

# Chemistry and Technology of Fuels and Oils

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### **Обоснование возможности использования отходов растительного производства в составе смазочной добавки для буровых растворов**

*Работа посвящена изучению и поиску альтернативных возобновляемых источников сырья для производства сложных эфиров жирных кислот с целью их дальнейшего применения в качестве смазочной добавки к буровым растворам и оптимизации себестоимости разрабатываемой продукции.*

*Сложные эфиры жирных кислот были получены на основе олеиновой кислоты и многоатомных спиртов, а также путем реакции переэтерификации метиловых эфиров жирных кислот, полученных из возобновляемых отходов растительного производства, с многоатомными спиртами. Подобраны оптимальные условия синтеза, проведен анализ физико-химических свойств полученных продуктов и определены направления дальнейшего исследования.*

**Ключевые слова:** буровой раствор, смазочная добавка, реология, гидрофобизация, фильтрационно-емкостные свойства, коэффициент трения.

L. A. Magadova<sup>1</sup>, Y. A. Topolyuk<sup>1</sup>, E. S. Bobkova<sup>1</sup>, I. N. Grishina<sup>1</sup>, N. A. Svarovskaya<sup>1</sup>, A. G. Merkurjeva<sup>2</sup>

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### **Justification the Possibility of Use Waste from Plant Production in Lubricant Additive Formulation for Drilling Fluids**

*This work is devoted to the study and search of alternative renewable sources of raw materials for production of esters of fatty acids for the purpose of their further application as lubricant additive for drilling fluids and to optimization of the cost value of developed products. The analysis of patent, scientific and technical literature has shown that production of lubricant additives for drilling fluids based on environmentally sound, renewable raw materials is actual task. The series of synthesis on receiving esters based on fatty acids on the basis of the pure oleic acid, technical oleic acid and polyatomic alcohols and by reaction of transesterification of methyl ethers of fatty acids, received from renewable waste of plant production, with polyatomic alcohols has been carried out. Optimum conditions of synthesis are picked up, the analysis of physical and chemical properties of the received products is carried out, the directions of further research are defined.*

**Key words:** drilling fluid, lubricant additive, rheology, hydrophobization, reservoir porosity and permeability, friction coefficient.

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### **Влияние термopаровой обработки на свойства HLaY-содержащих катализаторов крекинга на матрице из пилларированного алюминием монтмориллонита**

Проведены испытания разработанного HLaY-содержащего катализатора с матрицей из-pillарированного алюминием монтмориллонита в Na- и CaNa-формах в крекинге вакуумного газойля в целевые продукты — бензин и легкий газойль. Показано, что на катализаторе Al(2,5)CaNaHMM+HLaY после паровой обработки выход бензина повышается с 58,5 до 62,5%. Для получения легкого газойля испытывали катализатор на основе неактивированного монтмориллонита Al(2,5)CaNaMM+HLaY. Максимальный выход легкого газойля, равный 65,9–65,1%, был получен после паровой обработки этого катализатора при соотношении катализатора и сырья равном 2:1. Различными методами анализа определено влияние паровой обработки на фазовый состав, пористую структуру, элементный состав и кислотные свойства изученных катализаторов.

**Ключевые слова:** pillарированный монтмориллонит, вакуумный газойль, каталитический крекинг, цеолит

N. A. Zakarina, A. K. Akurpekova, O. Dalelkhanuly, D. A. Zhumadullaev

JSC "Institute of Fuel, Catalysis and Electrochemistry named after D.V. Sokolsky", Almaty

### **Effect of Thermosteam Treatment on Properties of HLaY-Containing Cracking Catalysts on Matrix of Al-Pillared Montmorillonite**

