ignition promoters. The improvement of low-temperature properties due to the cracking of n-alkanes in the process of catalytic dewaxing leads to a significant decrease in the cetane number; therefore, in this paper, the application of the process of diesel fuel isodewaxing on a platinum catalyst is considered. This process makes it possible to significantly improve the low-temperature properties of the dewaxed product with a moderate decrease in its cetane number. The optimal conditions for the process of isodewaxing were determined, the optimal feed for the unit was selected.

Key words: *diesel fuel, cloud point, pour point, flash point, unified diesel fuel.*

И. Н. Куляшова[1], А. В. Сидельников[1], А. Д. Бадикова[1], А. Р. Сафина[1], А. Г. Мустафин[1,2]

[1]Уфимский государственный нефтяной технический университет,

[2]Уфимский институт химии Уфимского федерального исследовательского центра РАН

irina-0472@yandex.ru

Исследование физико-химических закономерностей получения полиэлектролитного комплекса как эффективного ингибитора солеотложений на основе хлорида полидиаллилдиметиламмония и лигносульфоната натрия

Представлен способ получения ингибитора солеотложений на основе полиэлектролитного комплекса, включающего в качестве исходных составляющих анионный природный полимер (лигносульфонат натрия) и катионный синтетический полимер (полидиаллилдиметиламмоний хлорид). Получение устойчивого полиэлектролитного комплекса проведено путем подбора мольных соотношений анионных и катионных составляющих в составе технических сырьевых смесей с использованием метода импедансной спектроскопии, заключающегося в измерении зависимости импеданса электрохимической ячейки от

частоты переменного тока. Экспериментально показана эффективность полученного полиэлектролитный комплекса как ингибитора солеобразования в пластовых водах различного состава в условиях воздействия температур.

Ключевые слова: лигносульфонат натрия, полидиаллилдиметиламмоний хлорид, анионный полиэлектролит, катионный полиэлектролит, метод импедансной спектроскопии, полиэлектролитный комплекс, мольные соотношения, ингибитор солеотложений.

I. N. Kulyashova[1], A. V. Sidelnikov[1], A. D. Badikova[1], A. R. Safina[1], A. G, Mustafin[1,2]
[1]Ufa State Petroleum Technical University,
[2]Research Center of the Russian Academy of Sciences, Ufa

Investigation of the Physico-Chemical Regularities of Obtaining a Polyelectrolyte Complex as an Effective Inhibitor of Salt Deposition Based on Polydiallylammonium Chloride and Sodium Lignosulfonate

A method for obtaining a salt deposition inhibitor based on a polyelectrolyte complex, including as initial components: anionic natural polymer – sodium lignosulfonate and a cationic synthetic polymer – polydiallyldimethylammonium chloride. Obtaining a stable polyelectrolyte complex was carried out by selecting the molar ratios of anionic and cationic components using a promising method of impedance spectroscopy, which consists in measuring the dependence of the impedance of an electrochemical cell on the frequency of alternating current. The resulting polyelectrolyte complex has the properties of an effective inhibitor of salt formation in reservoir waters of various compositions under the influence of temperatures.

Key words: *sodium lignosulfonate, polydiallyldimethylammonium chloride, anionic polyelectrolyte, cationic polyelectrolyte, impedance spectroscopy method, polyelectrolyte complex, molar ratios, salt deposition inhibitor.*

И. Н. Куляшова, А. Р. Сафина, А. Д. Бадикова, Д. Р. Киреева, Д. И. Бежан
Уфимский государственный нефтяной технический университет
irina-0472@yandex.ru

Определение оптимальных условий синтеза модифицирущей добавки на основе акриламида и лимонной кислоты с целью получения лигносульфонатного реагента для буровых растворов

Определены условия синтеза модификатора на основе акриламида и лимонной кислоты с целью получения лигносульфонатного реагента для буровых растворов. С целью подбора оптимальных условий синтеза модификатора, с последующим диспергированием в массе лигносульфоната натрия, варьировались соотношение исходных компонентов, температура и продолжительность процесса. С целью изучения изменения структуры макромолекулы лигносульфоната натрия и модифицированного лигносульфонатного реагента исследовано распределение частиц по размерам. Исследования поверхностной активности экспериментальных образцов проведено сталагмометрическим методом (метод счета капель). Экспериментально показана эффективность синтезированного модификатора и лигносульфонатного реагента регулировать параметры бурового глинистого раствора.

