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Contents

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Получение связующих пеков из остаточного сырья нефтепереработки

Представлены результаты исследования процесса термополиконденсации нефтяных остатков различного происхождения: тяжелых смол пиролиза, тяжелого газойля каталитического крекинга, крекинг-остатков. Для всех выбранных остаточных продуктов переработки нефти подобраны технологические условия и рекомендованы режимы получения (температура и продолжительность изотермической стадии) пеков с температурой размягчения 75 и 110°С. Показано, что из современных остаточных продуктов переработки нефти возможно получение связующих нефтяных пеков.

Ключевые слова*:* *тяжелые смолы пиролиза, тяжелый газойль каталитического крекинга, крекинг-остаток, термополиконденсация, связующие пеки, электродные пеки, углеродные материалы.*

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Preparation of Binding Pitch from Residual Refinery Feedstock

The results of studying the process of thermal condensation of oil residues of various origin: heavy pyrolysis tar, heavy catalytic cracking gas oil, cracking residues - and studying the physicochemical properties of the obtained pitch are presented. Process conditions were selected for all selected residual oil products and production modes (temperature and duration of the isothermal stage) of bakes with softening points of 75 and 110°C were recommended. It has been experimentally shown that from modern residual oil products it is possible to obtain binding oil bakes, which are necessary as carbon materials for various purposes.

Key words*:* *heavy pyrolysis tars, heavy catalytic cracking gas oil, cracking residue, distillate cracking residue, thermopolycondensation, binding pecks, electrode pecks, carbon materials.*

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Низкотемпературный крекинг тяжелой нефти на развитой поверхности минеральных соединений карбонатных пород

В статье определены особенности состава и свойств жидких продуктов низкотемпературного крекинга тяжелой нефти Ашальчинского месторождения на поверхности минеральных карбонатных добавок в интервале температур 250–360°С и давлений до 2 МПа в среде перегретого пара, а также в присутствии

оксидов Al_2O_3 и MnO_2. Показано, что деструкция смолисто-асфальтеновых компонентов на поверхности минеральных соединений карбонатных пород приводит к увеличению доли легкокипящих, насыщенных и ароматических углеводородов. С повышением температуры крекинга снижается разветвленность и алифатичность жидких продуктов, увеличивается ароматичность. При температуре 250°С крекируются спирто-бензольные смолы, при 300°С также происходит деструкция бензольных смол. Установлено, что оксид марганца ускоряет распад спиртобензольных смол, оксид алюминия – смолисто-асфальтеновых веществ в целом, содержание асфальтенов в продуктах практически не меняется. Увеличение температуры крекинга до 360°С приводит к конверсии асфальтенов до 36% с образованием газообразных продуктов, легкокипящих соединений, насыщенных и ароматических углеводородов.
Ключевые слова: *тяжелая нефть, карбонатные минералы, смолисто-асфальтеновые вещества, низкотемпературный крекинг, перегретый пар, бензиновая фракция, насыщенные и ароматические углеводороды.*
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Low-Temperature Cracking of Heavy Oil on the Developed Surface
of Mineral Compounds of Carbonate Rocks

The article defines the features of the composition and properties of liquid products of low-temperature cracking of heavy oil from the Ashalchinsky field on the surface of mineral carbonate additives in the temperature range of 250-360 C and pressures up to 2 MPa in superheated steam, as well as in the presence of Al_2O_3 and MnO_2 oxides. It is shown that the destruction of resinous-asphaltene components on the surface of mineral compounds of carbonate rocks leads to an increase in the proportion of low-boiling, saturated and aromatic hydrocarbons. As the cracking temperature increases, the branching and aliphaticity of liquid products decreases, and the aromaticity increases. At a temperature of 250 °C, alcohol-benzene resins are cracked, and at 300°C, benzene resins are also destroyed. It was found that manganese oxide accelerates the decomposition of alcohol-benzene resins, aluminum oxide-resinous-asphaltene substances in general, the content of asphaltenes in products practically does not change. An increase in the cracking temperature to 360 °C leads to the conversion of asphaltenes to 36 % with the formation of gaseous products, low-boiling compounds, saturated and aromatic hydrocarbons.
Key words: *heavy oil, carbonate minerals, resinous-asphaltene substances, asphaltenes, low-temperature cracking, superheated steam, ggasoline fraction, saturated and aromatic hydrocarbons.*

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Термокаталитические превращения тяжелого углеводородного сырья
в присутствии наноразмерных катализаторов на основе никеля и цинка

Статья посвящена исследованию получения наноразмерных каталитических комплексов металлов в углеводородных средах и их влиянию на процессы термокрекинга тяжелых углеводородов. Основное внимание уделено кластерам переходных металлов, таким как цинк и его устойчивости, и активности при высоких температурах. Рассматривается значимость нанокатализаторов как перспективная альтернатива для катализаторов классических процессов крекинга. Проведены эксперименты по получению ультрадисперсных наносуспензий металлов, таких как никель и цинк, в вакуумных газойлях. Исследованы процессы образования и устойчивости наночастиц при различных температурных режимах. Обнаружено, что наночастицы формируются при кипячении газойля и сохраняют устойчивость при температуре выше 365°C. Результаты показывают возможность использования нанокатализаторов для эффективной переработки тяжелых углеводородов.

Ключевые слова*: каталитические комплексы, наночастицы, никель, термокрекинг, углеводородные среды, ультрадисперсные суспензии, цинк.*

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Thermocatalytic Transformations of Heavy Hydrocarbon Raw Materials in the Presence of Nanoscale Catalysts Based on Nickel and Zinc

The article is devoted to the study of the production of nanoscale catalytic metal complexes in hydrocarbon media and their effect on the processes of thermal cracking of heavy hydrocarbons. The main focus is on clusters of transition metals such as zinc and its stability and activity at high temperatures. The importance of nanocatalysts as a promising alternative for catalysts of classical cracking processes is considered. Experiments have been carried out to obtain ultrafine nanosuspensions of metals such as nickel and zinc in vacuum gas oils. The processes of formation and stability of nanoparticles under various temperature conditions are investigated. It was found that nanoparticles are formed by boiling gas oil and remain stable at temperatures above 365°C.

The results show the possibility of using nanocatalysts for efficient processing of heavy hydrocarbons.

**Key words*:* catalytic complexes, nanoparticles, thermal cracking, hydrocarbons.*

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Плазмохимический пиролиз как способ получения турбостратного графена из сырья с высоким содержанием углерода

Изучен способ получения турбостратного графена на основе сырья с высоким содержанием углерода — технический углерод (печная сажа) и литейный графит. Показано, что в процессе плазмохимического короткоимпульсного пиролиза (флеш-пиролиза) формируется графеновая сажа, содержащая графен

в количестве 20–25% мас. Реализация процесса позволит получить ценный продукт из дешевого сырья при сравнительно невысоких энергозатратах.