*The tests of the developed HLaY-containing catalyst with a matrix of pillared aluminum montmorillonite in Na- and CaNa-forms were carried out in the cracking of vacuum gas oil into the target products - gasoline and light gas oil. It is shown that on Al(2.5) CaNaHMM + HLaY- catalyst after steam treatment, the yield of gasoline increases from 58.5 to 62.5%. To obtain light gas oil, a catalyst based on unactivated montmorillonite Al(2.5)CaNaMM + HLaY was tested. The maximum light gas oil yield, equal to 65.9-65.1%, was obtained after steam treatment of this catalyst at a catalyst: feed ratio of 2:1. The influence of steam treatment on the phase composition, porous structure, elemental composition, and acidic properties of the catalysts under study was determined by XRD, BET, NH<sub>3</sub> thermal desorption and X-ray fluorescence analysis.*

**Key words:** pillared montmorillonite, vacuum gas oil, catalytic cracking, zeolite.

**Н. М. Максимов, А. А. Зурнина, И. С. Докучаев, П. С. Солманов,  
Ю. В. Еремина, Е. О. Жилкина, В. Б. Коптенармусов, А. А. Пимерзин**

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### **Сравнительный анализ превращений модельных компонентов тяжелого нефтяного сырья в условиях крекинга в присутствии катализатора металлического и кислотного типов**

*В работе проведено исследование роли металлического катализатора и доноров водорода в процессе термического крекинга и сравнение результатов с типичным катализатором крекинга кислотного типа (ЭМКАТ). Показано, что роль металлического катализатора в процессе термического крекинга заключается в осуществлении реакций переноса водорода, преимущественно в неионных формах. Легкость дегидрирования донора водорода определяет интенсивность подавления реакций крекинга.*

**Ключевые слова:** модельные компоненты, тяжелое нефтяное сырье, крекинг, металлический катализатор, кислотный катализатор.

N. M. Maximov, A. A. Zurnina, I. S. Dokuchaev, P. S. Solmanov, Yu. V. Eremina, E. O. Zhilkina,  
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Samara State Technical University

### **Comparative Analysis of Heavy Oil Feedstock Model Components Conversions under Cracking Conditions in the Presence of Metal and Acid Type Catalysts**

*In this work the role of a metal catalyst and hydrogen donors in the thermal cracking process compared the results with a typical acid-type cracking catalyst (EMCAT) was investigated. As it was shown, the role of a metal catalyst in the thermal cracking process is to carry out hydrogen transfer reactions, mainly in non-ionic forms. The easiness of dehydrogenation of the hydrogen donor determines the intensity of suppression of cracking reactions.*

**Key words:** model components, heavy oil feedstock, cracking, metal catalyst, acid catalyst.

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### **Исследование процесса стеклования**

#### **узких нефтяных фракций в широком температурном диапазоне**

*Приведены результаты исследования фазового поведения шести образцов узких нефтяных фракций в диапазоне температур 150–350 К при атмосферном давлении, проведенные с помощью метода сканирующей калориметрии. Показано наличие корреляции между температурой стеклования исследованных нефтяных фракций и их средней температурой выкипания, молекулярной массой и начальной вязкостью.*

**Ключевые слова:** стеклование, узкие нефтяные фракции, температура, сканирующий калориметр, молекулярная масса, вязкость.

*V. G. Kutcherov*

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### **Study of the Glass Transition in Narrow Oil Fractions in Wide Temperature Range**

*The results of studying the phase behavior of six samples of narrow oil fractions in the temperature range 150–350 K at atmospheric pressure, carried out using the method of scanning calorimetry, are presented. The presence of a correlation between the glass transition temperature of the oil fractions studied and their average boiling point, molecular weight and initial viscosity is shown.*

**Key words:** glass transition, narrow oil fractions, temperature, scanning calorimetry, molecular mass, viscosity.

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## **Исследование физико-химических свойств исходных компонентов**

