IRSTI 61.51.15
UDC 665.62 **DOI 10.70239/arsu.2025.t80.n2.13**

A COMPREHENSIVE APPROACH TO THE SELECTION OF DEMULSIFIERS, COSIDERING EMULSION TYPE AND OIL COMPOSITION

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Abstract. This study addresses the selection and evaluation of demulsifiers used for the effective breakdown of oil-water emulsions during crude oil processing. Stable emulsions formed during oil production can cause pipeline blockages, equipment corrosion, and increased energy consumption. Chemical reagents—demulsifiers—that reduce interfacial tension and promote the separation of oil and water are widely used to resolve these issues. However, choosing an appropriate demulsifier depends on several factors, including the physicochemical properties of the oil and water, the type of emulsion, and technological parameters such as temperature and pH. The research involved a comparative analysis of both domestic and foreign demulsifiers (Emulsol K2, Catapin, BioDem-50, EC2116A, etc.). The article describes laboratory methods such as turbidimetry and interfacial tension measurement. Particular attention is paid to environmental safety, with a focus on the effectiveness of biodegradable demulsifiers. Given the tightening of environmental regulations, the use of eco-friendly and non-toxic demulsifiers is becoming increasingly important. The results indicate that an integrated approach tailored to specific field conditions is essential for selecting an effective demulsifier. This research aims to enhance the efficiency of oil preparation processes while ensuring their environmental sustainability.
Key words: emulsion, asphaltenes, resins, paraffins, water, oil, separation

Introduction

The separation of oil and water is a critical stage in the processing of crude oil, as it directly affects the efficiency of further refining and transportation. Oil-water emulsions, which are formed when water is dispersed within oil under mechanical agitation, pressure, or temperature changes, pose significant challenges to this process. These emulsions are highly stable and can cause various operational issues, such as clogging pipelines, increasing energy consumption, causing corrosion of equipment, and degrading the quality of the final product. In addition, their presence can lead to environmental concerns if not properly addressed, particularly in terms of waste disposal and contamination.

Emulsions typically arise in oil production due to the complex interaction between water and crude oil, which contains natural stabilizing agents such as asphaltenes, resins, paraffins, and fine solid particles. These components create a resilient interfacial film between the oil and water phases, making it difficult to separate them through conventional mechanical methods. As a result, chemical additives, known as demulsifiers, are frequently employed to break down these emulsions. Demulsifiers work by reducing the interfacial tension between oil and water, destabilizing the interfacial film, and facilitating the coalescence of water droplets, which accelerates the phase separation process.

However, the selection of an appropriate demulsifier is not straightforward. It requires a comprehensive understanding of several factors, such as the type of emulsion (direct, reverse, or multi-phase), the physicochemical properties of both the oil and water, and the operational conditions such as temperature, pressure, and pH levels. Additionally, as environmental regulations become more stringent, the demand for biodegradable and low-toxicity demulsifiers has increased, further complicating the selection process.

This study aims to provide a detailed analysis of the various types of demulsifiers, their mechanisms of action, and the methods used to evaluate their performance. By considering the unique characteristics of different emulsions, this research seeks to develop a comprehensive approach for selecting the most effective demulsifiers for specific field conditions, balancing efficiency with environmental sustainability. The ultimate goal is to improve the overall efficiency of the oil-water separation process, reducing operational costs, enhancing product quality, and minimizing environmental impact.

Research Materials and Methods

The research focused on the selection and evaluation of demulsifiers for the destruction of oil-water emulsions, with consideration of various factors such as emulsion type, chemical composition of oil and water, and environmental constraints. The methods used to assess the performance of demulsifiers and the testing procedures are outlined below:

1. Materials

The study utilized a range of domestic and foreign demulsifiers, each designed to handle different types of emulsions encountered in oil extraction. These demulsifiers were selected based on their chemical structure, mechanism of action, and suitability for specific conditions such as temperature, pH, and the presence of stabilizing agents.

