PALM-BASED EMULSIONS FOR OILFIELD CLEANING

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Oilfield cleaning is a crucial process in maintaining the efficiency and longevity of drilling operations. Contaminants such as drilling mud, oil residues, and other debris can accumulate in wellbores, oil rigs, and tools, leading to operational inefficiencies, equipment wear, and potential environmental hazards. Traditional oilfield cleaning solutions often rely on synthetic, non-biodegradable emulsions, which pose significant environmental risks, including water contamination and long-term ecological damage.

As a sustainable alternative, palm-based emulsions offer a biodegradable and eco-friendly solution for oilfield cleaning. Formulated with surfactants and palm-derived oils, these emulsions provide superior cleaning performance while significantly reducing environmental impact. By replacing non-biodegradable cleaning agents, palm-based emulsions contribute to a cleaner and greener oilfield operation, enhancing both efficiency and sustainability (*Figure 1*).

NOVELTY OF THE TECHNOLOGY

The technology employs emulsions formulated with oleochemical surfactants and palm-derived oils, leveraging the Winsor system and the hydrophilic-lipophilic deviation (HLD) framework for optimal performance. Using the ternary phase diagram approach, palm-based emulsions are engineered with Winsor III to achieve ultra-low interfacial tension for enhanced contaminant breakdown (Pal *et al.*, 2017) and Winsor IV for superior cleaning and wetting properties (Van Zanten & Ezzat, 2010). The presence of a negative curvature phase structure ensures outstanding stability in extreme conditions, including high salinity and elevated temperatures, making it an ideal choice for offshore and challenging oilfield environments (Zhou *et al.*, 2013). This innovative solution effectively cleans wellbore holes, oil rigs, and oil tools while also serving as a highly efficient displacement liquid (*Figure 2*).

ADVANTAGES

The palm-based emulsion was successfully formulated with the following key advantages, making it a superior and eco-friendly alternative for oilfield cleaning applications:

- **Optimised Viscosity for Efficient Application** Achieves a reduced viscosity of 0.008 Pa·s, ensuring smooth flow and ease of application.

Figure 1. Palm-based emulsions for oilfield cleaning.

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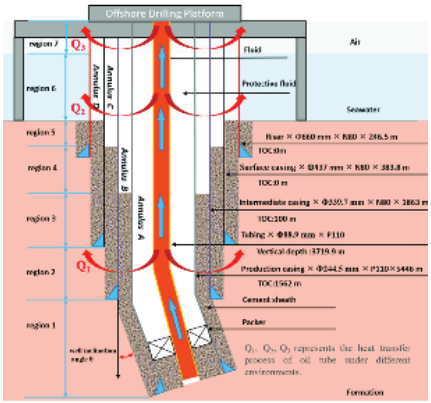
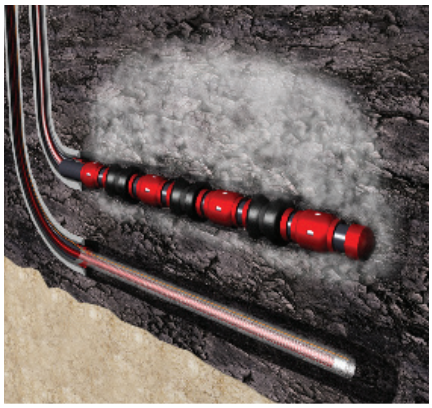


Schematic of wellbore structure

Offshore oil rig

Wellbore cleaning tools



The process of drilling fluid displacement in oilfield operations

Figure 2. Application of palm-based emulsions as cleaning agent for wellbore holes, oil rigs, oil tools and serving as displacement liquid.

- **Enhanced Rheological Performance**
  Exhibits rheological behaviour that aligns with the Herschel-Bulkley model, allowing it to withstand shear forces encountered during wellbore cleaning, thereby ensuring effective contaminant removal.

- **Improved Low-Temperature Stability**
  Demonstrates a low pour point of -9°C, ensuring functionality in cold environments without the risk of solidification.

- **Superior Interfacial Tension Reduction**
  Displays ultra-low interfacial tension (IFT) against paraffin oil, ranging between 0.3-0.5 mN/m, which enhances its ability to break down stubborn oil residues.