### **для полиэлектролитного комплекса — реагента для нефтегазодобычи**

*Исследованы физико-химические свойства исходных компонентов: поли-N,N-диметил-N,N-диаллиламмоний хлорид, лигносульфонат и полиэлектролитные комплексы на их основе. Подобраны оптимальные условия проведения и иницирующие соединения процесса полимеризации поли-N,N-диметил-N,N-диаллиламмоний хлорида. Математическое моделирование экспериментов проведено посредством программного комплекса STATISTICA 13. Представлены результаты определения размера частиц экспериментальных образцов поли-N,N-диметил-N,N-диаллиламмоний хлорида методом лазерной дифракции. Проведен сравнительный анализ состава функциональных групп по ИК-спектрам лигносульфоната сульфитного и нейтрально-сульфитного способа производства целлюлозы. Потенциометрическим титрованием изучена возможность комплексообразования лигносульфоната с ионами Fe (II) и полиэлектролитного комплекса на основе модифицированного лигносульфоната и поли-N,N-диметил-N,N-диаллиламмоний хлорида. Изучено воздействие экспериментальных образцов полученного полиэлектролитного комплекса на фильтрационные свойства бурового глинистого раствора в условиях температурной агрессии.*

**Ключевые слова:** поли-N,N-диметил-N,N-диаллиламмоний хлорид, лигносульфонат натрия, сульфитный и нейтрально-сульфитный способы производства целлюлозы, полиэлектролитный комплекс, потенциометрическое титрование, показатель фильтрации, буровой глинистый раствор.

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## **Research of Physical and Chemical Properties of Initial Components**

### **for Polyelectrolyte Complex-Reagent for Oil and Gas Production**

*The physicochemical properties of the initial components: poly-N,N-dimethyl-N,N-diallylammonium chloride, lignosulfonate, and polyelectrolyte complexes based on them were studied. Optimal conditions for conducting and initiating compounds of the polymerization process of poly-N,N-dimethyl-N,N-diallylammonium chloride were selected. Mathematical modeling of experiments was carried out using the STATISTICA 13 software package. The results of determining the particle size of experimental samples of poly-N,N-dimethyl-N,N-diallylammonium chloride by laser diffraction are presented. A comparative analysis of the composition of functional groups based on the IR spectra of lignosulfonate of the sulfite and neutral-sulfite method of cellulose production was performed.*

*Potentiometric titration was used to study the possibility of complexation of lignosulfonate with Fe (II) ions and a polyelectrolyte complex based on modified lignosulfonate and poly-N,N-dimethyl-N,N-diallylammonium chloride. The effect of experimental samples of the obtained polyelectrolyte complex on the filtration properties of drilling mud under conditions of temperature aggression is studied.*

**Key words:** poly-N,N-dimethyl-N,N-diallylammonium chloride, particle size, sodium lignosulfonate, sulfite and neutral-sulfite methods of cellulose production, polyelectrolyte complex, potentiometric titration, filtration index, drilling mud poly-N,N-dimethyl-N,N-diallylammonium chloride, particle size, sodium lignosulfonate, sulfite and

*neutral-sulfite methods of cellulose production, polyelectrolyte complex, potentiometric titration, filtration index, drilling mud.*

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**Способы и технологии создания нового поколения средств хранения и транспортирования горючего**

*Приведены основные научно-практические результаты в области создания технических средств нефтепродуктообеспечения нового поколения на основе модифицированных полимерных материалов. Представлены технические требования, методы оценки, способы и технологии модификации полимерных материалов для создания эластичных резервуаров и напорных плоскостворачиваемых трубопроводов для горючего. Установлено соответствие эксплуатационных свойств разработанных технических средств хранения и транспортирования горючего современным требованиям.*

**Ключевые слова:** полимерные материалы, эластичные резервуары, напорные рукава, комплексные требования, способы и технологии модификации, термопластичный полиуретан, температурный предел хрупкости.

*Yu. N. Rybakov, S. N. Volgin.*

The 25<sup>th</sup> State Scientific Research Institute of Chemmotology of the Russian Ministry of Defence

**Methods and Technologies for Creating a New Generation of Fuel Storage and Transportation Facilities**

*The main scientific and practical results in the field of creating petroleum products supply facilities of a new generation based on the modified polymeric materials are presented. The technical requirements, evaluation methods, methods and technologies for the modification of polymeric materials to create elastic tanks and pressure lay-flat pipelines for fuel are presented. The compliance of the operational properties of the developed fuel storage and transportation facilities with the modern requirements has been established.*

**Key words:** polymeric materials, elastic tanks, pressure hoses, complex requirements, modification methods and technologies, thermoplastic polyurethane, temperature brittleness limit.