- **Domestic Demulsifiers:**
  - **Emulsol K2:** A nonionic surfactant effective at low temperatures.
  - **Catapin:** A cationic demulsifier designed for high-asphaltene oils.
  - **BioDem-50:** A biodegradable, low-toxicity demulsifier.
  - **Hypochem 515**: An amphoteric demulsifier that works over a wide range of pH values.
- **Foreign Demulsifiers:**
  - **EC2116A (Baker Hughes):** A nonionic demulsifier effective at medium to high temperatures.
  - **NALCO DMO277 (Ecolab/Nalco Champion)**: A composition based on polyethylene glycol and ethoxylated alcohols.
  - **TRETOLITE DMO8669 (BASF)**: A demulsifier with high biodegradability.
  - **DOSSOLVAN 1189 (Clariant)**: Used in low-temperature conditions and for oils with high paraffin content.
  - **PETRO-SOL 9800 (Schlumberger)**: A multi-phase demulsifier suitable for complex emulsions.

The oils and water used in the study were representative of typical crude oil characteristics found in the field, with varying levels of asphaltenes, resins, and paraffins. Water used for preparing the emulsions was also analyzed for its mineral content, pH, and salinity to simulate real field conditions.

2. Methods

The performance of demulsifiers was evaluated through several laboratory techniques to assess their ability to break down emulsions and separate oil and water phases effectively. The primary methods used in the study are described below:

1.Bottle Test (Bottle Test Method)

The bottle test is a standard laboratory procedure used to simulate the emulsification process and evaluate the efficiency of demulsifiers. A known quantity of emulsion is mixed with a specific dose of demulsifier in a test bottle, and the mixture is then subjected to a controlled temperature (typically the operational temperature of the field). After a set period, the separation of the oil and water phases is observed and quantified.

Key parameters measured during the bottle test include:

- **Phase Separation Efficiency:** The volume of water separated from the emulsion.
- **Water Content in Oil:** The remaining water content in the oil after treatment.
- **Turbidity of Water:** The clarity of the separated water phase.

2.Turbidity Measurement

Turbidity measurements were used to evaluate the transparency of the water phase after treatment with the demulsifier. This is an important parameter for assessing how well the demulsifier has separated the oil and water phases and removed fine particles or other impurities. A higher transparency corresponds to a more effective separation process.

3. Interfacial Tension (IFT) Measurement

Interfacial tension measurements were used to quantify the ability of the demulsifier to break down the interfacial film between water and oil phases. A reduction in interfacial tension indicates that the demulsifier is effectively destabilizing the emulsion. This was measured using a tensiometer, which determines the force required to pull apart the interfacial film.

4.Rheological Analysis

Rheological tests were conducted to assess changes in the viscosity of emulsions before and after treatment with the demulsifier. A reduction in viscosity after treatment indicates that the demulsifier has successfully broken the emulsified structure, making it easier to separate the phases.

5. Ion-Exchange and Chemical Analysis

To assess the potential impact of demulsifiers on water chemistry, ion-exchange and chemical analysis were performed. This was particularly important in cases where the emulsion contained high mineral content, such as salts (Ca^{2+}, Mg^{2+}), which could influence the behavior of the demulsifier. These analyses helped determine whether the demulsifier caused any changes in the ionic composition of the water phase.

3. Experimental Procedure

1. **Preparation of Emulsions**: Emulsions were prepared by mixing crude oil with water under controlled conditions to achieve stable emulsions. The oil and water were combined in specific ratios (typically 80% oil to 20% water) and mechanically agitated to form either direct or reverse emulsions.
2. **Addition of Demulsifiers**: Different concentrations of demulsifiers were added to the emulsions based on the expected field concentrations. For each demulsifier, several dosages were tested to determine the optimal amount required for effective emulsion breakdown.
3. **Analysis and Evaluation**: After treatment, the emulsion was allowed to settle, and the separation process was monitored. The volume of water separated, the appearance of the water phase, and the clarity of the water were recorded. Rheological properties, turbidity, and interfacial tension were also measured to assess the effectiveness of the demulsifier.
4. **Data Analysis**: The results from the bottle test, turbidity, IFT, and rheological tests were analyzed statistically to determine the most effective demulsifiers and their optimal dosages for specific emulsion types.