- **Comparable Wetting and Spreading Properties**
  Achieves a contact angle of 21°-22° on paraffin oil, demonstrating similar wetting and spreading behaviour to petroleum-based alternatives, ensuring effective surface coverage and penetration.

- **Exceptional Cleaning Efficiency**
  Outperforms commercial products in cleaning tests, achieving:

  ❖ Better removal of soot and mineral oil-stained cloth, compared to the commercial sample.

  ❖ Up to 80% mud removal efficiency, meeting industry standards for wellbore cleaning.

  Their efficiency in removing contaminants leads to reduced downtime, ensuring that oilfield equipment and operations function smoothly with minimal interruptions.

- **Superior Biodegradability and Environmental Benefits**
  Exhibits 60% biodegradation within seven days, significantly outperforming commercial alternatives, which only achieved 20%-59% biodegradation after 21 days, reducing environmental impact and improving sustainability. Furthermore, with the global oil and gas industry shifting towards greener

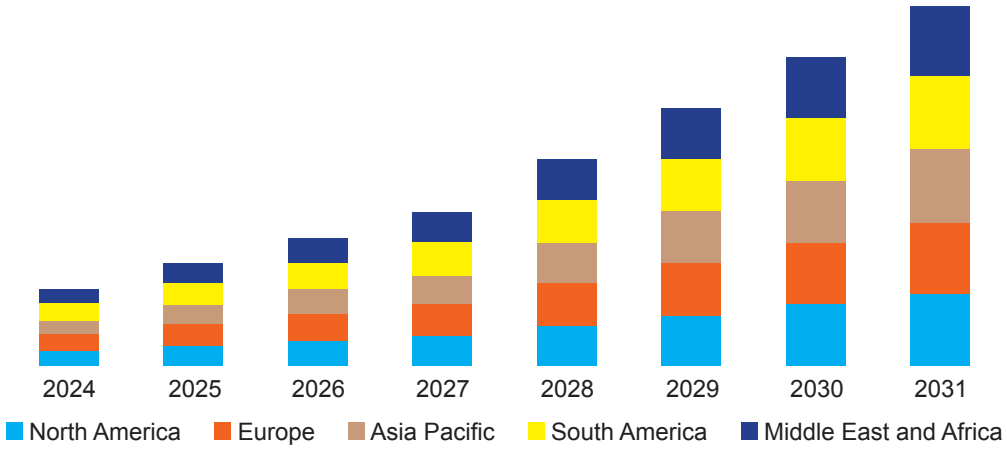


Figure 3. The global wellbore cleaning tool market.

solutions, palm-based emulsions present high adoption opportunities, catering to the increasing demand for sustainable oilfield technologies.

- **Salinity Stability**
  Maintains stability and performance in high-salinity environments, ensuring effectiveness in offshore and high-salinity oilfield applications.

- **Cost Savings**
  Palm-based emulsions highlight their significant advantages in cost savings, operational efficiency, sustainability, and market potential. By offering a lower-cost alternative to synthetic chemical-based cleaners, these emulsions help reduce overall operational expenses while maintaining high cleaning performance.

MARKET ANALYSIS

The global wellbore cleaning tool market is experiencing significant growth, which may indicate similar trends within Malaysia. In 2023, the global market was valued at approximately USD3.20 billion and is projected to reach USD4.72 billion by 2031, reflecting a compound annual growth rate (CAGR) of 5% (Data Bridge Market Research, 2024) (*Figure 3*).

Given Malaysia's well-established and active oil and gas industry, it is reasonable to infer that the increasing demand for wellbore cleaning solutions aligns with this global upward trend. The introduction of innovative and environmental-friendly cleaning technologies, such as the palm-based emulsion, presents a significant opportunity to capture market share while promoting sustainability in the sector.

ECONOMIC ANALYSIS

It is reported by the oil and gas industry that the price of commercial wellbore cleaning is USD500-USD600/55 gallons. This is equal to RM12-RM14/kg. The raw material cost to produce palm-based wellbore cleaning is RM4-RM5/kg.

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