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**Новый подход к организации метрологического обеспечения испытаний нефтепродуктов**

*В качестве цели метрологического обеспечения испытаний нефтепродуктов рассматривается достижение такого состояния процесса испытаний, которое гарантировало бы получение точной и достоверной измерительной информации о составе и свойствах нефтепродуктов. Это возможно только при объединении традиционных метрологических подходов и процедур управления процессом испытаний.*

**Ключевые слова:** метрологическое обеспечение испытаний нефтепродуктов, испытательная лаборатория, управление качеством.

*K. V. Shatalov*

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### **New Approach to the Organization of Metrological Support for Petroleum Products Testing**

*The goal of metrological support of petroleum product testing is to achieve a state of the testing process that would guarantee accurate and reliable measurement information about the composition and properties of petroleum products. This is only possible by combining traditional metrological approaches and test process control procedures.*

**Key words:** *metrological support of petroleum product testing, testing laboratory, quality management.*

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### **Увеличение эффективности и селективности разделения компонентов при хроматографическом анализе природного газа**

*При переработке и транспортировке природного газа большое значение имеет его компонентный состав, основным методом определения которого является газовая хроматография. В методе газовой хроматографии эффективность и селективность разделения являются важными характеристиками аналитического процесса. В настоящей работе исследовано влияние типа насадочных колонок и проведен подбор режимов хроматографирования при определении компонентного состава природного газа.*

*Наибольшее значение числа теоретических тарелок получено с использованием колонки Porapak R №4233 (3 м), наибольшая симметричность пиков с использованием колонки OPN/Porous-Sil C №4355 (3м), а наилучшее разрешение показывают колонки Hayesep Q №1754, 3 м, Hayesep D №4741(2 м), Porapak Q №1723 (2 м). Таким образом, показано, что подбор условий проведения анализа может существенно улучшить эффективность, селективность хроматографического определения компонентного состава природного газа.*

**Ключевые слова:** газовая хроматография, природный газ, насадочные колонки, селективность разделения, эффективность разделения.

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### **Increasing the Efficiency and Selectivity in the Chromatographic Analysis of Natural Gas**

*Composition of natural gas plays an important role in gas processing and transportation. The common method for natural gas composition determination is gas chromatography. In the gas chromatography efficiency and selectivity are essential characteristics of analytical process. In this work, the influence of a type of packed column on separation*

efficiency and selectivity during natural gas chromatographic analysis was investigated under several operation modes. The highest theoretical plates number was obtained using Porapak R column 4233 (3 m), the best symmetry of the peaks was achieved using the OPN/Porous-Sil C column 4355 (3m), and the highest resolution was shown when Hayesep Q # 1754, 3 m, Hayesep D # 4741 (2 m), Porapak Q # 1723 (2 m) were applied under selected chromatographic modes. It was shown that optimization of operation conditions can significantly improve efficiency and selectivity of chromatographic separation of natural gas compounds.

**Key words:** gas chromatography, natural gas, packed columns, separation selectivity, separation efficiency.

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### **Деструкция парафиновой фракции нефти микроорганизмами**

*Исследовано разложение алкановой (парафиновой) фракции нефти микроорганизмами-нефтедеструкторами. Показана четко прослеживаемая зависимость скорости деструкции от длины цепи. Увеличение количества алканов с меньшей длиной цепи говорит о разрушении надмолекулярных нефтяных структур и окислении более высокомолекулярных соединений. Выявлены видовые и штаммовые особенности разложения алканов. С помощью метода главных компонент выявлено, что *Rhodococcus erythropolis* и *Acinetobacter guillouiae* используют разную стратегию разложения алканов. Показано, что нефтедеструкторы не способны одинаково эффективно разлагать все фракции нефти. Опираясь на предыдущие исследования, можно утверждать, что для *R. erythropolis* предпочтительной является алкановая фракция, для *A. guillouiae* — ароматическая.*