Ключевые слова*: плазмохимический пиролиз, графеновая сажа, турбостратный графен, технический углерод, конструкционный графит.*

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Plasmachemical Pyrolysis as a Way for Creating Turbostratic Graphene from Feedstock with High Carbon

A way for making turbostratic graphene based on petrol feedstock with high carbon content – technical carbon and metallurgical graphite – was researched. It was shown that in the process of plasmachemical impulse pyrolysis (flash-pyrolysis) the formation of a graphene soot containing 20-25% mass. of graphene occurs. Realization of this process allows production of valuable product using energy-efficient method.

Key words*: plasmachemical pyrolysis, graphene soot, turbostratic graphene, technical carbon, construction graphite.*

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Исследование состава и физико-химических свойств композиционного реагента на основе модифицированного лигносульфоната для гидрогелевых буровых растворов

Исследована возможность получения гидрогелевого композиционного реагента на основе полиэлектролитного комплекса, путем подбора мольных соотношений анионного модифицированного лигносульфонат натрия и катионного крахмала методом импедансометрии, заключающегося в измерение зависимости импеданса электрохимической ячейки от частоты переменного тока. Введение фосфоновых групп в состав лигносульфоната предполагает возможность дополнительных комплексов, что способствует повышению эффективности снижения вязкости и повышения термостойкости бурового раствора при введении модифицированного лигносульфоната. Катионный крахмал формирует основную структуру геля, в то время как модифицированный лигносульфонат улучшает механические и реологические свойства раствора. Это взаимодействие приводит к созданию сетчатой структуры, которая увеличивает вязкость и устойчивость к разрушению внешними воздействиями. Гидрогелевые буровые растворы, создаваемые на основе представленного композиционного реагента, способствуют более эффективному переносу бурового шлама и повышению ингибирующей способности бурового раствора.

Ключевые слова: *катионированный крахмал, лигносульфонат натрия, фосфоновые соединения, импедансометрия, ингибирующая способность, степень набухания, гидрогелевый буровой раствор, показатель фильтрации.*

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Investigation of the Composition and Physico-Chemical Properties of a Composite Reagent Based on Modified Lignosulfonate for Hydrogel Drilling Fluids

The possibility of obtaining a hydrogel composite reagent based on a polyelectrolyte complex by selecting the molar ratios of anionic modified sodium lignosulfonate and cationic starch by the impedance measurement method, which consists in measuring the dependence of the impedance of an electrochemical cell on the frequency of alternating current. The introduction of phosphonic groups into the composition of lignosulfonate suggests the possibility of additional complexes, which helps to increase the effectiveness of reducing viscosity and increasing the thermal stability of drilling mud with the introduction of modified lignosulfonate. Cationic starch forms the basic structure of the gel, while modified lignosulfonate improves the mechanical and rheological properties of the solution. This interaction leads to the creation of a mesh structure that increases viscosity and resistance to destruction by external influences. Hydrogel drilling fluids created on the basis of the presented composite reagent contribute to more efficient transfer of drilling mud and increase the inhibitory ability of drilling mud.

Key words*: cationated starch, sodium lignosulfonate, phosphonic compounds, impedance measurement, inhibitory ability, degree of swelling, hydrogel drilling mud, filtration index.*

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Получение нестандартной полимерной композиции для повышения физико-механических характеристик дорожного битума и асфальтобетонной смеси на его основе

В работе изучен процесс получения полимерного композиционного материала на основе отходов и побочных продуктов нефтехимических производств с целью модификации некондиционного товарного битума для повышения его физико-механических характеристик. При этом полученная полимерная композиция, состоящая из пылевидного полиэтилентерефталата, термонестабильного полиэтилена высокого давления и биоразлагаемого поликапролактона, рассматривается в качестве замены традиционным и дорогостоящим термоэластопластам типа бутадиен-стирол. В ходе лабораторных исследований определены основные показатели исходного битума, битума с добавлением пластифицирующей добавки и пластифицированных растворов каждого из полимеров. Описан процесс получения полимерных композитов и их влияние на битумное вяжущее, а также получены образцы асфальтобетонных смесей. Раскрыта возможность вторичного использования (рециклинга) нестандартных полимеров с получением нового материала для улучшением свойств дорожного битума, а также получения на его основе высококачественной горячей асфальтобетонной смеси.

Ключевые слова: *нефтяной дорожный битум, полиэтилентерефталат, пылевидный полиэтилентерефталат, полиэтилен высокого давления, поликапролактон, пластифицирующая добавка,*

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Obtaining a Non-Standard Polymer Composition to Improve the Physical and Mechanical Characteristics of Road Bitumen and Asphalt Concrete Mixture Based on It

The paper considers the process of obtaining a polymer composite material based on waste and by-products of petrochemical industries in order to modify substandard commercial bitumen to improve its physical and mechanical characteristics. At the same time, the resulting polymer composition consisting of pulverized polyethylene terephthalate, thermonestable low-density polyethylene and biodegradable polycaprolactone is considered as a replacement for traditional and expensive thermoplastics such as styrene butadiene (used as a comparative sample). In the course of laboratory studies, the authors identified the main indicators of the initial bitumen; bitumen with the addition of a plasticizing additive; further, plasticized solutions of each polymer; The process of obtaining polymer composites and their effect on the bitumen binder is described; and samples of asphalt concrete mixtures are obtained. The authors reveal the possibility of secondary use (recycling) of non-standard polymers to obtain a new material to improve the properties of road bitumen, as well as to obtain a high-quality hot asphalt concrete mixture based on it.

Key words*: petroleum bitumen, polyethylene terephthalate, low-density polyethylene, low-density polyethylene, polycaprolactone, plasticizing additive, polymer-bitumen composition, polymer-bitumen binder, asphalt concrete mixture, hot asphalt.*

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Разработка технологии получения полиуретанового клея на основе природного компонента

В статье рассмотрена возможность квалифицированного применения побочного продукта целлюлозно-бумажной промышленности — лигносульфоната в качестве компонента полиуретанового клея. На первом этапе разработки технологии получения полиуретанового клея произведена осушка лигносульфоната производства АО «Соликам-Скбумпром» с остаточной влагой 4,824% мас. при оптимальном технологическом режиме (время сушки — 3 ч, температура — 90 °С, скорость подачи сухого воздуха — 125 м^3/ч). На втором этапе с помощью осушенного лигносульфоната разработаны рецептуры полиуретанового клея. Показано, что сопоставимые с товарным аналогом ООО «Полихим Системс» физико-механические свойства, достигаются при максимальном содержании лигносульфоната (40% мас.) в составе полиуретанового клея.

Ключевые слова: *полиуретан, полиуретановый клей, лигносульфонат, биополиол, изоцианат, моноалкильные эфиры жирных кислот.*
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Development of Polyurethane Adhesive Production Technology
Based on a Natural Component

The article considers the possibility of qualified application of a by-product of the pulp and paper industry — lignosulfonate as a component of polyurethane adhesive. The lignosulfonate produced by JSC «Solikam-Skbumprom» was dried with a residual moisture of 4.824% by weight. at optimal technological conditions (drying time – 3 hours, temperature – 90°C, dry air supply rate – 125 m3/h) at the first stage of the development of polyurethane adhesive production technology. The compositions of polyurethane adhesive were developed using dried lignosulfonate at the second stage of technology development. It is shown that the physico-mechanical properties comparable to the LLC «Polychem Systems» commercial sample at a maximum content of lignosulfonate (40% by weight) in polyurethane adhesive.

