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Каталитический оксикрекинг вакуумного газойля

Исследован процесс каталитического оксикрекинга вакуумного газойля в присутствии цеолитсодержащего катализатора ОМНИКАТ-210П. Установлено, что температура и степень окисления оказывают одинаковое влияние на степень превращения сырья и выход продуктов реакции, тогда как температура и время контакта — антибатны. Показано, что ввод кислорода способствует образованию дизельной фракции и углеводородного газа. Определение физико-химических характеристик узких фракций позволило оценить качество потенциальных товарных прямогонных продуктов оксикрекинга вакуумного газойля в зависимости от технологических условий процесса.

Ключевые слова: каталитический оксикрекинг, окислительный крекинг,
вакуумный газойль, цеолитсодержащий катализатор, фракционный состав.
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Catalytic Oxycracking of Vacuum Gas Oil

The process of catalytic oxycracking of vacuum gas oil in the presence of a zeolite-containing catalyst OMNIKAT-210P was studied. As a result of studying the influence of technological parameters on process parameters, it was found that temperature and degree of oxidation have the same effect on the degree of conversion of raw materials and the yield of reaction products, while temperature and contact time are antithetical. It has been shown that the introduction of oxygen promotes the formation of diesel fraction and hydrocarbon gas. Determination of the physicochemical characteristics of narrow fractions made it possible to assess the quality of potential commercial straight-run products of oxycracking of vacuum gas oil, depending on the technological conditions of the process.

Key words: *catalytic oxycracking, oxidative cracking, vacuum gas oil, zeolite-containing catalyst, fractional composition.*

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Новый подход к расчету режима минимального орошения
при ректификации многокомпонентных смесей

В статье рассмотрены наиболее распространенные аналитические методы расчета параметров режима минимального орошения при ректификации многокомпонентных смесей с учетом заданных требований к качеству получаемых продуктов разделения. Предложена и описана расчетная методика, позволяющая значительно упростить процедуру определения минимальных флегмового или парового чисел, а также

составов дистиллята или остатка в режиме минимального орошения по сравнению с известными способами.

Ключевые слова: ректификация, ректификационная колонна, режим минимального орошения, многокомпонентная смесь, разделение смеси, расчет процесса ректификации, качество продуктов ректификации, область предельной концентрации.
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A New Approach to Calculating Minimum Reflux Operation Mode for Fractionation of Multicomponent Mixtures

The article discusses the most common analytical methods for calculating the parameters of the minimum reflux operation mode during the fractionation of multicomponent mixtures, taking into account the specified requirements for the distillation products quality. A calculation method is proposed and described that makes it possible to significantly simplify the procedure for determining the minimum reflux or vapor ratios, as well as the compositions of the distillate or residue in the minimum reflux operation mode in comparison with known methods.

Key words: *fractionation, fractionating column, minimum reflux operation mode, multicomponent mixture, mixture separation, fractionation process calculation, fractionation products quality, limiting concentration area.*

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Изучение влияния условий приготовления пропиточного раствора и термообработки на активность катализаторов гидроочистки

Изучено влияние качества сырья (карбоната кобальта) и условий термообработки на активность катализаторов Co-Mo и Ni-Mo в гидроочистке смесевой дизельной фракции. Степень чистоты карбоната кобальта и температура синтеза определяют состав пропиточного раствора, что в свою очередь влияет на активность катализатора. В качестве контроля качества карбоната кобальта предложен метод спектроскопии комбинационного рассеяния. Выявлено влияние термообработки катализатора на его активность. Обнаружено, что предельные температуры прокаливания для катализаторов Co-Mo и Ni-Mo сильно отличаются.

Ключевые слова: катализатор гидроочистки, пропиточный раствор, карбонат кобальта, термообработка, полианионы, спектроскопия комбинационного рассеяния, обессеривание.
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The Influence of Impregnation Solution Preparation
and Heat Treatment Conditions on the Activity of Hydrotreating Catalysts

The influence of raw materials quality (cobalt carbonate) and heat treatment conditions on the activity of Co-Mo and Ni-Mo hydrotreating catalysts for a mixed diesel fraction has been studied. The influence of cobalt carbonate quality and the synthesis temperature on the properties of the impregnation solution is shown. The method of Raman spectrometry is proposed as a quality control of cobalt carbonate. The influence of catalyst heat treatment on its activity is revealed. It was found that the ultimate calcination temperatures for Co-Mo and Ni-Mo catalysts are very different.

Key words: *hydrotreating catalyst, impregnating solution, cobalt carbonate, calcination, polyanions, Raman spectrum, desulfurization.*

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Новые композиционные материалы на основе закрытоячеистого пенополиуретана
и проиродных наноматериалов

В работе изучена возможность применения природных наноматериалов (природных алюмосиликатных нанотрубок (галлуазита) и наноцелллюлозы) как модифицирующих добавок к коммерческому пенополиуретану с целью варьирования огнеустойчивости и механических характеристик. Серии композиционных пенополиуретанов, содержащих различные массовые доли модифицирующих добавок, были получены методом полимеризации in situ. Исследовано влияние добавок на структуру пенополиуретанов, сжимаемость и огнеустойчивость. Обнаружено, что введение в состав пенополиуретанов добавок приводит к изменению среднего размера пор и к уменьшению сжимаемости пен. Однако после достижения максимальной жёсткости композиционных пен дальнейшее увеличение содержания добавки приводит к регрессу данной характеристики. Установлено, что увеличение содержания добавок положительно сказывается на огнеустойчивости полученных композиционных материалов.