Statistical Analysis. The experimental data was subjected to statistical analysis to ensure reliability and reproducibility. The effectiveness of each demulsifier was compared based on the degree of phase separation, turbidity reduction, and changes in interfacial tension. Statistical methods, including analysis of variance (ANOVA), were applied to identify significant differences between the demulsifiers and optimize their performance in various field conditions.

5. Environmental Considerations

In addition to the laboratory tests, the study also assessed the environmental impact of the demulsifiers. Biodegradability tests were conducted to determine the environmental safety of the selected demulsifiers, particularly those with bio-based components, such as BioDem-50. The focus on low-toxicity and biodegradable demulsifiers aimed to align the research with modern ecological standards.

In summary, the research combined a variety of laboratory methods to evaluate and compare the performance of different demulsifiers in breaking down oil-water emulsions. The results of these tests, along with statistical analysis and environmental considerations, provided valuable insights into the optimal selection and use of demulsifiers in real-world oil extraction and processing conditions.

Results and its discussion

The study highlights the complexity involved in selecting the appropriate demulsifier for oil-water emulsions, focusing on factors such as emulsion type, the chemical composition of the oil and water, temperature, and other technological parameters. Several key points emerged from the research:

1. Emulsion Types and Stability: The study demonstrates the diverse types of emulsions encountered in oil extraction, including direct (water-in-oil) and reverse (oil-in-water) emulsions, which can be highly stable due to the presence of stabilizing substances such as asphaltenes, resins, paraffins, and solid particles. These emulsions are difficult to separate, often leading to corrosion, increased energy consumption, and operational inefficiencies.
2. Effectiveness of Demulsifiers: The research compares both domestic and foreign demulsifiers, noting their varying effectiveness depending on emulsion stability, temperature, and chemical composition. Domestic demulsifiers, such as Emulsol K2, Catapin, and BioDem-50, show promising results in specific conditions, including low temperatures and high-asphaltene oils. Foreign demulsifiers like EC2116A (Baker Hughes) and NALCO DMO277 (Ecolab) are also highly effective under medium-to-high-temperature conditions.
3. Laboratory Testing Methods: Several laboratory tests were used to evaluate the performance of demulsifiers, including bottle tests, turbidity measurements, and interfacial tension assessments. The bottle test, in particular, proved invaluable in simulating real-world conditions and providing insights into the efficiency of various demulsifiers. Additionally, measuring interfacial tension helps in understanding how well a demulsifier can destabilize the interfacial film, which is crucial for achieving efficient phase separation.
4. Environmental Considerations: With growing ecological concerns, there is an increasing emphasis on the selection of biodegradable and low-toxicity demulsifiers. The study stresses the importance of balancing efficiency with environmental safety, recommending the use of bio-based chemicals like BioDem-50, which offer minimal environmental impact while maintaining high performance.
5. Optimization of Demulsifier Dosage: The results suggest that optimizing the dosage of demulsifiers is crucial to minimize operational costs while ensuring effective separation of phases. This requires careful analysis of the specific conditions of the oilfield, including the salinity, temperature, and chemical composition of the emulsion.

Conclusion

In conclusion, the development of a comprehensive approach to the selection of demulsifiers is essential for improving the efficiency and environmental sustainability of oil preparation processes. The study emphasizes that there is no one-size-fits-all solution for demulsifier selection; instead, a careful, case-by-case analysis is required. Laboratory testing, including bottle tests and interfacial tension measurements, plays a critical role in identifying the most effective demulsifier for a given set of conditions. Additionally, the shift toward biodegradable and low-toxicity demulsifiers aligns with both ecological standards and industry needs, ensuring that oil preparation processes become both more efficient and environmentally responsible. The research lays the groundwork for future developments in demulsifier technology and encourages the adoption of more tailored, efficient solutions in the petroleum industry.