Key words*: polyurethane, polyurethane adhesive, lignosulfonate, biopolyol, isocyanate, monoalkyl esters of fatty acids.*

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Применение электронной феноменологической спектроскопии как экспересс метода исследования свойств сырья для получения многофункциональных углеродных материалов

Показана возможность применения электронной феноменологической спектроскопии (ЭФС) для экспресс-исследования физико-химических свойств тяжелых нефтяных остатков – сырья для получения углеродных материалов, пеков, коксов и др. С применением ЭФС получены ряд закономерностей, в частности, обнаружена зависимость коксуемости от энергии активации вязкого течения для высокомолекулярных многокомпонентных систем. При использовании методов ЭФС, время одновременного определения физико-химических свойств сырья сокращается до 20–25 мин вместо десятков часов при применении традиционных методов. Метод ЭФС не заменяет стандартные аналитические методы контроля, однако применим для контроля изменения качества остаточного сырья при изменении технологических режимов и качества нефти. Кроме того метод ЭФС применим для быстрой оценки пригодности сырья для получения углеродных материалов в научных и заводских лабораториях и легко поддаются автоматизации.

Ключевые слова: *тяжелые нефтяные остатки, электронная феноменологическая спектроскопия, коксуемость, энергия активации вязкого течения.*
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Application of Electron Phenomenological Spectroscopy as Quickly Method
of Properties Defenetion of Hydrocarbon Feedstock for Production of Carbon Materials

The method for using electron phenomenological spectroscopy (EPS) for express definition physico-chemical properties of heavy oil residue. Using the EPS methods relationship between coking number and actvation energy of viscous flow for multicomponent systems with high molecular weight was discovered. Using the methods, based on EPS, the time for definition of many physico-chemical properties reduces from several hours to 20-25 minutes. Developed methods for express definition of properties can be easily automatized. EPS methods are not used as standard methods for quality control but can be used as methods for control of technological processes and also for quick testing of feedstock usability for creation of carbon materials in research and industrial laboratories.

Key words*: heavy oil residue, electron phenomenological spectroscopy, coking number, activation energy of viscous flow.*

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Спектроскопия комбинационного рассеяния как способ экспресс-прогнозирования
фазовой структуры полиэтилентерефталата

Предложена экспресс-методика определения фазового состояния материалов на основе полиэтилентерефталата с применением портативного спектрометра комбинационного рассеяния света. Предложено рассчитывать степень кристалличности как отношение интенсивности пика, характерного для кристаллических образцов, к сумме интенсивностей пиков кристаллических и аморфных образцов. Соответствие значений степени кристалличности образцов, определенных по экспресс-методике и методом дифференциальной сканирующей калориметрии, характеризуется коэффициентом детерминации 0,9684.

Ключевые слова: *полиэтилентерефталат, кристалличность, аморфность, Vivilen, спектроскопия комбинационного рассеяния, 3D-печать, аддитивные технологии.*
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Analysis of Phase Structure of Polymeric Materials by Raman Spectroscopy

Express method of determining the phase state of materials based on polyethylene terephthalate using a portable Raman spectrometer is proposed. It is assumed to calculate the degree of crystallinity as the ratio of the crystalline samples peak intensity to the sum of peak intensities of crystalline and amorphous samples. The correspondence

between the values of the degree of crystallinity of the samples determined by the developed express method and the differential scanning calorimetry method is characterized by the coefficient of determination value $R^2 = 0.9684$.
Key words*: polyethylene terephthalate, crystallinity, amorphous, Vivilen, Raman spectroscopy, 3D printing, additive technologies.*

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Исследование адсорбционных свойств модифицированного адсорбента
в анализе нефти геохимическим и хемометрическим методами

С целью прогнозирования перспективности лицензионных участков недр на нефть и газ предложен к использованию в условиях реальной геохимической съемки модуль-сорбер с термически графитированной сажей, модифицированной фуллереном C_{60}. Методом хромато-масс-спектрометрии идентифицированы извлеченные с помощью данного сорбента посредством пассивной адсорбции углеводородные соединения, в том числе реперные, характерные для залежи нефти пашийского горизонта. Показано наличие в извлеченной смеси алканов, аренов, циклических соединений, альдегидов, спиртов с числом атомов углерода C_5–C_{19}, а также побочных продуктов и других соединений. На основании данных хроматографического анализа с применением хемометрического метода построена карта поверхности распределения вероятности модели на фрагменте одного из лицензионных участков с указанием областей, отражающих наличие углеводородов в продуктивных пластах и их отсутствие.
Ключевые слова: *углеродный адсорбент, модуль-сорбер, пассивная адсорбция, термодесорбция, газовая хромато-масс-спектрометрия, геохимическая съемка.*
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Investigation of the Adsorption Properties of a Modified Adsorbent
in Oil Analysis Geochemical and Chemometric Methods

In order to predict the prospects of licensed subsurface areas for oil and gas, a sorber module with thermally graphitized carbon black modified with fullerene C_{60} has been proposed for use in real geochemical surveying. Using chromatography-mass spectrometry, hydrocarbon compounds extracted using this sorbent by passive adsorption, including reference ones, characteristic of the oil deposits of the Pashyan horizon, have been identified. The presence of alkanes, arenes, cyclic compounds, aldehydes, alcohols with the number of carbon atoms C_5–C_{19}, as well as by-products and other compounds in the extracted mixture is shown. Based on the data of chromatographic analysis

using the chemometric method, a map of the surface of the probability distribution of the model on a fragment of one of the licensed sites was constructed, indicating the areas reflecting the presence of hydrocarbons in productive formations and their absence.

Key words*: carbon adsorbent, sorber module, passive adsorption, thermal desorption, gas chromatography-mass spectrometry, geochemical survey.*

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Определение коэффициентов тепло- и массоотдачи в газовой фазе в хаотичном и регулярном насадочном слое при противоточном режиме

Рассмотрены стационарные процессы тепло-и массообмена в нерегулярных и регулярных насадочных слоях при пленочном противотоке жидкости с газовым потоком в колонне. Приведены выражения, полученные нами ранее для чисел Шервуда и Нуссельда на основе моделей турбулентного пограничного слоя, для хаотичных насадок без орошения. На основе применения диссипативной модели получено выражение для безразмерного параметра трения на поверхности газ — жидкость, который учитывает наличие жидкой фазы в виде стекающей пленки. Даны примеры расчета чисел Шервуда и Нуссельта, как для сухих, так и для орошаемых нерегулярных насадок и регулярных с интенсификаторами. Показано согласование с экспериментальными данными и с расчетом по эмпирическим выражениям.