Ключевые слова: пенополиуретан, природные наноматериалы, галлуазит,
наноцеллюоза, композиционные материалы, огнеустойчивость.
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New Composite Materials Based on Closed Cell Polyurethane Foam
and Pro-Nanomaterials: Improved Fire Resistance and Mechanical Stability

This study presents the feasibility of application of natural nanomaterials (natural aluminosilicate nanotubes (halloysite) and nanocellulose) as modifying additives to commercial polyurethane foam in order to vary its fire resistance and mechanical properties. Series of composite polyurethane foams containing different mass fractions of modifying additives were obtained by in situ polymerization. The influence of additives on the structure of polyurethane foams, compressibility and fire resistance was investigated. The introduction of additives into the

composition of polyurethane foams was found to change the average pore size and to decrease the compressibility of foams. However, after reaching the maximum stiffness of composite foams, further increase in the content of additives leads to regression of this characteristic. It is shown that the increase in the content of additives has a positive effect on the fire resistance of the obtained composite materials.
Key words: *polyurethane foam, natural nanomaterials, halloysite, nanocellulose, composite materials, fire resistance.*

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Сравнение промотирующей активности амидов этилендиаминтетраускусной кислоты и некоторых аминокислот в процессах нуклеации и роста гидратов метана и диоксида углерода

В работе была оценена промотирующая активность амидов этилендиаминтетраускусной кислоты (ЭДТА) и аминокислот в отношении образования гидратов метана и углекислого газа. Большинство исследуемых соединений в концентрации 0,05% мас. показали себя промоторами образования гидратов на разных стадиях процесса (нуклеация, рост); при этом формирования пены не наблюдалось. Выявлено, что реагент на основе ЭДТА и лейцина является промотором образования как гидрата метана, так и диоксида углерода. В случае гидрата углекислого газа наименьшее время индукции оказалось для соединений ЭДТА с аспарагином (19 ± 1 мин) и с цистеиновой кислотой (29 ± 1 мин), что в 1,7 и 2,5 раза меньше, чем для системы без добавок.

Ключевые слова: газовые гидраты, метан, диоксид углерода, хранение газа, кинетические промоторы гидратообразования, аминокислоты, этилендиаминтетрауксусная кислота
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Comparison of the Promoting Activity of Amides of Ethylenediaminetetraacetic Acid and Some Amino Acids In the Nucleation and Growth of Hydrates of Methane and Carbon Dioxide

This work evaluated the promoting activity amides of ethylenediaminetetraacetic acid (EDTA) with amino acids in relation to the formation of methane and carbon dioxide hydrates. Most of the studied compounds promotes hydrate formation at different stages of the process (nucleation, growth) at 0.05 mass%; no foaming was observed. It was revealed that the reagent based on EDTA and leucine promotes the formation of methane and carbon dioxide hydrates. In the case of carbon dioxide hydrate, the compounds EDTA with asparagine (19 ± 1 min) and cysteic acid (29 ± 1 min) showed the shortest induction time, 1.7 and 2.5 times less than for the blank system.

Key words: *gas hydrates, methane, carbon dioxide, gas storage, kinetic hydrate promoters, amino acids, ethylenediaminetetraacetic acid.*

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Ингибиторы гидратообразования низкой дозировки на основе сополимеров малеинового ангидрида с изопропилакриламидом

Изучено влияние сополимеров на основе малеинового ангидрида на процесс образования гидрата метан-пропановой смеси. В качестве со-мономера был выбран изопропилакриламид. Реакцию полимеризации проводили в петролейном эфире, затем цикл малеинового ангидрида раскрывали с использованием таких нуклеофилов как дибутиламин и диэтаноламин. Часть полученных полимеров при концентрации 0,5% мас. продемонстрировала понижение температуры начала гидратообразования на уровне кинетического ингибитора гидратообразования Luvicap EG, однако конверсия газа в гидрат в случае предложенного реагента была выше. Наилучший результат по переохлаждению показал образец с повышенным содержанием фрагмента изопропилакриламида, где в качестве нуклеофила использовали дибутиламин. Наименьшая конверсия газа в гидрат наблюдалась для полимера с повышенным содержанием малеинового фрагмента, раскрытого также дибутиламином.

Ключевые слова: газовые гидраты, модель природного газа, кинетические ингибиторы гидратообразования, полималеаты.
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Low-Dosage Hydrate Inhibitors Based on Maleic Anhydride Copolymers with Isopropylacrylamide

In this work, the effect of copolymers based on maleic anhydride on the formation of a methane-propane mixture hydrate was studied. Isopropyl acrylamide was chosen as the co-monomer. The polymerization reaction was carried out in N,N-dimethylformamide, then the maleic anhydride cycle was opened using nucleophiles such as dibutylamine and diethanolamine. Some of the obtained polymers demonstrated hydrate onset supercooling similar to the commercial kinetic hydrate inhibitor Luvicap EG at 0.5 mass% concentration. However, the water-to-hydrate conversion was higher in the case of the proposed reagent. A sample with a high content of isopropyl acrylamide fragments with dibutylamine as a nucleophile showed the best results in hydrate onset subcooling. The lowest water-to-hydrate conversion was observed for a polymer with a high content of maleic fragment, also opened by dibutylamine.

Key words: *gas hydrates, natural gas model, kinetic hydrate inhibitors, polymaleates.*

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Изучение влияния промоторов на процесс образования гидрата метана в статических условиях

В данной работе представлены экспериментальные исследования образования гидрата метана из замороженных растворов, содержащих малое количество промоторов (додецилсульфат натрия и три-сульфированное касторовое масло), в статических условиях методом дифференциальной сканирующей калориметрии. Выявленные закономерности протекания фазовых превращений в изучаемых условиях (кристаллизация льда и/или гидрата – совместное плавление льда и образование гидрата), совмещенные с визуализацией формирующихся гидратов, позволили установить факторы, влияющие на интенсивность роста гидрата метана при плавлении льда: протокол получения гидратов (контроль температуры и давления на разных стадиях процесса) и сила взаимодействия кристаллитов гидратов друг с другом и со стенками ячейки.

Ключевые слова: газовые гидраты, плавление льда, метан, промоторы, дифференциальная сканирующая калориметрия.

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Effect of Promoters on Methane Hydrate Formation under Static Conditions

This paper studied the process of methane hydrate formation from frozen solutions containing small amounts of promoters under static conditions using differential scanning calorimetry (DSC). The research revealed regularities of phase transformations under the studied conditions (from ice and/or hydrate crystallization to joint ice melting and hydrate formation). Coupling the DSC tests with visualization of the forming hydrates allowed the factors affecting the growth rate of methane hydrate during ice melting to be established. These factors included the protocol for obtaining hydrates, which involved temperature and pressure control at different stages of the process, and the force of interaction of hydrate crystallites with each other and with cell walls.