Ключевые слова: акриламид, лимонная кислота, лигносульфонат натрия, модифицированный лигносульфонатный реагент, поверхностное натяжение, буровой раствор, эффективная вязкость, показатель фильтрации.

I. N. Kulyashova, A. R. Safina, A. D. Badikova, D. R. Kireeva, D. I. Bejan
Ufa State Petroleum Technical University

Optimal Conditions for the Synthesis Based on Acrylamide, Citric Acid and Sodium Lignosulfonate in Order to Obtain a Reagent for Drilling Fluids

The conditions for the synthesis of a modifier based on acrylamide and citric acid in order to obtain a lignosulfonate reagent for drilling fluids are determined. In order to select optimal conditions for the synthesis of the modifier, followed by dispersion in the mass of sodium lignosulfonate, the ratios of the initial components, temperature and duration of the process varied. In order to study the changes in the structure of the macromolecule of sodium lignosulfonate and the modified lignosulfonate reagent, the particle size distribution was studied. Studies of the surface activity of experimental samples were carried out by the stalagmometric method (the method of counting drops). The effectiveness of the synthesized modifier and lignosulfonate reagent to regulate the parameters of drilling mud has been experimentally shown.

Key words: *acrylamide, citric acid, sodium lignosulfonate, modified lignosulfonate reagent, particle size, surface tension, drilling mud, effective viscosity, filtration index.*

Yinghua Gong[1,2], Tianduo Li[2]*, A.A. Krainov[1], D. V. Voronin[1], A. P. Semenov[1]*,
V. N. Dubinich[1], A. A. Panchenko[1], V. A. Vinokurov[1]

[1] Gubkin University, Moscow, Russian Federation;

[2] Shandong Provincial Key Laboratory of Molecular Engineering, School of Chemistry and Chemical Engineering, Qilu University of Technology (Shandong Academy of Sciences), Jinan, China.

litianduo@qlu.edu.cn, semenov.a@gubkin.ru

Functional Materials Based on Carboxylated Nanofibrillar Cellulose

In this work, we synthesized samples of carboxylated nanofibrillar cellulose (NFC) and a derivative that is a product of chemical crosslinking of carboxylated NFC with ethylenediamine. The results of transmission electron microscopy revealed that crosslinking does not lead to noticeable morphological changes in the NFC structure. The chemical modification of the carboxylated NFC was confirmed by FTIR spectroscopy. It was found that chemical crosslinking of carboxylated NFC with ethylenediamine leads to an increase in the colloidal stability of aqueous suspensions, water retention capacity, and dynamic viscosity of gels. The study of the rheological characteristics showed that the aqueous dispersions of the obtained samples are pseudoplastic liquids and have thixotropic properties.

Keywords: *carboxylated nanofibrillar cellulose, crosslinked nanofibrillar cellulose, ethylendiamine, viscosity.*

Yuesheng Zhu[1], Yongmin Shi[2,3]*, Bo Yang[1], Jun Shi[1], Hu Zhao[1]

[1] Luliang Field Operation District, Xinjiang Oilfield Company, Petro China, Karamay Xinjiang, China;

[2] Shaanxi Key Laboratory of Chemical Additives for Industry, College of Chemistry and Chemical Engineering, Shaanxi University of Science and Technology, Xi' an, China;

[3] School of Earth and Space Sciences, Peking University, Beijing, China.

sym@pku.edu.cn

Permeability Characteristics and Influencing Factors of Fracturing Fluid in Glutenite Reservoir Based on NMR