Ключевые слова: ***тепломассоотдача, насадка, математическая модель, пограничный слой, турбулентный режим, диссипация энергии.***

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Determination of Heat and Mass Transfer Coefficients in the Gas Phase in a Chaotic and Regular Packing Layer in Countercurrent Mode

Stationary processes of heat and mass transfer in irregular and regular packing layers with a film counterflow of liquid with a gas flow in a column are considered. The expressions obtained earlier by the authors for the Sherwood and Nusseld numbers based on models of the turbulent boundary layer for chaotic nozzles without irrigation are presented. Based on the application of the dissipative model, an expression is obtained for the dimensionless friction parameter on the gas-liquid surface, which takes into account the presence of a liquid phase in the form of a flowing film. Examples of calculating the Sherwood and Nusselt numbers are given, both for dry and irrigated irregular nozzles and regular ones with intensifiers. Agreement with experimental data and calculation based on empirical expressions is shown.

Key words*: heat and mass transfer, nozzle, mathematical model, boundary layer, turbulent regime, energy dissipation.*

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Experimental Analysis on the Geochemical Characteristics

of Trace Elements in Typical Shale Marine Environments

This article comprehensively utilizes trace elements and the physicochemical characteristics of pyrite minerals to quantitatively characterize typical marine shale sedimentary environments. The cores, scanning electron microscope, and XRD whole-rock analyses combined with the information of TOC and fractional porosity are used. The analysis results show that the main types of occurrence of trace elements include granular, agglomerate, banded, cubic, and heteromorphic pyrite. Trace elements framboids particle size statistics show that the Wufeng Formation, Longyi 15 member and Longyi 2 member have larger particle sizes, while other members of Longmaxi Formation have trace elements framboids particle sizes of less than 5 μm. At the same time, it can be observed that the changes in trace element content and ratios in the vertical direction significantly increase the overall retention degree from Long 11 to Longyi 17, with a slow increase in retention degree during the Longyi 11~16 sedimentation period and a rapid increase during the Longyi 17 sedimentation period. All of these indicate that the ancient environment of the Wufeng Formation changed rapidly, and the redox conditions were a sustained weak reducing environment.

Keywords: *shale marine environments, experimental analysis, trace elements, geochemical characteristics.*

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Study on the Influencing Factors and Control Mechanisms

of Rock Fracture Propagation Direction in Hydraulic Fracturing

Hydraulic fracturing is a key technology for improving the efficiency of oil and gas resource development. The effective control of fracture propagation direction directly affects reservoir stimulation and economic benefits. This study analyzes the influencing factors of rock fracture propagation direction during hydraulic fracturing, combining the state of in-situ stress, rock mechanical properties, and fracturing fluid characteristics. The research investigates the control mechanisms of fracture propagation direction from perspectives such as in-situ stress adjustment and optimization, fracturing fluid design optimization, fracturing parameter adjustment, and multi-fracture collaborative propagation control. The goal is to lay a foundation for ensuring high-quality hydraulic fracturing operations. The study shows that the difference in in-situ stress is the dominant factor in fracture propagation direction. Rock heterogeneity can cause fracture deflection and branching. The viscosity of the fracturing fluid and injection rate play a significant role in adjusting the fracture propagation dynamics and direction. By optimizing well placement to adjust in-situ stress distribution, optimizing fracturing fluid design and

injection parameters, and applying collaborative induction methods in multi-cluster fracturing operations, the uniformity of the fracture network and the effectiveness of reservoir stimulation can be improved. This provides strong support for oil and gas resource development.
Keywords: *hydraulic fracturing, rock fractures, propagation direction, influencing factors, control mechanisms.*

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Operational Status Prediction of Dynamic Equipment
in Crude Oil Pipelines Based on Deep Learning Algorithms

This study addresses the issue of predicting the operational status of dynamic equipment in crude oil pipelines by introducing a deep learning algorithm. First, the necessity of predicting the operational status of dynamic equipment in crude oil pipelines is analyzed. From the perspectives of data collection, model construction, predictive analysis, and fault diagnosis, a predictive model based on deep learning algorithms is established for the operational status of dynamic equipment in crude oil pipelines. Finally, a case study is conducted using an oil pump along the pipeline as an example to demonstrate the feasibility of deep learning algorithms in predicting the operational status of dynamic equipment in crude oil pipelines. The research shows that dynamic equipment along crude oil pipelines, which operates continuously over long periods, has a relatively high probability of operational failure. The application reveals that using support vector machines and dynamic degradation index calculation methods provides a prediction value and degradation index at a given moment. By using the dynamic degradation of the oil pump as a monitoring indicator, the deep learning algorithm can issue an early warning an average of 15.8 minutes ahead, compared to traditional threshold monitoring methods. Furthermore, it enables fault cause analysis through a knowledge base, yielding significant application effectiveness. The study concludes that deep learning algorithms can provide timely predictions for the operational status of dynamic equipment in crude oil pipelines. To ensure the safe operation of dynamic equipment along crude oil pipelines in the future, this method can be further promoted and applied.
Keywords: *deep learning algorithms, crude oil pipeline, dynamic equipment, operational status prediction, case study.*

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Study on Influencing Factors of Nitrogen-Assisted Solution Mining
for Salt Cavern Gas Storage Based on the Analytic Hierarchy Process

The construction of an underground gas storage cavern that meets design requirements is a complex systematic engineering project. Currently, there is limited analysis of the factors influencing nitrogen-assisted solution mining for salt cavern gas storage in China, and a systematic, intuitive analytical methodology has yet to be established. Based on field data from a gas storage facility in North China, this study establishes a three-level hierarchical structure of influencing factors for nitrogen-assisted solution mining using the Analytic Hierarchy Process (AHP). A computational model was developed to analyze the weight of each influencing factor, and the weight values were determined. The calculations reveal that the top six factors with the highest weights affecting the cavern construction results are, in descending order: cavern size design (0.1246), salt layer characteristics (0.1145), wellbore structure (0.0969), lithological features (0.0857), QHSE management system (0.0794), and on-site gas-liquid interface monitoring (0.0772). These six factors account for 57.83% of the total weight, representing the majority of the influencing factors. In contrast, the bottom three factors—drilling crew experience, personnel training, and wellhead procedures—have relatively low weights, collectively contributing less than 5% of the total. On-site construction efforts should prioritize the top three factors: cavern size design, salt layer characteristics, and wellbore structure. Additionally, detailed formation evaluation, enhanced on-site safety management, comprehensive and accurate gas-liquid interface monitoring, and optimized circulation design are critical aspects of current nitrogen-assisted solution mining operations. The findings of this study provide a reference for guiding on-site operations to achieve rapid, stable cavern construction and effective cavity shape control during nitrogen-assisted solution mining.