Key words: *gas hydrates, ice melting, methane, promoters, differential scanning calorimetry.*

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Исследование кинетики диссоциации гидрата тетрафторэтана методом ЯМР-спектроскопии

В работе исследован процесс диссоциации гидрата 1,1,1,2-тетрафторэтана (фреон-134а) методом импульсного ЯМР высокого разрешения. Экспериментально установлен диффузионно-кинетический характер процесса, его кинетические параметры (константа скорости и время полупревращения), а также особенности – стабилизация остаточного гидрата продуктами его разложения. Показано, что данный эффект значительно ослабляется с ростом температуры, а энергия активации диссоциации гидрата

фреона сравнима с таковой для разложения относительно устойчивых при атмосферном давлении гидратов.

Ключевые слова: газовый гидрат, диссоциация гидрата, кинетика диссоциации, модель Аврами – Ерофеева – Колмогорова, ЯМР-спектроскопия.
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Study of Kinetics of Tetrafluoroethane Hydrate Dissociation
Using NMR Spectroscopy

The article studies the process of 1,1,1,2-tetrafluoroethane (Freon-134a) hydrate dissociation by pulsed high-resolution NMR. The diffusion-kinetic nature of the process, its kinetic parameters - the rate constant and the half-life time, as well as the features – the stabilization of the residual hydrate by the products of its decomposition were experimentally established. This effect is significantly weakened with increasing temperature, and the activation energy of freon hydrate dissociation is comparable to that ones for the hydrates that are relatively stable at atmospheric pressure.

Key words: *gas hydrate, hydrate dissociation, dissociation kinetics, Avrami–Erofeev–Kolmogorov model, NMR spectroscopy.*

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Классификация методов синтеза полигидроксилированных фуллеренов.
Часть 2. Одностадийные и многостадийные процессы

Выполнен анализ существующих методов синтеза полигидроксилированных фуллеренов с применением прямого химического взаимодействия, а также альтернативных способов создания, с целью выявления оптимальных методик получения, для их реализации в различных технологических и биомедицинских областях. Обобщена и классифицирована научная литература данной сферы исследований. Дана оценка эффективности и возможности практического реализации разработанных методов синтеза на основании всестороннего рассмотрения литературной и патентной информации.

Ключевые слова: фуллерен, полигидроксилированный фуллерен, фуллеренол, методы синтеза.
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Classification of Methods for the Synthesis of Polyhydroxylated Fullerenes. Part II

A complete analysis of the existing methods of synthesis of polyhydroxylated fullerenes using direct chemical interaction, as well as alternative methods of creation has been carried out in order to identify the optimal methods of obtaining, for their implementation in various technological and biomedical fields. The scientific literature on this field of research is summarized and classified, and a comparative assessment of the efficiency and feasibility of practical implementation of the developed synthesis methods is given on the basis of a comprehensive review of literature and patent documents.
Key words: *fullerene, polyhydroxylated fullerene, fullerenol, synthesis methods.*

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Гидроформилирование низших олефинов и применение продуктов оксосинтеза на основе альдегидов C_4–C_5 в производстве сложноэфирных смазочных масел.
Часть II. Родиевые процессы гидроформилирования низших олефинов, разработанные ООО «РН-ЦИР»

Описаны процессы R-OXO гидроформилирования на комплексах родия с фосфитными лигандами, разработанные в ООО «РН-ЦИР» – процесс селективного получения н-бутираля из пропилена (R-OXO I), процесс получения смеси н- и изобутираля в равных долях (R-OXO II), процесс селективного получения н-пентаналя из смеси линейных бутенов (R-OXO III). Дано описание схемы гидроформилирования пропилена с мембранным отделением катализатора от тяжелых продуктов реакции. Проведен анализ направления использования продуктов оксосинтеза C_3–C_5 в качестве сырья для получения сложноэфирных смазочных материалов
Ключевые слова: гидроформилирование, оксосинтез, олефины C_2–C_4, родиевые катализаторы, неополиолы, сложноэфирные смазочные масла.
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Hydroformylation of Low Molecular Olefins and Preparation of Oxosynthesis Products Based on C_4–C_5 Aldehydes in the Production of Ester Lubricating Oils.
Part II. Rhodium Catalyzed Hydroformylation of Low Molecular Olefins Developed by United Research and Development Center

The processes of R-OXO hydroformylation on rhodium complexes with phosphite ligands developed by United Research and Development Center are described – the process of selective production of n-butyral from propylene (R-OXO I), the process of obtaining a mixture of n- and isobutyral in equal parts (R-OXO II), the process of selective production of n-pentanal from a mixture of linear butenes (R-OXO III). The description of the scheme of hydroformylation of propylene with membrane separation of the catalyst from heavy reaction products is discussed. The analysis of the direction of using C_3–C_5 oxosynthesis products as raw materials for the production of ester lubricants is carried out.
Key words: *hydroformylation, oxosynthesis, olefins C_2–C_4, Rhodium catalysts, neopolyols, ester lubricants.*

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Thermogravimetric Analysis of Heavy Oil Oxidation in the Presence of Nickel Based Catalysts

This study investigates the catalytic effects of Nickel-ligated catalysts derived from tall oil (NiTO) and sunflower oil (NiSFO) on the oxidation of heavy oil. Thermogravimetric (TG) analysis were employed to assess the thermal behavior and kinetics of heavy oil degradation. The Friedman isoconversional method provided the activation energies (E_a), which were then used to derive thermodynamic parameters including changes in enthalpy (ΔH), entropy (ΔS), and Gibbs free energy (ΔG). The TG analysis revealed that both NiTO and NiSFO influence the degradation kinetics of heavy oil. Moreover, NiTO exhibited a consistent catalytic effect across a wide range of conversions, lowering the onset temperature of degradation and promoting faster degradation rates, which suggests a rapid breakdown at lower temperatures. Conversely, NiSFO demonstrated a substantial decrease in activation energy at mid-range conversions, indicating a highly efficient catalysis during these stages. In addition, thermodynamic analysis indicated that both catalysts alter the energetic profile of the reaction. Notably, NiSFO reduced ΔG significantly at lower conversions, enhancing the spontaneity of the reaction, while NiTO was associated with lower ΔG values across most conversions, implying a more favorable reaction throughout the process. The findings suggest that the choice of catalyst can be tailored based on the desired conversion range and reaction spontaneity in industrial heavy oil processing. These insights could be crucial for optimizing thermal treatments in heavy oil upgrading, offering potential improvements in the efficiency of in-situ combustion and enhanced oil recovery technologies.