The low permeability conglomerate reservoir in Mahu sag has huge resource potential. However, due to the large distribution of fine throats and complex pore seepage system, Mahu tight glutenite reservoir is characterized by large production difference of single well, high oil and gas decline rate and low recovery factor. In this paper, the microstructure and composition characteristics of Mahu conglomerate are studied by means of NMR, Water sensitive injury experiment was carried out. The results show that the strong heterogeneity of the reservoir in Mahu Baikouquan formation seriously affects the physical property characteristics and pore throat development characteristics. The strong heterogeneity leads to the uneven advance of water drive front, and the highest recovery factor is 30%. With the increase of the number of soak back flow, the fracture closed unevenly, resulting in the low flowback rate of soaking well after fracturing. The higher the proppant concentration is, the stronger the conductivity is. Compared with carbon dioxide, natural gas and deoxidized air, the oil displacement efficiency of carbon dioxide is the highest (70–85%), followed by natural gas (55%). In the aspect of research on the law of cross permeability between fractures and matrix, the natural energy release and exploitation of conglomerate reservoir is carried out. The recovery factor is relatively low, but after natural gas flooding, the core matrix will supply oil to the fractures in the process of backflow, which eventually makes the oil saturation in the matrix decrease significantly, and the degree of crude oil production increases. The matrix in the middle of the fracture is the main residual oil enrichment area. It is of great significance to improve the recovery rate of conglomerate.

Keywords:

Kongzhong Liu[1], Xiaoyu Dong[2], Yao Zhou[3]*, Pingan Duan[2], Jiu Cheng[2]

[1] CNOOC China Ltd._Zhanjiang, Guangdong, China;

[2] CNOOC China Ltd._Hainan, Hainan, China; [3] China University of Petroleum-Beijing, Beijing, China.

email_zhouy@sina.com

Three-Proof Optimization of Gas Turbine Generator Set of Offshore Platform

The Marine environment is characterized by high salt content and humidity in the air, and the gas components in gas generators are complicated and corrosive, leading to the occurrence of low temperature and hot corrosion on the surface and inside of gas generators, which seriously affects the performance, reliability and service life of gas turbines. Taking AGT-7B gas turbine as the research object, this paper conducts a theoretical analysis on the corrosion resistance of low-temperature components, high-temperature components and non-metallic components of gas turbine.By conducting salt spray corrosion test, anti-corrosion ability test after surface protection and gas corrosion test before and after coating on the selected alloys of high-temperature components, a series of anti-corrosion design schemes of gas turbine components under marine environment are obtained, and the protection measures of the whole gas turbine generator set under marine environment are given.

Keywords: *hot corrosion, low temperature corrosion, AGT-7B gas turbine, corrosion protection scheme*

***Pingsheng Wang[1,2], Ruibao Zhao[2], Yuancheng Guo[1], Junjie Wu[2], Fenglin Hou[2], Yuanxing Zhu[2] **

[1] School of Civil Engineering, Zhengzhou University, Zhengzhou, China;

[2] Zhengzhou China Resources Gas Co. Ltd, Zhengzhou, China

zhuyuanxing@126.com

Urban Gas Load Forecasting Based on Time Series Methods

Accurate forecasting of natural gas load forecasting is of great practical significance to balance supply and demand of gas system. Load forecasting is categorized in long-term, mid-term and short-term. Among them, mid-term load forecasting that monitors monthly operations is of decisive significance to urban gas pipe network planning, gas engineering project construction and design. In this study, we adopt Prophet model that reflects the seasonal fluctuations and holidays influence to forecasting the monthly gas load of urban gas and compare the results with the other two forecasting methods such as autoregressive integrated moving average model (ARIMA) and exponential smoothing prediction method (ESM). The models were trained and tested on gas consumption data gathered in one central city in China from 2017 to 2021. The result shows that an increasing trend with an average growth rate between 10% and 20% year by year, a decreasing trend at an average rate of 14.9% on legal holiday. According to this study, the Prophet model has an excellent performance in monthly natural gas forecasting.