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ЭМУЛЬСИЯ ТҮРІ МЕН МҰНАЙ ҚҰРАМЫН ЕСКЕРЕ ОТЫРЫП, ДЕЭМУЛЬГАТОРЛАРДЫ ТАҢДАУДЫҢ КЕШЕНДІ ТӘСІЛІ

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Андатпа. Бұл зерттеу шикі мұнайды өңдеу барысында мұнай-су эмульсияларын тиімді жою үшін қолданылатын демульгаторларды таңдау және бағалау мәселелерін қарастырады. Мұнай өндіру кезінде пайда болатын тұрақты эмульсиялар құбырлардың бітелуіне, жабдықтың коррозиясына және энергия шығынының артуына себеп болады. Бұл эмульсияларды тиімді бөлу үшін демульгаторлар қолданылады, бірақ олардың таңдалуы мұнай мен судың физика-химиялық қасиеттеріне, эмульсия түріне және температура, pH сияқты технологиялық

параметрлерге байланысты. Зерттеу барысында отандық және шетелдік бірнеше демульгаторлар (Emulsol K2, Catapin, BioDem-50, EC2116A, т.б.) салыстырмалы түрде зерттелді. Эмульсияларды жою үшін фазааралық керілуді төмендететін және су мен майдың бөлінуіне ықпал ететін химиялық реагенттер-деэмульгаторлар кеңінен қолданылады. Мақалада турбидиметрия және фазааралық кернеуді өлшеу сияқты зертханалық әдістер сипатталған. Дегенмен, дұрыс эмульгаторды таңдау көптеген факторларға, соның ішінде эмульсия түріне, мұнай мен судың физика-химиялық сипаттамаларына және Технологиялық параметрлерге байланысты. Сонымен қатар, экологиялық қауіпсіздікке ерекше мән беріліп, биологиялық ыдырайтын демульгаторлардың тиімділігі зерттелді. Экологиялық талаптар тұрғысынан биологиялық ыдырайтын және қауіпті емес эмульгаторларды қолдану маңызды бола түсуде. Нәтижелер көрсеткендей, әрбір жағдайда тиімді демульгаторды таңдау үшін нақты жағдайға бейімделген кешенді әдіс қажет. Зерттеу мұнайды дайындау процестерінің тиімділігін арттырумен қатар, олардың экологиялық тұрақтылығын қамтамасыз етуге бағытталған.
Түйін сөздер: эмульсия, асфальтендер, шайырлар, парафиндер, су, мұнай, бөлу.

КОМПЛЕКСНЫЙ ПОДХОД К ПОДБОРУ ДЕЭМУЛЬГАТОРОВ С УЧЁТОМ ТИПА ЭМУЛЬСИИ И СОСТАВА НЕФТИ

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Аннотация. Данное исследование рассматривает вопросы выбора и оценки демульгаторов, применяемых для эффективного разрушения водонефтяных эмульсий в процессе переработки сырой нефти. Устойчивые эмульсии, возникающие при добыче нефти, приводят к засорению трубопроводов, коррозии оборудования и увеличению энергозатрат. Для эффективного разделения этих эмульсий широко применяются химические реагенты — демульгаторы, снижающие межфазное натяжение и способствующие разделению воды и нефти. Однако выбор подходящего демульгатора зависит от физико-химических свойств нефти и воды, типа эмульсии, а также технологических параметров, таких как температура и pH. В исследовании сравнительно анализировались как отечественные, так и зарубежные демульгаторы (Emulsol K2, Catapin, BioDem-50, EC2116A и др.). В статье описаны лабораторные методы, такие как турбидиметрия и измерение межфазного натяжения. Особое внимание уделено экологической безопасности: исследована эффективность биологически разлагаемых демульгаторов. В условиях ужесточения экологических требований возрастает значение использования экологически безопасных, нетоксичных реагентов. Полученные результаты показали, что для выбора эффективного демульгатора необходим комплексный подход, адаптированный к конкретным условиям. Исследование направлено на повышение эффективности подготовки нефти и обеспечение экологической устойчивости процессов.
Ключевые слова: эмульсия, асфальтены, смолы, парафины, вода, нефть, разделение.