Keywords: *heavy oil, in situ-combustion, transition metals, sunflower, tall oil.*

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Catalytic Combustion Enhancement in-situ for Heavy Oil Recovery

It is common knowledge that in-situ combustion is highly promising method for improving heavy oil recovery. The present research explores the effects of Cobalt-ligated catalysts derived from sunflower oil (CoSFO) and tall oil (CoTO) on heavy oil oxidation, aiming to enhance in-situ combustion process. Through differential scanning calorimetry (DSC) we assessed the oxidation kinetics of heavy oil in the presence and absence of these catalysts. Our findings indicate that both CoSFO and CoTO significantly improve the oxidation process, particularly in the high-temperature oxidation (HTO) phase crucial for combustion front stabilization. Notably, CoTO demonstrated superior efficacy in reducing oxidation times across all conversion levels, suggesting its potential to optimize the efficiency of EOR techniques. This research highlights the promise of Cobalt-ligated catalysts in advancing heavy oil recovery and suggests directions for future studies to further investigate their industrial applications.

Keywords: *heavy oil, in situ-combustion, ligand, EOR, catalysts.*

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Inovative Solutions towards Achieving Comprehensive Restoration of Petroleum-Contaminated Soils

Composting is an effective and cost-efficient engineering technique used to treat agricultural waste. It involves the conversion of organic materials into stable compounds and the rapid degradation of organic matter through microorganisms found in feces. The resulting high-quality fertilizer can improve soil physical, chemical, and biological properties. However, the excessive use of heavy metals in livestock breeding can restrict the use of livestock manure for composting. Long-term application of compost products containing heavy metals can cause irreversible damage to farmland soil environments. This paper summarizes several important factors that affect the detoxification of heavy metals in composting and discusses the passivation effect of typical heavy metal passivators. The detoxification mechanism of heavy metals in compost is summarized from two perspectives: the humification effect of heavy metals and the environmental interface effects of microorganisms. This paper provides a foundation for improving the agronomic use value of avian manure aerobic composting products and for studying heavy metal passivation in compost. The application of aerobic composting in the remediation of petroleum-contaminated soil exhibits a dual impact, primarily focusing on the synergistic effects on petroleum hydrocarbon degradation and soil improvement. Such research endeavors are poised to offer innovative solutions towards achieving comprehensive restoration of petroleum-contaminated soils.

Keywords: *composting, heavy metal, passivation mechanism, detoxification.*

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Study on Water Intrusion Flow Model of the Tight Gas Reservoir

Aiming at the problem that the water intrusion control factors of multi-stage fracturing horizontal wells in tight gas reservoirs in edge and bottom water are not clear, the linear supply boundary is used to characterize the water intrusion characteristics and derive the mathematical characterization formula, considering the stress sensitivity and diffusion mechanisms of tight gas, and the water intrusion flow model of multi-stage fracturing horizontal well in tight gas reservoirs in edge and bottom water is established, and the bottom pressure and its derivative curves are obtained by Laplace and perturbation transformation. Furthermore, the influence of water intrusion strength, matrix-fracture channeling capacity, storage capacity coefficient, fracture segment spacing, fracture conductivity and other factors on the degree of water intrusion and water exposure time were analyzed. By fitting the well test data of the established model, the water intrusion intensity parameters can be obtained, and the water intrusion control of gas wells can be

guided according to this parameter. The data analysis of two typical wells in the western oilfield was carried out by applying the established model, and the analysis results were well matched with the actual production, which verified the reliability of the model, and according to the analysis results, the treatment measures of the two wells were proposed, and the two wells obtained good production results.

Keywords: *edge bottom water, multi-stage fracturing horizontal wells, degree of water intrusion,see water time.*

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Preparation and Performance Evaluation of P(St-AM) Microencapsulated Gel-Breaking Agents with Core-Shell Structure

Utilizing emulsion polymerization, a microcapsule breaker with a polystyrene-polyacrylamide core-shell structure was synthesized. Ammonium persulfate served as the breaker, polystyrene as the shell, and polyacrylamide as the drug-carrying agent. The results demonstrated that the synthesized microencapsulated gel-breaker exhibited a uniform spherical shape, superior water dispersion, and enhanced thermal stability. Conductivity tests indicated that the core-shell structure of the microcapsules effectively regulated the release of ammonium persulfate as a gel-breaking agent, resulting in delayed polymer gel-breaking.

Keywords: *microencapsulation, glue breaker, oilfield chemistry, polymers.*

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Some Approaches to the Assessment of Shale Oil and Gas Resources

In recent years, with the continuous development of exploration technology, great achievements have been made in shale oil exploration in the ST Basin in my country. However, in practice, due to insufficient understanding of the formation mechanism, evaluation standards and resource potential of shale oil, this has brought certain constraints and limitations to the exploration and evaluation of shale oil. This article conducts a comprehensive analysis of the main controlling factors of shale oil resource potential in Area A of the ST Basin. Based on the "three-thirds" relationship between TOC and oil content, the shale oil and gas resource classification evaluation method is determined. Using the shale oil reservoir evaluation method, the shale oil in Area A of the ST Basin was evaluated. The study found that Block A not only has good reservoir performance, but also has excellent oil and gas quality, and the brittle minerals have good compressibility. The shale oil resources in area A were calculated based on relevant parameters, and it was found that the potential shale oil resources in this block reached $9.66 \cdot 10^9$ t. The research provides certain technical support for the exploration and development of shale oil in China.