Keywords: *load forecasting, urban gas, prophet, gas storage and peak shaving.*

En Li, Yun Liu✉, Xintong Zeng, Lin Zheng, Senlin Wu, Yifan Wang

School of Petroleum Engineering, Yangtze University, Wuhan, China

enli970712@gmail.com

For Acidic and Inhibitor-Containing Systems

A dissociation model suitable for the formation of gas hydrate in acidic and alkali-containing systems is established. By introducing inertia weight factor, an improved sinusoidal and cosine algorithm is obtained to optimize BP neural network and build ISCABP gas hydrate prediction model. The ISCABP model and other thermodynamic models were used to predict the hydrate formation conditions of four groups of (CH_4+CO_2+ H_2S) gas mixtures in acidic system, and the hydrate formation conditions of six groups of gas + liquid phase in alkoxide system. The temperature range is 240.15-308.45 K, and the pressure range is 0.05-82.56 mPa. The concentrations of H_2S and CO_2 in the mixture were 4.95-27.93% (mol) and 6.79-8.4% (mol), respectively. The results show that ISCABP hydrate model has the best predictive value. The model has strong applicability to gas field production, and can provide a theoretical basis for determining the injection amount of inhibitor and formulating the field safe operation strategy.

Keywords: *natural gas hydrate, ISCABP neural network, inertia weight, flow assurance, reverse learning.*

Zheng Wang[1], Yuehua Wen[2] *, Yilin Li[1], Jingpeng Wang[1], Wei Liu[2]

[1] PetroChina Xinjiang Oilfield Company, Karamay, Xinjiang China;

[2] State Key Laboratory of Petroleum Resources and Engineering, China University of Petroleum, Beijing, China

15161135603@163.com

Effect of Poroelasticity on the Integrity of Cement Sheath in Heavy Oil Wells

Integrity of cement sheath is critical for safe and effective operation of heavy oil wells. The cement sheath has been generally treated as elastic solid in existing models for integrity analysis. However, it has been evidenced by some recent research findings that cement is essentially a porous solid, and thus poroelasticity effect may be remarkable. In this paper, we established a transient poro-thermo-mechanical coupling finite element model and investigated the pore pressure and stress evolution within the cement sheath during the heat injection process of heavy oil wells, with the emphasis on clarifying the effect of poroelasticity of cement and formation on the integrity of cement sheath. It is found that temperature rise during heat injection results in considerable pore pressure increase and thus greatly affects the stress distribution within the cement sheath. For the cement sheath between the casing and the rock formation, the pore pressure within the cement sheath decreases gradually with time due to fluid diffusion into the formation. In contrast, the high pore pressure remains almost constant within the cement sheath between two casings, resulting in tensile effective stress within the cement sheath and raise a high risk of failure, which cannot be predicted by existing elasticity model.
Keywords: *cement sheath integrity, poro-thermo-mechanical model, heat injection.*

Cao Jifei[1,2], Zou Deyong[1]*, Li Cheng[2], Huang Zhe[2], Cui Yudong[3]

[1] School of Petroleum Engineering, China University of Petroleum (East China), Qingdao, China;

[2] Drilling Technology Research Institute, SINOPEC Shengli Oilfield Service Corporation, Dongying, China;

[3] Shengli Oil Production Plant, Shengli Oilfield Company, SINOPEC, Dongying, China

371214766@qq.com

Simulation Analysis of Igneous Rock Breaking Law under Cut-Impact Load

Aiming at the problem of low efficiency of breaking Igneous rock, the models of breaking Igneous rock under cut-impact loads by spherical cutter, wedge cutter, and conical cutter were established respectively based on rock mechanics and finite element theory, and the Igneous rock breaking processes of three types of cutter under different combinations of impact parameters are simulated. The variation curves with impact parameters of Igneous rock breaking depth and volume, mechanical specific energy, and average tangential force of cutters are subsequently obtained, and the influence of cutter types, impact frequency, impact force on rock breaking efficiency were analyzed. Moreover, the mechanical properties of the cores collected from Hashan block and Mulei block in Junggar basin are analyzed by expariments under the condition of confining pressure. When the confining pressure reaches 60 MPa, the compressive strength of HS-3 and ML-3 rock samples reach 730.72 MPa and 301.75 MPa respectively. The results show that the impact resistance of spherical cutter is the best. When the weight of bit is 600 N and cutting speed is 1000 mm/s, the rock breaking efficiency of spherical cutter is the lowest, followed by conical cutter, and the wedge cutter is the highest. The drilling bit used in breaking Igneous rock under cut-impact loads should be a combination of these three types of cutters, which could improve the rock breaking efficiency by impact operation, and ensure the service life of bit. The results could provide basis for the design of drill bit and the parameters selection of impact tools for Igneous rock.