Keywords: *salt cavern gas storage, nitrogen-assisted solution mining, influencing factors, analytic hierarchy process (AHP), hierarchical structure.*

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Quantitative Characterization of Microscopic Pore Structure

of Tight Sandstone Gas Reservoirs Based on Micron Ct Scanning

To study the microscopic pore structure of tight sandstone reservoirs, digital core technology using micro-CT scanning combined with mathematical algorithms in Avizo software is used to construct a digital core model and quantitatively characterize the rock sample's pore structure. Taking the rock samples of the Stone-Box formation reservoir in Area J of the northern Ordos Basin as an example, we carried out a three-dimensional visualization and quantitative analysis of the pore structure of the rock samples using computer image processing algorithms and 'maximal ball' algorithms and applied numerical simulation to obtain the core pore structure parameters, such as pore throat dimensions, throat lengths, and the number of collocations, and finally realized the quantitative characterization of the micro-pore structure of the reservoir. The results show that the combination of threshold segmentation and light/dark difference segmentation can accurately identify and extract the pore-throat region in the rock samples; when the prism length of the digital core is more than 400 pixels, the porosity obtained tends to be close to the fixed value; the dense sandstone reservoir in the study area has many isolated pores with uneven

distribution, and the shape of the pores is mostly ellipsoidal or nearly circular, with the pore radius mainly distributed in 3.89~8.48μm and the throat radius mainly distributed in 0.56-7.31μm. The pore radius is mainly 3.89-8.48μm, and the throat radius is mainly 0.56-7.31 μm, which provides favorable reservoir space for oil and gas storage; the pore and throat coordination number varies, and the permeability is less than $1 \cdot 10^{-3}$ μm^2, such as rock samples A, B, and C, with a model coordination number of 1-3, and the permeability is greater than $1 \cdot 10^{-3}$ μm^2, such as rock samples D and E, with a model coordination number of 2-5. The present study contributes to the quantitative evaluation of the micro-parameters of the reservoir and the visualization of the micro-structure of rock samples. This study helps the quantitative evaluation of reservoir micro-parameters and provides technical support for the visual and quantitative characterization of the microstructure of rock samples.
Keywords: *tight sandstone, ordos basin, micron-CT scan, characterization of pore throat structure.*

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Development and Application of New Type Environmentally-Friendly Oil-Based Drilling Fluid

Compared with the water-base drilling fluid, oil-based drilling fluid has always been one of the important technical guarantees in high temperature deep well, high-inclination directional well and all kinds of complex seismic exploration. With 5#white oil selected and taken as continuous phase, emulsifying agent, organic soil, tackifier, fluid loss agent, lime, other treatment agents and dosages are optimized and the optimal formula of oil-base drilling fluid is determined. This new type environmentally-friendly oil-base drilling fluid possesses good rheological properties, suspension capability, high temperature stability, stronger anti-pollution ability and common emulsion-breaking voltage of more than 2000 V. During the field application, this fluid possesses regular borehole diameter, good lubricity, stable borehole, simple preparation process, easy site maintenance and good reservoir protection features. Furthermore, it can solve complex formation, water expansion of clay shale, poor lubrication & drag reduction effect, poor reservoir protection effect and other technically-difficult problems.
Keywords: *environmental protection, oil-base drilling fluid, performance evaluation.*

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Study on Evaluation Methods, Selection and Applicability
of Key Parameters of Typical Shale Oil Resources

The Ordos Basin in China is rich in unconventional shale oil and gas resources. This area has become an important base for the exploration and development of unconventional oil and gas resources in China. In this paper, the key parameters of shale oil trap area, reservoir thickness, EUR per well, recovery factor, horizontal well water injection development parameters, and quasi-natural energy development well control area of the Chang 7 Member are systematically studied. The volume method, single well EUR method and geological abundance analogy method are optimized, and the applicability of the method and resource evaluation are carried out to quantitatively evaluate the oil resources of the Chang 7 shale oil in the Ordos Basin. Reservoir conditions and source rocks of the Chang 7 shale oil in the Ordos Basin are the key factors for resource evaluation. The volume method, EUR analogy method and resource abundance analogy method are suitable for the evaluation of shale oil resources in the Ordos Basin. The geological resource of the Chang 7 shale oil evaluated by volume method is 3.116 billion tons, 2.549 billion tons by EUR analogy method, and 3.297 billion tons by resource abundance analogy method.

Keywords: *shale oil reservoir, key parameters, resource evaluation, Chang 7 Member.*

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Research on the Application of Ar Technology in Oil and Gas Emergency Management

Augmented reality technology is a technology that calculates the position and angle of the camera image in real time and adds corresponding images, videos, 3D models and other information, which is widely used in business, medical, entertainment, military, engineering and manufacturing, etc. Due to the complexity and dangers of the work in the field of oilfield, the traditional management method is difficult for oilfield employees to understand the principles of the equipment and the operation process in a short period of time, which leads to the misuse of the employee which causes serious consequences. To address the above problems, this paper introduces augmented reality technology into the oilfield operation training system to realize the operation guide for employees with intuitive and realistic virtual labeling demonstration effect, which improves the efficiency of employee training and reduces the occurrence of dangerous situations. In this paper, we build a mobile augmented reality system for oil depot operation guide, and utilize Unity3D engine, ARToolKit and ARKit development library to build an augmented reality prototype system, which is used to locate virtual information with the logo as the benchmark for small equipment and the scene plane as the benchmark for large equipment. According to the operation process of the oil depot, the equipment structure, operation principle, operation method and operation steps are displayed with audio, video, virtual model, virtual animation and other information to assist employees in understanding the equipment. Finally, through human-computer interaction technology, the virtual model can be picked up, moved and scaled, and then released to the mobile terminal, realizing the mobile augmented reality prototype system of the oil depot operation guide.

Keywords: *mobile augmented reality, petroleum reservoir operation wizard, multiple marker identification, planar detection; virtual labeling.*

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Economic Evaluation of Oilfield Chemical Oil Repellent

Experimental Research and Development Project

In this paper, we design and develop modified hyperbranched polyamide amine and modified hyperbranched polyethyleneimine for pressure reduction and drag reduction in low-permeability reservoirs and emulsion breaking of crude oil, respectively, in view of the exploitation problems faced by unconventional oil and gas reservoirs and old oil fields at the late stage of oil field exploitation. The results showed that the pressure reduction efficiency reached 44.46% at the injection of 2PV with the concentration of 2g/L and the measured permeability of 0.07mD in the core. The pressure reduction mechanisms of hP-SE-LH and hP-SL-LH were explored by interfacial tension and wettability. The results showed that the unique hyperbranched structure of hyperbranched polymers can be adsorbed at multiple sites to form a film on the rock surface, which can effectively reduce the capillary force and lower the dosage of pressure-reducing and dampening agents. The emulsion-breaking mechanism of CHPEI was investigated by the interfacial tension, transmittance, and average particle size. The results show that CHPEI, with its highly branched structure and high interfacial activity, can replace the original interfacial membrane of emulsion and effectively reduce the interfacial strength, which is conducive to the agglomeration and settlement of oil droplets, indicating that the emulsion-breaking mechanism is the flocculation and agglomeration mechanism and the topping-up and replacement mechanism. At the same time, this paper formulates the field development plan, combines the local market price of drilling and completion, offshore, FPSO and ancillary services, calculates the total investment of the project, and lists the investment table by year according to the development plan. Then based on this, combined with the sub-annual production estimate, the main operating costs and profitability analysis of the project are derived, and finally combined with the discounted cash flow analysis, the results of the economic evaluation of the project are derived.