Keywords: *shale oil, shale oil and gas resource description, evaluation criteria, potential evaluation.*

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Detection of Bubble Flow by Cluster Analysis of Ultrasound Waves' Spectral Properties

As a non-invasive tool, ultrasound waves can be applied to probe gaseous content of the drilling fluid in offshore oil-drilling operations. The approach is believed to improve sensitivity and accuracy of a gas-kick detection system. In this research, four types of bubble flow are designed to simulate undeveloped gas kicks, and their effects on changes of ultrasound waves are investigated. The bubbles are found to have changed power distribution of the sound waves that have been reflected by the bubbles and received by side sensors. The pattern of power spectrum changes around the master frequency is found to be closely related to the type of bubble flow. Such changes are grouped on the basis of cluster analysis, and it is found that bubble strings and bubble groups would produce substantially different effects and that bubble mergences would largely alter spectral property of the sound waves. By establishing relationship between power-change pattern of sound waves and the behavior of a bubble flow, the research is intended to seek a more predictive way of recognizing early-stage gas kicks for offshore oil-drilling practices.

Keywords: *ultrasound waves, gas kick, cluster analysis, spectral properties.*

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Synergistic Effect of Oxidation Dissolution and Acid Fracturing in Improving Shale Gas Production Capacity

Shale gas is an extremely important unconventional oil and gas resource, and its efficient development can effectively alleviate the current tense energy situation. However, shale gas reservoirs often have extremely poor permeability, and reservoir transformation has become a key technology for achieving their efficient development. However, the commonly used hydraulic fracturing technology is difficult to achieve its target production capacity, and other engineering technologies related to reservoir transformation urgently need to be proposed and attempted. The synergistic operation of oxidation dissolution and acid fracturing may provide new ideas for the effective transformation of shale reservoirs. To this end, a comparative analysis was conducted on the synergistic effects of oxidation dissolution and acid fracturing operations in improving shale gas production capacity. The research results indicate that the dissolution effect of oxidants is more effective than acid solution in the transformation process of shale reservoirs. The use of acid only widens the crack width from the initial 4.4 mm to the final 5.1 mm. However, the use of oxidants will result in the final width of hydraulic fractures reaching 8.3 mm. Meanwhile, the effects of acid concentration and oxidant concentration on hydraulic fracture conductivity and shale gas production capacity were investigated. The results indicate that increasing the acid concentration below the low concentration range can significantly enhance the fracture conductivity, thereby promoting the production capacity of shale gas. However,

within a higher concentration range, its effect on shale gas production is significantly limited. It is recommended to set the acid concentration design value at 0.5 wt% during the acidizing and fracturing reservoir transformation process of the shale gas reservoir in Changning block. In addition, an increase in the concentration of oxidants can widen the width of fractures and increase permeability, thereby promoting the migration and extraction of shale gas. To avoid the increase in development costs caused by high oxidant concentration in the working fluid, it is recommended to design the oxidant concentration at 3 wt%.
Keywords: *shale gas, acid fracturing, oxidative dissolution, enhanced oil recovery.*

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Research on the Axial Stress Distribution Law of Mountain Pipeline under the Action of Lateral Landslides

This article studies the distribution law of axial stress in mountain pipelines under the action of lateral landslides. Firstly, a mechanical model is established for analysis, taking into account the geometric nonlinearity of the pipeline and the physical nonlinearity of the longitudinal resistance of the soil outside the landslide. The theoretical calculation method for the axial stress of the pipeline under two conditions of tension or pressure is obtained, and the calculation formula for the axial stress of mountain pipelines under the action of lateral landslides is summarized. The finite element method was used to simulate and calculate buried pipelines affected by lateral landslides based on nonlinear contact problems. The single variable method was used to analyze the influence of soil parameters, landslide body parameters, mountain body parameters on both sides, and some other parameters on the axial stress of mountainous pipelines. The axial stress distribution of buried pipelines under different influencing factors was analyzed, and the axial stress distribution in four different directions of pipelines 0, 3, 6, and 9 was obtained, Analyze the variation pattern of axial stress in the pipeline at the location of stress concentration, and the results indicate that stress concentration occurs in the pipeline at the middle and edge positions of landslide displacement; According to the relationship between the axial stress of the pipeline and various influencing factors, the relationship between the maximum axial stress of the pipeline and a single factor is fitted, and the axial stress distribution law of the mountain pipeline under the lateral landslide effect is finally obtained.
Keywords: *lateral landslide, axial stress, finite element model.*

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Characteristic of AMPS-Based Self-Healing Material and the Effect on the Properties of Oil Well Cement Slurry

The self-healing cement used in oil wells aims to provide long-term interlayer isolation by enabling the cement system to repair itself. This paper compared the absorption properties of 2-acrylamido-2-methyl propanesulfonic acid (AMPS)-based superabsorbent polymer (SAP) and acrylic acid (AA)-based SAP in water and cement slurry filtrate. The effect of cement slurry filtrate on the water absorption properties of the two SAPs was evaluated. The results showed that the calcium ions in the cement slurry would crosslink with the carboxyl groups in the AA-SAP, increasing the crosslink density and greatly reducing its absorption rate in water. Compared to AA-SAP, AMPS-SAP is more suitable for oil well cement slurries. AMPS-SAP can help reduce the fluid loss of cement slurry. The addition of 0.4% AMPS-SAP in cement slurry results in a 64 mL decrease in fluid loss. The properties (rheological properties, thickening time, and compressive strength) of cement slurry meet the requirements for well cementing construction.

Keywords: *self-healing cement, superabsorbent polymer, oil well cement, AMPS.*

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Diagenesis and Genetic Model of Calcareous Interbeds in Marine Strata

Calcareous interbeds control the migration of oil and water in marine strata. However, in China, the origins of such calcareous interbeds have not been investigated in detail. In this paper, we present a study of calcareous interbeds in marine strata of the Zhujiang Formation in the Wenchang Oil Field, which is located in the southeast of Hainan Province, China. The lithological characteristics, types and features of diagenesis, and formation of the calcareous interbeds were investigated using core, thin-section, scanning electron microscopy, and cathodoluminescence observations, and stable carbon and oxygen isotope data. The calcareous interbeds consist of mixed sediments, which are dominated by bioclastic limestones containing terrigenous clasts, along with subordinate calcareous sandstone. The interbeds are densely cemented. The bioclasts are dominantly brachiopods, pleopods, and foraminifera, with minor amounts of echinodermata, bivalves, red algae, ostracods, and bryozoa. Diagenesis involved calcitic cementation, associated with relatively weak compaction. Carbon and oxygen isotopic data indicate the pore water that formed the carbonate cement was mostly sourced from seawater and minor amounts of meteoric water. The degree of carbonate cementation was significantly related to the bioclast content. On the basis of our study, a genetic model for the macroscopic and microscopic formation of calcareous interbeds is proposed.