Keywords: *Igneous rock, impact, spherical cutter, wedge cutter, rock breaking efficiency.*

Shengli Gao[1]*, Wenyi Zhang[2]*

[1] Xi'an Shiyou University, Xi'an , Shaanxi, China;

[2] Key Laboratory of Oil and Gas Reservoir Geology of Shaanxi Province. Xi'an, China.

gshl@xsyu.edu.cn, 731454376@qq.com

Calculation of Formation Overpressure and Its Role in Hydrocarbon Accumulation

Based on the acoustic time difference data of more than 200 Wells, the equilibrium depth method is used to calculate the recovery of overpressure. According to the average excess pressure of a single well, the excess pressure plane and section maps of Chang 7-Chang 8 of Yanchang formation in Ordos Basin were drawn up. The results show that during the maximum burial period, high pressure anomalies start from the upper and lower strata of Chang 6 member of Yanchang formation, and the amplitude of abnormal pressure varies with different regions. The Tianchi-Baibao line in the northwest of the study area and the Qingcheng-Ningxian line in the west formed two high value areas, which spread from northwest to southeast, and the excess pressure difference (length 7-length 8) was mostly 10-20 Mpa.The area with large formation excess pressure difference is a potential favorable exploration area for Chang 8 reservoir. At present, large Chang 8 reservoirs are found in the southwest of the basin, and most of them are located in areas with high abnormal pressure. This method has strong theoretical value and practical guiding significance in basin oil and gas exploration, and is expected to be widely applied and promoted.

Keywords: *logging sonic differential time, chang 8 formation, equilibrium depth method, formation overpressure calculation, Ordos Basin.*

Jingfu Mu*, Hongjun Qiao, Qing Guo

Research Institute of Shaanxi Yanchang Petroleum (Group) Co., Ltd, Shaanxi, China.

474822008@qq.com

A Fracture Toughness-Based Evaluation Method for Deep Shale Oil Reservoir Compressibility

Compressibility is a key parameter in shale volumetric fracturing design and effect evaluation, which reflects the ability of shale oil reservoirs to be pressed open and form complex network fractures of a certain scale under existing technology conditions. Existing compressibility index evaluation methods are mainly based on static data such as experimental data or logging evaluation, and the influencing factors of compressibility are different, resulting in unsatisfactory evaluation results. In order to solve the shortcoming of using brittleness index only to evaluate shale reservoir compressibility, this paper not only considers the influence of fracture toughness on compressibility, but also introduces another influencing parameter – critical mechanical energy release rate. The effect of type I fracture toughness on shale joint and fracture development and the average critical mechanical energy release rate during shale reservoir sliding are studied. Finally, combined with the sliding average critical mechanical energy release rate and brittleness index, a primary model of shale reservoir compressibility evaluation based on fracture development index is established. This method can provide ideas for accurately evaluating the compressibility of deep shale reservoirs.

Keywords: *shale oil, fracability, rock mechanics, brittleness evaluation.*

Dandan Yuan[1], Yuehua Wen[2], Shiyuan Xie[1], Hao Zhang[1], Wei Liu[2] *

[1] PetroChina Xinjiang Oilfield Company, Karamay, Xinjiang, China;

[2] State Key Laboratory of Petroleum Resources and Engineering, China University of Petroleum, Beijing, China

1134697219@qq.com

Experimental Study on Mechanical Properties of Cement Doped with Different Latex Contents