**Ключевые слова:** микроорганизмы-нефтедеструкторы, парафиновые углеводороды, микробная трансформация.

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### **Destruction of Oil Paraffin Fraction by Microorganisms**

*The destruction of the (paraffinic) oil fraction by microorganisms-oil has been studied investigated. A clear dependence of the destruction rate on the chain length is shown. An increase in the number of alkanes having a shorter chain indicates the destruction of supramolecular oil structures and the oxidation of higher molecular compounds. Species and strain features of the alkane destruction are revealed. Using the principal components analysis, it is found that *Rhodococcus erythropolis* and *Acinetobacter guillouiae* demonstrate different behavior in the decomposition of alkanes. It is established that oil destructors are not capable of destructing all oil fractions with equal efficiency. Based on previous studies, it can be stated that *R. erythropolis* destruct mainly the alkane fraction, while the aromatic fraction is preferably destructed by *A. guillouiae*.*

**Key words:** microorganisms-oil destructors, paraffinic hydrocarbons, microbial transformation.



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### **Состояние и перспективы развития производства малеинового ангидрида в России**

*Проанализирован рынок малеинового ангидрида в России. Проведена оценка существующих технологий производства малеинового ангидрида и предложена оптимальная технология. Выбрана конфигурация со стационарным слоем катализатора. Выявлены возможные проблемы, возникающие на всех этапах строительства и дальнейшего производства и предложены пути решения данных проблем.*

**Ключевые слова:** малеиновый ангидрид, стационарный слой катализатора, Амурский газоперерабатывающий завод, окисление n-бутана, фумаровая кислота, ректификационная колонна.

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### **The Condition and Development Prospects of Maleic Anhydride Production in Russia**

*The maleic anhydride market in Russia was analyzed. An assessment was made of existing production technologies for maleic anhydride. The optimal installation location and the production technology of the target product are proposed, having studied all the specifics of this production. The configuration with a stationary catalyst bed is selected. Possible problems are identified that arise at all stages of construction and further production, and ways to solve these problems are proposed.*

**Key words:** maleic anhydride, stationary catalyst bed, reactor, n-butane oxidation, fumaric acid, distillation column.

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### **The Relationship between CO<sub>2</sub> Adsorption and Microporous Volume in a Porous Carbon Material**

*In this work, we have characterized four types of porous carbon material by N<sub>2</sub> adsorption at 77 K and CO<sub>2</sub> adsorption at the freezing point. The results show that both the BET equation based on the N<sub>2</sub> adsorption isotherm and the D-A model parameters obtained from the CO<sub>2</sub> adsorption isotherm are not applicable for analyzing the CO<sub>2</sub> adsorption characteristics in porous carbon materials. The density functional theory (DFT) analysis results of the CO<sub>2</sub> adsorption isotherm show that the adsorption of CO<sub>2</sub> in a porous carbon material occurs mainly in micropores, and the micropore volume calculated by the DFT model is in good agreement with the adsorption isotherm. Therefore, the DFT model based on the CO<sub>2</sub> adsorption isotherm is a reliable characterization method and can accurately reflect the CO<sub>2</sub> adsorption characteristics of activated carbon.*

**Keywords:** porous carbon material; pore structure; adsorption characterization.

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### **A New Prediction Model of Water Breakthrough Time of Horizontal Well in Inclined Edge-Water Low Permeability Gas Reservoir**

*At present, the existing water breakthrough time models in edge-water gas reservoirs are mainly based on the vertical well scheme and ignore the impact of the formation dip angle and non-Darcy flow effect, thus resulting in some differences between the predicted and actual measured data. To improve the accuracy of prediction, we have considered the effect of gravity caused by the dip angle in the edge-water gas reservoir. The established mathematical model of a low permeability edge-water gas reservoir is based on the theory of gas-water two-phase seepage. The prediction model of water breakthrough time in a horizontal well considers the influence of the formation dip angle, starting pressure gradient, and non-Darcy flow effect. The prediction model sensitivity analysis has been carried out. The results show that the predicted time of the new model is closer to the actual water breakthrough time in the gas reservoir than that of the existing models. The sensitivity analysis results show that the water breakthrough time decreases with increase in the gas well production, and increases with increase in formation dip angle, horizontal well length, and original distance between the gas-water interface and the well bottom. For the same horizontal well length, the water breakthrough time calculated considering the non-Darcy flow effect is shorter than the time calculated without considering the non-Darcy flow effect. The research results provide the necessary background for accurate prediction of the water breakthrough time in edge-water gas reservoirs.*

**Keywords:** edge-water gas reservoir, non-Darcy effect, starting pressure gradient, reservoir dip angle, water breakthrough time.