Keywords: *low permeability reservoirs, pressure-reducing and drag-reducing agents, crude oil demulsification, chemical oil repulsion, development projects, economic evaluation.*

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A Method for Rapid Prediction of Fracture Networks in Hydraulic Fracturing

Based on the models that describe fractures, a new method for predicting fracture networks in hydraulic fracturing was developed, including mathematical models and specific procedures. The feasibility of this method was investigated, and it was found that the fracture network predicted by this method in numerical simulations is not significantly different from that obtained in fracturing simulations, and it fits well with actual production data. The effectiveness of this method in predicting fracture networks in tight gas reservoirs was studied, and the results showed that the prediction effect was good, with clear presentations of simulated pressure and remaining reserves.

Keywords: *tight gas reservoir, hydraulic fracturing, fracture network predictive mathematical model, fracture network prediction steps.*

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Experimental Study on the Simulation of Hydrate Decomposition and Collapse Cycles in Deepwater Horizontal Drilling

Natural gas hydrates, with over 90% of their reserves located in deep-sea environments exceeding 800 meters in depth, represent a highly efficient and clean energy source with significant development potential. This has made them a focal point of attention both domestically and internationally. Horizontal well technology, including complex structures based on horizontal wells, will be one of the key technologies for the commercial development of natural gas hydrates in the future. However, drilling horizontal wells within gas hydrate reservoirs presents numerous difficulties and challenges. To address these issues, a self-developed simulation experimental device for horizontal drilling in gas hydrates has been created to conduct laboratory simulations of deepwater hydrate production wells. This research aims to characterize the relationship between hydrate dissociation efficiency and drilling parameters during the drilling process, and to observe wellbore stability under varying formation parameters, providing theoretical foundations and guidance for field applications.

Keywords: *horizontal well, hydrate dissociation, wellbore collapse, wellbore stability.*

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Optimization Method for the Structure of Drain Sand Jet Pump in Deep Coalbed Methane Wells

A small sample datasets jet pump efficiency prediction model based on SHAP-LSSVR is proposed to address the issue of determining multiple structural parameters in the design of jet pumps used in drain sand of coal-bed methane wells. We use 30 sets of CFD numerical simulation results a-s samples for this experiment, and use the SHAP values of each sample as the weight of the penalty factor to improve the least squares support vector regression (LSSVR) algorithm. The average relative errors obtained by LSSVR and SHAP-LSSVR were 2% and 1.1%, respectively, with r-squared values of 0.74 and 0.92. The results show that SHAP-LSSVR can enable different samples to play different roles in the fitting process, and is suitable for optimizing the structure of jet pumps-with

small sample set. Finally, we use the particle swarm optimization algorithm to search for the global optimum in the structural parameter space, and the optimal parameter combination was obtained. The error between the predicted results and CFD numerical simulation was 1.8%.

Keywords: *jut pump, LSSVR, SHAP, performance prediction.*

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A Novel Optimization Method for Electricity-Heat-Gas Multi-Energy System Management under Carbon Emission Reduction Requirements

In order to promote the implementation of carbon emission reduction targets, this paper proposes an optimal scheduling method of the electricity-heat-gas multi-energy system (MES) to stimulate carbon emission reduction, to improve the insufficient level of MES carbon capture and renewable energy consumption. Firstly, it utilizes the time-shift characteristic of oil and gas storage tanks for peak shaving and valley filling, and cooperates with power-to-gas conversion equipment to further improve the consumption level of wind power. Secondly, we consider the demand response of electricity and heat based on time-of-day pricing, and construct an economic dispatch model of multi-energy system with carbon trading mechanism. Finally, the model is solved using the CPLEX, and different scenarios are set up to verify the effectiveness of the optimization method proposed in this paper.

Keywords: *natural gas, carbon emission, carbon capture power plant, multi-energy system, flexibility.*

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Flow Field Characteristics and Flow Response in Biodiesel Swirl Atomization under External Excitation

This study investigates the effects of adjusting valve opening as an external excitation method on the swirling atomization flow field of biodiesel. Spray experiments were conducted under varying pressures and valve openings, controlled via a programmable logic controller system. Critical atomization characteristics were captured using a high-speed camera, while particle size distribution was analyzed with a laser particle size analyzer. Data analysis was conducted using MATLAB. The results indicate that external excitation notably increases the spray cone angle from 63.5° to 66.5° and substantially reduces the breakup length from 22 mm to 12 mm. Additionally, droplet size was highly responsive to external excitation, with the Sauter mean diameter decreasing from 98.71 μm to 81.67 μm.

These findings demonstrate that external excitation can effectively optimize atomization performance, with proper control of excitation conditions significantly improving atomization efficiency.

Keywords: *swirl atomization, external excitation, image processing, flow field characteristics, spray dynamics.*

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Simulation Study on Acid Fracturing Productivity of Fractured Carbonate Reservoir
Based on Thermal-Hydraulic-Mechanical-Chemical Field Couped

The world's energy is accelerating towards the stage of deep game, and there is a trend of adjustment, differentiation and reconstruction. Oil and gas resources are still the main source of core competitiveness in the oil and gas industry. As the same time, the production of carbonate reservoirs is limited by geological and engineering conditions, especially in areas with developed fractures. A thermal-hydraulic-mechanical-chemicalmulti-field coupled model is developed in this paper for exploring the acid fracturing productivity of fractured carbonate reservoir. The rock deformation, two-phase flow, heat transport and acid flow reaction are all solved in extended finite element method. The main controlling factors of productivity are studied by combining engineering geological condition in the fractured reservoir, and it involves fracture density, stress sensitivity, fracture morphology and acid fracturing mode. The mechanism of the main controlling factors of productivity are clarified in fractured reservoir. The acidizing modes under different fracture densities are demonstrated and the fracture strategy is determined.