Increasingly complex oil production formations and fracturing stimulation measures have put forward higher requirements for the performance of oil-well cement. Adding a certain amount of latex to the cement slurry can improve the ability of the cement to resist impact damage so that the integrity of cement can be maintained throughout the fracturing operation and the life cycle of the well. Therefore, this paper carried out rock mechanics experiments on cement stones doped with different latex contents (0%, 3%, 8%, 15%) under different stress paths, and clarified the effect of latex content on the deformation and strength parameters of cement stones. It finds that adding latex can improve the mechanical properties of cement stone and reduce its elastic modulus, but adding too much latex may cause large unrecoverable volumetric plastic deformation. With the increase of latex content, the elastic modulus of cement decreased significantly, and the uniaxial compressive strength of cement decreases with the increase of latex content, however, the decrease is not significant. The unrecoverable volumetric plastic deformation of cement increases with the increase of latex content, and it also increases with the increase of confining pressure. It provides theoretical support for the optimization of cement slurry systems and directs the fine design of cement slurry systems.

Keywords: *cement slurry, different latex contents, mechanics experiments of cement, deformation and strength parameters of cement.*

Junyao Deng[1,2], Ai Zhang[3], Yuan Ji[1,2], Xiaoyi Sun[1,2], Junlin Su[3] *

[1] PetroChina Coalbed Methane Company Limited, Bejing, China;

[2] China United Coalbed Methane National Engineering Research Centre Co. Ltd., Beijing, China;

[3] State Key Laboratory of Oil and Gas Reservoir Geology and Exploitation, Southwest Petroleum University, Chengdu, Sichuan, China

sjlzr2006@163.com.

Research on Gel Plugging Technology of Coalbed Methanein Deposit

Daji block is an important arear of producing and energy in Lifen block of coalbed gas. There are the natural leak-causing crack, water in the formation, narrow security density window, serious leakage and poor plugging in this area. In order to solve the problems, this paper adopted the compound gel plugging technology, which has the advantages of both supramolecular organic gel and inorganic gel, to prevent leakage in this well area. Laboratory tests show that the safe construction time of the composite gel can be controlled within 1-1.5 hours, and the pressure bearing capacity of cracks of 4.0 □ 3.5 mm and 3.0 □ 2.5 mm can respectively reach 3.3 and 4.5 MPa.

It has strong cementing ability to rock particles, and the pressure bearing capacity of 14cm squeezed into the 6-8 mesh sand filling pipe can be 5.6 MPa. Field application show that the special gel technology have the characteristics of easy pump injection and simple construction as well as improve the plugging effect of Daji block.

Keywords: *coalbed methane, plugging, gel, linfen.*

Jin Li[1], Xiuli Sun[1] *, Di Wu[2], Siming Zhai[2], Shuangchun Yang[1], Adilet Toktonaliev[1], Yi Pan[1]

[1] Liaoning Petrochemical University, Fushun, Liaoning, China;

[2] Fushun Petrochemical Company Number 2 Plant of PetroChina Company Limited, Fushun, Liaoning, China.

sxl19781978@126.com

Application of Oil Shale Molecular Sieve Catalyst: a Review

In the catalytic cracking reaction of oil shale, molecular sieve is a catalyst with wide application potential because of its good thermal stability and hydrothermal stability. In this paper, the research progress of molecular sieve catalysts and metal-supported molecular sieve catalysts in the field of catalytic pyrolysis of oil shale is reviewed, and the structural characteristics of commonly used molecular sieves and the influencing factors of molecular sieves on the pyrolysis products of oil shale are summarized. Then, it is proposed that molecular sieves loaded with corresponding transition metals, alkali and alkaline earth metals (AAEM) can further increase the oil yield and improve the composition of shale oil products. Finally, the future research direction of molecular sieve in catalytic pyrolysis of oil shale is put forward, including the preparation method of catalyst can be greener, the preparation of molecular sieve-loaded nanoparticles and molecular sieve catalysts that can be applied to in-situ exploitation of oil shale.

Keywords: *hcatalytic pyrolysis, oil shale, molecular sieve, metal supported molecular sieve, reaction dynamics.*