Keywords: *diagenesis, genetic model, calcareous interbeds, marine strata, Zhujiang Formation; Wenchang Oil Field.*

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Development and Performance Evaluation of Paraffin
and Aromatic Hydrocarbon Synergistic Lotion Wax Remover

The chemical paraffin removal agent QLJ-1 was developed by analyzing the composition of crude oil, the wax content and the point of paraffin removal in the wellbore of an oilfield in northwest China. The orthogonal test was used to determine the formula as follows: mixed organic solvent (70% aromatics, alkane volume ratio of 2:2:1) + mixed surfactant (7% Tween-80, AEO-9, fatty acid salt mass ratio of 1:2:1) +23% pure water. The results of kinetics and emulsion stability study show that the saturated wax dissolution amount of QLJ-1 is 1.62 g, the wax dissolution rate is 0.0263 g/min, the wax dissolution equilibrium time is about 1h, and the emulsion stability time is 6 d. The wax dissolving effect of QLJ-1 is better than that of the current paraffin remover. The research results of this paper can provide technical support for improving the chemical paraffin removal process in an oilfield in Northwest China.
Keywords: *emulsion type wax remover, wax dissolving rate, kinetics of wax dissolving, emulsion stability.*

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Interpretable Deep Learning Approach for Production Forecasting of Fractured Horizontal Wells

Timely and accurate forecasting of well production in tight gas reservoirs is of paramount importance for comprehensive field development and financial decision-making. Despite the application of deep learning (DL) models in constructing predictive frameworks, their intricate nature and limited interpretability present challenges for petroleum engineers, hindering their understanding of learned inference mechanisms and trust in predictions. This study advocates for the adoption of interpretable DL solutions, incorporating SHapley Additive exPlanations (SHAP), to provide explicit elucidations of a prediction model by implemented by gated recurrent networks. The method's efficacy is substantiated using data from the Tao2 gas field in the Ordos Basin, China. The outcomes underscore the model's exceptional predictive capabilities. Leveraging the SHAP method for global interpretation provides valuable insights into the collective impact of various factors. Simultaneously, employing SHAP for local interpretation furnishes personalized explanations for well productivity predictions. The findings gleaned from this research are poised to enhance well operations and field development planning.

Keywords: *deep learning, SHAP, well production, interpretability, gated recurrent unit.*

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Research on Geochemical Response Characteristics of Dry Hot Rocks Injected with Scale Removal pH Modified Fluid

Geothermal energy has abundant reserves, is clean and environmentally friendly, and is an important alternative energy source for future oil and gas resources. However, during the development of dry hot rock geothermal energy, scaling in hydraulic fractures can easily lead to a decrease in water injection and thermal recovery capacity, affecting the effectiveness of thermal recovery. By comparing the differences in the temperature of the produced liquid in the enhanced dry hot rock geothermal system before and after scaling, the impact of scaling on geothermal development was analyzed, thereby proving the necessity of scale removal in the dry hot rock development process. The influence of different factors on the geochemical response characteristics of dry hot rocks during the descaling process using pH modified fluids was explored. The research results indicate that the generation of precipitates such as calcium carbonate in cracks can lead to a gradual decrease in the temperature of the produced liquid during geothermal development. During the experiment, the temperature of the extracted liquid decreased from the initial 178°C to the final 90°C. In addition, when the pH of the injected liquid is 4.5, the generation of precipitates such as calcium carbonate in hydraulic fractures is minimal, resulting in better geothermal development and the highest temperature of the produced liquid. However, when designing the pH value of the injection solution, it is still necessary to consider the corrosive and destructive effects of the injection solution's acidity and alkalinity on the development system. Finally, due to the sufficient heat exchange between injected water and dry hot rock at lower injection rates, the temperature of produced water will be higher. However, the effectiveness of geothermal development will deteriorate with the increase of injection rate, so it is more reasonable to design the injection rate of injected water at 6 L/min. Research can provide theoretical basis and technical support for the efficient development of dry hot rock geothermal resources.

Keywords: *geothermal energy, PH modifier, descaling, dry hot rock, geochemistry.*

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Characterization of Pore Structure and Water-Driven Residual Oil Distribution in Low-Permeability Reservoirs Based on Digital Cores

In order to solve the problems of unclear mechanism of residual oil formation and storage state at the late stage of water-driven development in low-permeability sandstone reservoirs, a three-dimensional digital core model was constructed based on CT scanning technology. A three-dimensional digital core model of the reservoir was

constructed based on CT scanning technology, and an unstructured tetrahedral mesh model was established to extract the connected pore structure and quantitatively characterize the micro-pore structure of the rock samples. A mathematical model of oil-water two-phase microscopic seepage flow was established based on NS equation and level set algorithm, and a finite element method was used to solve the model and simulate the microscopic water-driven oil flow. The results show that: the pore throat size and connectivity are the main factors determining the permeability of the reservoir; obvious viscous fingering phenomenon can be observed in the simulation of microscopic water-driven oil, and the residual oil of the water-driven oil mainly exists in the form of reticulated residual oil, blind-end pore residual oil, residual oil in small pore throats, residual oil in the parallel channels, and oil film; increasing the intensity of the injection can effectively utilize the reticulated residual oil and the residual oil in small pore throats, and the improvement of the viscosity ratio can obtain a larger wave and oil-water ratio, which can be used to improve the oil-water flow. Improvement of viscosity ratio can obtain larger wave and volume, and improvement of wettability can effectively utilize the remaining oil in the blind-end pores and oleophilic pore channels.