Keywords: *fractured carbonate reservoir, acid fracturing, multi-field coupling, main controlling factors, productivity.*

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Research on Geological Risk Prediction of Drilling in Deep Complex Strata

As an important area for shale gas development in China, the southern Sichuan region has complex geological conditions in its deep shale gas reservoirs (buried at depths of 3500-4500m), and frequent accidents such as well leakage, blowout, and collapse occur during drilling, seriously restricting development efficiency. This article proposes a drilling geological risk prediction method based on well seismic integration for complex deep

formations in southern Sichuan. The aim is to accurately identify geological risks by comprehensively characterizing lithology, fractures, and rock mechanics characteristics, and provide technical guidance for drilling construction. The study takes a shale gas block (R block) in southern Sichuan as a case area, and combines logging, logging, and seismic data to systematically analyze the geological characteristics and potential risks of each formation using techniques such as lithology logging matching analysis, ant tracking fracture prediction, and rock mechanics parameter calculation. The results indicate that the Shaximiao Formation to Xujiahe Formation in Block R are mainly composed of mudstone, which is prone to well collapse; The Leikoupo Formation and Jialingjiang Formation are at risk of being difficult to drill due to the development of limestone and gypsum layers; Cracks are concentrated in the Leikoupo Formation to Maokou Formation, which can easily cause well leakage; There is a significant difference in fracture pressure between the Longmaxi Formation and the Baota Formation, and areas with large horizontal stress differences are prone to drilling leakage. Based on the above analysis, a comprehensive prediction template for drilling geological risks has been established, clarifying the risk types and distribution patterns of each formation. The integrated well seismic prediction method proposed in this article achieves multi-dimensional comprehensive evaluation of geological risks, providing theoretical basis and technical support for the safe and efficient development.

Keywords: *Southern Sichuan region, deep shale gas, geological risks associated with drilling, integrated well seismic system, lithology prediction, crack prediction, rock mechanics.*

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Evaluation of Progress Priorities in Petroleum Refining

Engineering Project Groups Based on Combined Weighting Method

The key to the construction progress of petroleum refining engineering project groups lies in the progress management of production sub-network projects. It is essential to identify the key projects with the highest progress priority among numerous production sub-network projects, as the progress management of key projects is central to managing the progress of sub-network projects. This paper proposes a priority evaluation method for sub-network projects within petroleum refining engineering project groups, which is a multi-attribute group decision-making approach. The method is based on project progress priority evaluation indicators and utilizes an improved AHP-CRITIC subjective and objective combined weighting method to determine the weights of each indicator while also incorporating a weighted calculation of the decision-making professional comprehensive qualities. An improved VIKOR method is then employed for ranking, leading to the comprehensive index value Q_i for sub-network projects using a weighted summation model, followed by prioritization based on ascending numerical values. Case analysis demonstrates that the constructed evaluation model can effectively assess the priority of projects within the sub-network, thereby providing a scientific and effective basis for conducting research on the progress optimization management of project groups.

Keywords: *petroleum refining engineering project groups, progress priority; Index system, improved AHP-CRITIC method.*

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A New Seepage Model and Its Semi-analytical Solution for Transient Pressure Analysis of Gas Wells in Triple Medium Gas Reservoirs with a Local Discontinuous Zone

In this paper the author first built and solved a new seepage model for transient pressure analysis of gas wells in triple medium gas reservoirs with a local discontinuous zone by a semi-analytical method. The results obtained by the semi-analytical method proposed in this paper were compared with those obtained by Boundary Elementary method. The factors which affect the pressure transient behavior were analyzed. If the circular discontinuous zone is impermeable and the well located external to the circular discontinuous zone, a "salient" and two "concaves" on the derivative curve will arise during the radial flow period. The "salient" is the reflection of the internal circular impermeable discontinuous zone, and the two "concaves" are the reflections of crossflow between the matrix system or vug system and the fracture system. The longer the shortest distance between the internal circular impermeable discontinuous zone and the well, the later the "salient" on the derivative curve arises and the lower the top of the "salient" is. The bigger the radius of the internal circular impermeable discontinuous zone, the wider the span of the "salient" on the derivative curve will be and the higher the top of the "salient" will be. The model proposed in this paper reveals the complicated seepage law in triple medium gas reservoirs with an internal circular discontinuous zone and contributes a new model to the model library for well testing. It makes us be able to complete well test interpretation for this type of complicated gas reservoir and obtain some important parameters such as elastic storativity ratio of any kind medium, permeability, crossflow coefficient, etc. Besides, it also makes us be able to identify the existence of an internal impermeable zone, the size of it, and the distance from a well to an internal impermeable zone. The model proposed in this paper is most important that it is built and solved firstly by semi-analytical method and the solution is very fit for numerical calculation of computer.

Keywords: *local discontinuous zone located outside a gas well, matrix-fracture-vug triple medium gas reservoir, pressure transient behavior, semi-analytical solution, numerical inversion, type curve.*

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Enhanced Oil Recovery through Control Technology Pressure Management and Water Control

This study challenges the conventional assumption that profile control inherently enhances oil recovery, demonstrating its dependency on post-treatment pressure elevation. Through numerical simulations of four operational scenarios, results show that profile control without pressure elevation reduces water injection volume and oil production, while integrated pressure-conformance strategies increase oil recovery by 65% with optimized water utilization efficiency. A mechanistic model reveals that merely sealing high-permeability zones fails to mobilize oil in low-permeability layers unless injection pressure is elevated to reconfigure displacement gradients. Field-scale simulations of polymer gel treatments demonstrate that elevating pressure to 20 MPa post-plugging diverts 37.5% of injected water into under-swept regions, expanding sweep efficiency by 32.7%. The core mechanism lies in pressure field reconfiguration, where a 4.8 MPa pressure differential activates low-permeability zones, reducing per-unit oil cost by 18%. This research provides a paradigm shift from passive water control to active pressure-conformance synergy, offering scientifically grounded strategies for high water-cut reservoirs.
Keywords: *profile control technology, EOR, numerical simulation; pressure control, temporary plugging and divert.*

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Study on Fracture Damage Caused by Polymer Fracturing Fluid

to Sandstone with Different Fracture Widths

Fractures of different widths are formed during the sandstone fracturing process, and these fractures are the main channels for oil and gas flow after fracturing. However, the polymers injected into the well have a certain size and will block the micro - fractures formed by fracturing, thus affecting the hydraulic fracturing effect. This paper establishes a set of experimental methods to test the blocking situation of polymers in fractures of different widths and analyzes the principle of polymer blocking micro - fractures from a microscopic perspective. Fracture width, polymer concentration and temperature all have an impact on fracture damage. Especially, the results show that when the width of micro-fractures is less than 10 μm, the blocking effect of polymers is the strongest, and the hydrogen bonds between polymers and rock surfaces are the main reasons for the blocking effect of polymers. A plate of polymer-induced damages to different fractures has been formed, which enables an intuitive understanding of the damage situation of polymers injected into wells on fractures.
Keywords: *fracturing fractures, polymer fracturing fluid, fracture widths, fracture damage.*

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Self-Attention Prediction Model of Production Dynamic Parameters

in Low Permeability Reservoirs Based on Deep Learning

Accurate prediction of production dynamic parameters is important for optimising reservoir development and improving recovery. In this study, a composite deep learning model combining convolutional neural network (CNN), bi-directional long and short-term memory network (BiLSTM), and self-attention mechanism is proposed for predicting the dynamic parameters of reservoir production, especially daily oil production and water cut rate. CNN is used to extract the local temporal features, BiLSTM captures the long term dependencies, and the Attention mechanism enhances the model to pay attention to the key temporal patterns. Combined with multiple well studies, it is proved that the CNN-BiLSTM-Att model has a very high accuracy in the prediction of production dynamic parameters. Through the comparative analysis with traditional models and the prediction of single-well effects based on the evaluation indexes of MAE, MAPE, MSE, RMSE, and R^2, the results show that the composite model is excellent in both prediction accuracy and robustness are better than the existing models. This study provides valuable insights for intelligent reservoir management and a novel prediction method for solving complex reservoir production nonlinear dynamic problems.