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### **Calculation Model of Frictional Pressure Drop for Gas Well during Foam Drainage**

*In the process of enhanced development of gas wells, the liquid loading may cause obstacles for the effective production of the gas wells. Gas-foam drainage technology has the advantage of low cost and simple operation. The design of the drainage technology requires providing a reliable formula to evaluate the friction coefficient of foam in the tube. In this paper, we have applied a theoretical analysis and indoor experiments to study the liquid volume lifted by the gas-foam flow and the pressure gradient in the well pipe in the process of foaming drainage, and established the calculating formula for the foaming friction in the well pipe, considering the different injection speed of the foaming agent. The validation results show that the formula meets the engineering accuracy, which can provide a theoretical foundation for comprehensive analysis of the foaming technology in production gas wells.*

**Keywords :** liquid loading, gas drainage, foaming agent, friction calculation.

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### **Black Rice Husk Ash Is a Useful Template for Foam Stability to Enhance Oil Recovery**

*In the present study, we have studied the advantages of using black rice husk ash nanoparticles as a foam stabilizer. It was shown that nanoparticles can potentially improve the foam stability; therefore, using nanoparticles allows one to reduce the surfactant or polymer concentration needed to control gas mobility in the reservoir. In the previously published studies, the authors reported the results of using nanoparticles for this particular application. The study aims to improve the foam-forming ability and foam stability when used in enhanced oil recovery technologies. Therefore, we have investigated the ability of the black rice husk ash to provide foam stability and foaming ability of additives. Black rice husk ash was used to produce stable foam in the process of injection of CO<sub>2</sub> and N<sub>2</sub> gases. Various characterization techniques were used to investigate the properties of the black rice husk ash. Black rice husk ash at various concentrations (ppm) was mixed with high-performance anionic foaming surfactants. In this study we used sodium dodecyl benzene sulfonate (SDBS) anionic surfactant. The static foam tests were performed at ambient temperature by bubbling the CO<sub>2</sub> and N<sub>2</sub> gases through the solution. The CO<sub>2</sub> and N<sub>2</sub> gas-injection laboratory technical evaluations have been reported. The analysis results showed that the contents of silica nanoparticles of black rice husk ash can enhance the foaming ability and provide stability of the foam. Black rice husk ash has attracted increasing interest as a potential additive when used in enhanced oil recovery (EOR) technologies.*

**Keywords:** nanoparticles, black rice husk ash, SDBS, surfactant, CO<sub>2</sub>, foam stability, EOR.

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### **Experimental Study of Anisotropic Characteristics of a Specific Formation Shale**

*The bedding surfaces of shale in the Longmaxi formation are well developed. To study the influence of bedding surfaces on the mechanical properties of shale, we have carried out uniaxial and triaxial compression tests on shale specimens of Longmaxi formation in Southern Sichuan, China. The results show that when the samples are subjected to compression, the properties of shale, including strength characteristics, elastic parameters, and fracture mode in the shale samples, are characterized by strong anisotropy. The confining pressure effect is due to the existence of well-developed bedding surfaces in shale. The results provide a theoretical basis for horizontal wellbore stability analysis and hydraulic fracturing design in shale gas wells.*

**Keywords:** Longmaxi formation; shale; bedding surfaces; anisotropy.

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### **Simulation Study of Hydrocarbon Generation Characteristics in Siliceous Rock**