Keywords:

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Study on the Synthesis and Performance Evaluation of a Composite High-Temperature Flushing Isolation Fluid Stabilizer

Under ultra-high temperature and high-density conditions, most existing wash isolation liquid suspending agents have limited suspension capabilities at low dosages. This study enhances the suspension ability, optimizes the surface charge distribution, and reduces the probability of precipitation by surface modification and graft polymerization of inorganic mineral materials, thus preparing an organic-inorganic hybrid high-temperature suspension component. By introducing crosslinkers and active monomers with large steric hindrance and high rigidity, the study optimizes the microstructure of the polymer molecular chain, enhances rotational freedom, and improves thermal resistance, leading to the preparation of organic micro-crosslinked ultra-high temperature suspension components. The composite anti-high temperature wash isolation liquid suspending agent prepared in this study combines the characteristics of both inorganic and organic materials. While ensuring rheological properties, it can control the free liquid of the isolation liquid with a density of 2.2 to 2.6 g/cm^3 at 200°C to 0 mL, with a density difference of no more than 0.03 g/cm^3 after 2 hours of standing, effectively improving the sedimentation stability under high temperature and ultra-high temperature conditions for high-density isolation liquid systems. The results of this study provide a theoretical basis for the safety of deep well cementing operations.

Keywords: *isolation liquid, suspension capability, surface modification, graft polymerization, organic materials.*

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Synthesis of a New Type of Gemini Surfactants and Study on the Repair Performance of Near-Well Reservoir

In this paper, a new type of Gemini surfactant was synthesized by esterification reaction of phthalic anhydride and fatty alcohol polyoxyethylene ether to improve the pollution problem and achieve the purpose of reservoir restoration in the near-wellbore area. The target product was characterized by infrared spectroscopy and hydrogen nuclear magnetic resonance spectroscopy. The ability of Gemini surfactant to reduce boundary surface tension, wettability, dispersion, viscosity reduction, oil washing and core damage recovery were studied. Gemini surfactant The critical micelle concentration (cmc) and the corresponding □-cmc of Gemini surfactant are 26 mg/L and 30.26 μN/m, respectively. Gemini surfactant has a good ability to wash oil, which effectively reduce the interfacial tension of oil and water.At the same time, the benzene ring in the molecular structure of Gemini surfactant dissolve the organic matter in the pollution source, and the core permeability could be restored.

Keywords: *fatty alcohol polyoxyethylene ether, surface activity, pollutant formation, core damage recovery.*

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Characterization and Application of Quartz from Different Sources in Typical Shale Reservoirs

In this paper, taking the Wufeng Formation-Longmaxi Formation shales in the southeastern region of the Sichuan Basin as an example, the thin section, X-ray, geochemical testing and TIMA techniques are used to systematically study the source analysis and characterization of quartz fractions, and in turn, the mechanism of the development of highly brittle shale reservoirs is revealed. The results of the study show that the high quartz mineral content segments are well stacked with the organic matter enriched segments. Excess silica occurs in the lower part of the Wufeng -Longmaxi Formation, and some samples in the middle and upper part of the Wufeng and Longmaxi Formation have excess silica deficit; the K_2O/Na_2O ratio is generally >1, reflecting that the reservoir quality is affected by the biogenic silica. Land-sourced detrital quartz grains, on the other hand, are significantly larger and are generally distributed over a range of tens to more than a hundred micrometers, often with clay minerals and organic matter around the periphery. Biogenic siliceous fossils are mainly developed in the lower part of the Wufeng-Longmaxi Formation, dominated by biogenic siliceous remains such as radiolarians. TIMA test results show that quartz belongs to the mineral type with absolutely dominant content ratio in the bottom samples of the Wufeng-Longmaxi Formation and reflects the characteristics of fine-grained-muddy carbonaceous horizontal laminar deposition. There are three

different types of quartz grain distribution patterns in shale reservoirs, including excess silica type, multi-source silica type, and land-source silica type. The layers of highly brittle shale reservoirs are all at the bottom of Wufeng-Longmaxi Formation, which is rich in biogenic silica, and at the same time, they are also in the active layers of montmorillonite and other abundant volcanic activities, and they are developed in the closed basins as well as the deep-water land scaffolds, so that the reservoirs have a good self-sealing; at the same time, the combination of microcrystalline quartz+organic matter makes the reservoirs have an excellent mechanical brittleness.

Keywords: *shale reservoir, quartz, organic matter, mechanical properties.*

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Study on the Division of Remaining Recoverable Reserves Abundance in Specific Reservoirs

The Yanchang group Chang 6 reservoir in the Tiebiancheng area, after decades of exploitation, exhibits localized zones of relatively high permeability but is predominantly characterized as an extra-low permeability oil reservoir with minimal natural productivity. The reservoir's strong heterogeneity poses challenges in achieving production targets, resulting in significant variations in well yields. Therefore, a scientific division of potential zones within the blocks, targeted exploitation strategies are necessary. This study classifies the recoverable reserves abundance of the Chang 6 reservoir in the Tiebiancheng area into four distinct types, based on the analysis of two oilfield indicators: material potential field and flow state field. These types are categorized as follows: high velocity and high abundance (Type I), low velocity and high abundance (Type II), high velocity and low abundance (Type III), and low velocity and low abundance (Type IV). Moreover, tailored exploitation strategies are proposed, considering the characteristics of different favorable target zones. A computational simulation of regional oil production, with zoning exploitation strategies taken into account, indicates an anticipated cumulative oil production of 1463·10^4 m^3 by 2027, whereas the cumulative oil production of the control group is projected to reach 1387·10^4 m^3, resulting in a notable difference of 76·10^4 m^3, signifying a considerable improvement in the recovery rate.