Keywords: *reservoir engineering, reservoir production prediction,deep learning, convolutional neural network, BiLSTM, self-attention, intelligent reservoir management.*

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Stability Study of Carbon Nanotube-Deionised Water Nanofluid Electrolyte

As a new type of electrolyte, nanofluidic electrolytes can improve the energy storage and conversion efficiency, which can be used in batteries and electrolysis for hydrogen production, and its preparation and application have attracted the attention of many scholars. However nanoparticles constrain further application of nanofluidic electrolytes due to their instability. Carbon nanotubes, which are stable in nature, were chosen as the dispersant in this paper, carbon nanotube-deionised water nanofluidic electrolytes were prepared. The stability of the nanofluid and its relationship with conductivity was investigated through sedimentation observations and absorbance measurements and analyses. It was shown that: the preparation sequence of preparing nanoparticle dispersion first and then adding CTAB additives could obtain nanofluidic electrolytes with better stability; the smaller the concentration of nanoparticles in the carbon nanotube-deionised water nanofluidic electrolytes, the higher the stability; the additives could effectively increase the dispersive stability of the nanofluidic electrolytes, and the dispersive stabilising effects were CTAB, PVP, and SDS, from high to low.

Keywords: *carbon nanotubes, electrolyte, stability, concentration, additives, preparation sequenc.*

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The Characteristics of Differential Sedimentary Filling
under the Activity of Boundary Faults in Continental Faulted Lake Basins

This study investigates how boundary fault activity and growth controlled stratigraphic infilling patterns in the Ludong Sag, a single-faulted dustpan-shaped continental lacustrine basin. Through integrated analysis of core samples, well logs, and seismic profiles, we reconstructs the activity intensity and segmented growth patterns of the steep-slope boundary fault during the deposition of the Jiufotang Formation. Additionally, we classify sedimentary facies architectures and propose a genetic model to elucidate fault-driven sedimentation dynamics. During the Jiufotang Formation period, the Ludong Sag experienced significant rifting. Seismic reflection data allowed subdivision of the stratigraphy into upper, middle, and lower intervals. Integrated analysis of fault throw versus line backstripping curves, combined with well-seismic calibration, revealed that intense boundary fault activity during the Lower Jiufotang stage rapidly increased accommodation space. This expansion promoted rapid clastic sediment accumulation on the boundary fault's hanging wall. Furthermore, fault segmentation led to the development of two distinct nearshore subaqueous fan systems. During the Middle Jiufotang stage, boundary fault activity markedly declined. Reduced accommodation space (due to prior sedimentary infilling) and gentler paleotopographic slopes resulted in widespread but thin sand deposition, creating a basin-wide "sand-rich" condition.

A fan delta system developed, characterized by extensive distribution, thin layers, and finer-grained lithologies. In the Upper Jiufotang stage, boundary fault activity peaked with diminished segmentation. Two superimposed nearshore subaqueous fan systems formed, while the depocenter's deep lacustrine environment facilitated the deposition of thick mudstone-shale sequences.

Keywords: *Songliao Basin, Ludong Sag, boundary fault activity, sedimentary filling.*

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Tracing the Origin of Hydrogen Sulfide in the J Oilfield

The J Oilfield in eastern China is rich in oil and gas resources, but hydrogen sulfide (H_2S) contamination has been identified within its production blocks, requiring clarification of its genetic sources. This study combines geological characterization of the target blocks with physicochemical analyses of rock, oil, natural gas, and formation water samples from Block A and Block B, supplemented by sulfur isotope measurements. Results demonstrate that all tested samples contain sulfur. The normal composition of crude oil and the dryness coefficient of natural gas indicate that both blocks produce wet gas. Notably, natural gas from Block B contains elevated carbon dioxide levels (up to 85%), a hallmark of thermochemical sulfate reduction (TSR). Total Dissolved Solids in formation water vary significantly between the blocks: Block A exhibits extreme sulfate ion concentration gradients (13.9 to 4,162.1 mg/L), consistent with bacterial sulfate reduction (BSR), while Block B shows high sulfate ion

concentrations (381.2 to 3,459.2 mg/L). Sulfur isotope analysis reveals distinct $\delta^{34}S$ signatures: H_2S in Block A ranges from $\delta^{34}S$ = -2.5‰ to 3.8‰, H_2S in Block B ranges from $\delta^{34}S$ = 14.2‰ to 15.8‰, and the sulfur isotope fractionation values between samples further demonstrate that Block A exhibits BSR-related characteristics, with sulfate ions in formation water inferred as the sulfur source, Block B exhibits TSR-related features linked to Cretaceous evaporite salts as the sulfur source. Laboratory simulations of H_2S genesis were conducted, successfully validating the aforementioned inferences.

Keywords: *hydrogen sulfide, sulfur isotope analysis, BSR, TSR.*

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Synthesis of a Novel Titanium Dioxide Nanocomposite Polymer and Performance Evaluation

Fracturing fluid is the "blood" of reservoir reconstruction technology. Single-well myriad square fluid and thousand square sand have become the main methods of volume fracturing in uncon-ventional oil and gas horizontal wells. With the gradual exploitation of oil and gas fields to the deep, higher performance requirements have been put forward for fracturing fluid. In this paper, nano-TiO_2 was modified by vinyltrimethoxysilane, and a new type of nanocomposite polymer (PTAS) was synthesized by aqueous solution polymerization of modified nano-TiO_2 with acrylamide (AM), acrylic acid (AA) and 2-acrylamide-2-methylpropylsulfonic acid (AMPS). The synthesis conditions such as monomer ratio, polymerization temperature, polymerization time, and initiator dosage were optimized by using the viscosity of the base solution as an index. The structure and properties of PTAS were characterized by Fourier transform infrared spectroscopy, scanning electron microscopy, transmission electron microscopy, and thermogravimetric analysis. The experimental results showed that the nano-TiO_2 was successfully modified by vinyltrimethoxysilane, and the modified nano-TiO_2 was successfully attached to the polymer molecular chain. The performance evaluation results of PTAS showed that compared with the polymer without nano-TiO_2 P(AM-AA-AMPS), the salt resistance, sand carrying, temperature resistance, shear resistance, and gel breaking properties of PTAS were improved, This is due to the additional modified nano-TiO_2, which enhances the polymer network structure and improves its structural stability, so that the polymer can maintain good thickening behavior performance while reducing the molecular weight, reducing the residue content after gel breaking, and reducing its damage to the formation. PTAS has a good potential for application in hydraulic fracturing.

Keywords: *polymer, fracturing fluid, acrylamide, modified nano-TiO_2, high performance.*