*Late Triassic-early Jurassic silica rocks are widely developed in Northeast China. To evaluate the silica rock hydrocarbon generating capacity, we have simulated the hydrocarbon evolution process by thermal simulation experiments and analyzed the hydrocarbon generation characteristics. The experiments were carried out at six temperature points 250, 270, 290, 310, 330, and 350°C, and the content of the gaseous and liquid products was measured. The experiments results showed that the organic-rich siliceous rocks are characterized by a relatively high hydrocarbon-generating capacity. The gaseous products are generated at different temperatures, while natural gas is mainly generated when the peak period of oil generation is completed. Natural gas includes hydrocarbon and non-hydrocarbon gases. Hydrocarbon gases include methane, ethane, propane, butane, pentane, and other heavy hydrocarbon gases. Non-hydrocarbon gases include hydrogen, nitrogen, carbon monoxide, and carbon dioxide. Carbon dioxide is the main component of the gas products, followed by hydrogen, methane, nitrogen, and other gases, but the total content of other gases is extremely low. Carbon dioxide generated during all stages of the oil generation process accounts for the vast majority, but in geological conditions, it will eventually be consumed by hydration. Nitrogen is mainly produced in the early stage. The content of hydrogen and hydrocarbon gases increases with increase in temperature, but hydrogen is usually depleted in the actual reservoir due to its strong chemical activity.*

**Keywords:** thermal simulation; silicious rock; hydrocarbon generation.

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### **Analysis of COVID-19 Impact on Natural Gas Supply Reliability**

*In this study, we have analyzed the impact of COVID-19 on natural gas supply reliability. Natural gas supply reliability is defined as the ability to satisfy the market demand and is determined by both supply-side and demand-side policy. To evaluate the gas supply reliability of the natural gas pipeline system, we have applied the method of gas supply capacity calculation based on the results of the previous gas supply reliability studies. The method combines the unsteady flow hydraulic analysis, simulation of the state transition process, and the forecasting analysis of the demand and consumption. The analysis presents a case study based on the gas pipeline system in China. The analysis results indicate that the COVID-19 consequences will cause a decrease in gas supply reliability.*

**Keywords:** COVID-19, gas supply reliability, demand side, market demand.

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### **Study of Forecasting and Estimation Methodology of Oilfield Development Cost Based on Machine Learning**

*Due to the oil price fluctuations in recent decades, international and national oil companies have developed programs of strategically oriented development and assets optimization. Many companies have also promptly promoted opportunities for oilfield joint ventures. Therefore, a fast and accurate assessment methodology of oilfield assets, including planning and costs assessment, is expected to be proposed. Oilfield development cost assessment can be dynamically affected by a number of factors, including oilfield internal indexes and macroeconomic indexes. Based on a machine learning algorithm and combining mathematical and statistical methodology, the Microsoft Azure machine learning studio has been used for modeling the oilfield development cost. The proposed method has adopted three algorithms: a neural network, a boosted decision tree, and a decision forest. Results showed that the boosted decision tree and decision forest algorithms can achieve PFI ranking with stable training results. The results of the machine training model have been analyzed, and they showed that the permutation feature importance (PFI) model can provide reasonable scientific and technical support for oil companies and help to attain more effective and accurate estimation and prediction of oilfield assets.*

**Keywords:** oilfield; development cost; estimation; forecasting; machine learning.

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### **Measurement for CBM Bubble Parameters by Double-Sensor Conductivity Probe**

*Since the current commonly used bubble detection method cannot meet the requirements of real-time bubble detection in terms of the detection target and volume, this paper proposes a method of real-time detection of coal-bed methane (CBM) bubble parameters in a borehole with a double-sensor conductivity probe and designs the corresponding test device. The ellipsoid correction algorithm was adopted for the calculation of the bubble volume to reduce the error. Simulation test results indicated that the proposed device can quickly and reliably measure local bubble parameters, including void fraction, bubble velocity, and bubble volume. This technique can be applied to monitor the fluid parameters of different strata of main coal in CBM well simultaneously and provide a basis for the comparison of reservoir properties of different main coal seams and the effect of CBM well exploitation.*

**Keywords:** gas-water two-phase fluid, CBM, bubble, double-sensor conductivity probe, detection.