Keywords: *Chang 6 reservoir, remaining recoverable reserves, abundance zoning, exploitation strategy.*

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Seismic Sequence and Source Analysis of Typical Sandstone Reservoirs

In order to understand the problem of sediment sources in the Xujiahe Formation of the Central Sichuan Uplift, high-density two-dimensional seismic data was used, and LCS2 (the second section of the Xujiahe Formation) was taken as the research object. Combined with logging interpretation results, typical seismic facies were identified within the sequence, including slope seismic facies, foreset seismic facies, and cut channel filling seismic facies. The pre-sedimentary seismic facies can be divided into two types: S-shaped and oblique pre-sedimentary facies. The stacked seismic facies representing the rapid filling environment of sediments are mainly distributed in the southeast of the study area, while the northwest mainly develops relatively low-energy sedimentary mechanisms of S-shaped seismic facies. The seismic facies of river filling are mainly distributed in the eastern and southeastern parts of the work area. On the plane, the seismic phase of the river channel filling has a trend of gradually widening and shallowing towards the northwest direction. In addition, the distribution of sedimentary facies was analyzed using seismic attributes. The southeastern and central parts of the study area are mainly composed of near source rich sand braided river alluvial plains, while the northwestern part is mainly composed of near shore rich mud braided river alluvial plains. The distribution of sedimentary facies belts generally shows a southwest to northeast distribution. From southeast to northwest, the sedimentary facies show a clear trend of changing from rich sand to rich mud. Based on the comprehensive distribution characteristics of seismic and sedimentary facies, it is believed that the river channels above the ancient uplift in central Sichuan basically enter the region from the south or southeast, and transport sediments from southeast to northwest. Based on the above evidence, it is inferred that the sediment of the Xujiahe Formation in the central Sichuan Uplift mainly comes from the "Qianzhong Ancient Uplift" or "Fanjing Mountain Ancient Land" in the southern and southeastern parts of the Sichuan Basin.

Keywords: *province analysis, seismic facies, sandstone reservoir.*

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Fault Leakage Behaviors and CO_2 Migration in Different Types of Geological Carbon Storage

Geological carbon storage is considered to be an effective measure to mitigate climate crisis. The method in which CO_2 is stored depends on its phase state and the depth at which it is injected. In this study, the fault-reservoir system is constructed to elucidate the fault leakage behaviors and CO_2 migration in different geological storage environments. Whether CO_2 is buoyant or sinking depends on the fluid density difference between CO_2 and H_2O. When carbon dioxide is injected into deep saline aquifer, CO_2 would preferentially migrate upward along the fault plane due to CO_2 buoyancy forces, and CO_2 plume accumulates beneath the caprock and floats at the top of the reservoir eventually. For CO_2 storage in deep ocean reservoir and volcanic basalt, no upward migration of CO_2 plume is observed during carbon storage. Fault plane is the preferential pathway for carbon downward

transportation during ocean-based CO_2 storage, providing a virtually unlimited environment. Compared with deep ocean storage, the much shorter sinking times makes volcanic basalt for carbon storage safer and more effective. It is illustrated that the fluid density difference between CO_2 and H_2O is the decisive factor in determining CO_2 sinking velocity. This investigation of searching CO_2 sinking reservoirs provides a promising alterative reference for remove and storage large volumes of the greenhouse gas.

Keywords: *fault leakage, geological carbon storage, carbon sequestration, CO_2 injection, CO_2 plume, greenhouse gas.*

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Preparation and Mechanism of Low-Molecular-Weight Amine-Based Inhibitor That Completely Inhibits Surface Hydration of Clay Minerals

The inhiition of surface hydration is the most fundamental technical measure for controlling shale borehole stability, but little research has been conducted on the inhibition of surface hydration. In this study, the low-molecular-weight amine inhibitor NH-2 was prepared. The inhibition performance of the NH-2 inhibitor was studied by linear expansion experiment, shale rolling recovery, isothermal adsorption, X-ray diffraction and thermogravimetric analysis. The inhibition mechanism was studied by X-ray diffraction and X-ray photoelectron spectroscopy. The results showed that 1 wt% NH-2 had a lower linear expansion ratio than did 5 wt% KCl and 1 wt% polyamine. The shale rolling recovery rate of the drilling fluid significantly improved after the addition of the NH-2 inhibitor. After the inhibitor NH-2 was added, the unit adsorbed water content of sodium montmorillonite decreased from 0.1104 g/g to 0.0331 g/g. The basal spacing of dry sodium montmorillonite increased from 1.01 nm to 1.3 nm, while that of wet sodium montmorillonite decreased from 1.9 nm to 1.31 nm. The DTG curve has only one low-temperature peak, and the sodium ion content in sodium montmorillonite was greatly reduced. These results showed that the NH-2 inhibitor has good inhibition performance. The inhibitor NH-2 enters the interlayer space of sodium montmorillonite through intercalation, displaces exchangeable cations, and minimizes the base spacing of sodium montmorillonite. Thus, the surface hydration of sodium montmorillonite was completely inhibited. In addition, the decomposition temperature of the NH-2 inhibitor was 232°C, which indicates good thermal stability. This study provides an inhibitor with high temperature resistance and efficient inhibition of hydration.

Keywords: *shale gas, sodium montmorillonite, surface hydration, inhibitor, inhibition performance.*

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Corrosion Behavior of N80 Steel in Underground Supercritical CO_2 Environments

In the CCUS project, CO_2 utilization had achieved remarkable results in oil displacement. But, at present, one of the main reasons that seriously affected the large-scale application of CCUS projects was that the corrosion behavior of underground environment on pipe string or wellbore was not fully evaluated. It was revealed that the wellbore corrosion behavior in the harsh environment in the process of CO_2 flooding was the key to ensure the safe production of oil fields. Therefore, this paper took the corrosion environment with temperature of 81.7°C, pressure of 52.3 MPa and high salinity in the well depth of 4517 m as the research object, to study the corrosion behavior of oil casing N80 steel through corrosion rate, corrosion morphology and electrochemical experiments. The results showed that the corrosion rate increased with the increase of experimental time, behaved by the charge transfer resistance decreased. However, when the experiment increased from 800 h to 1000 h, the pitting corrosion rate increased from 1.47 mm/a to 1.782 mm/a, which was consistent with the ratio of anode/cathode Tafel constants and corrosion density. This was mainly because the relatively dense $FeCO_3$ corrosion product layer generated on the N80 steel surface gradually brook down due to synergistic effect of amorphous CrO_3, Fe^{2+}/Ca^{2+} complex salt and Cl^- during the experiment, which promoted the initiation and development of the corrosion pits. Compared with the bare N80 steel, the incomplete corrosion product layer aggravated the rapid development of pitting corrosion.

Keywords: *N80 steel, underground supercritical CO_2 environments, corrosion rate, corrosion morphology, electrochemistry.*