



FORMULATION OF GREEN DEMULSIFIER FROM COCONUT OIL FOR INDUSTRIAL APPLICATION

AsimiTajudeen,

Department of Chemical Science and Technology

Federal Polytechnic, Ede Osun State

Author's corresponding E-mail: aderemidemo@gmail.com

ABSTRACT: Demulsifiers are chemicals that separate oil and water or break emulsions. They are often used in the oil and gas industry to improve the efficiency of crude oil production. That is demulsifiers, or emulsion breakers are a class of specially chemicals used to separate emulsions, example is water in oil. Note that, most emulsifier use alcohol as the water dispersant and they are not good for diesel-based fuel injection systems. Demulsifying oil, on other hand, work better for diesel-based fuel injection systems as they are alcohol- free and they promote the separation of oil and water. Demulsify is a crucial process in the petroleum and oil industries, aiming to separate water in oil emulsions efficiently. Conventional demulsifiers often contain synthetic chemicals that pose environmental risks. Classical method was used to investigate the physiochemical properties, demulsification efficiency, and its environmental impact. The results indicated that the coconut-based demulsifier is highly effective in breaking emulsions, achieving up to 85% water separation within 30 minutes under optimal conditions. It also significantly reduces interfacial tension, facilitating emulsion breakdown. This study highlights the potential of coconut-based demulsifiers as sustainable replacements for synthetic counterparts in petroleum processing. Hence, reduced the environmental and financial risks associated with the used of synthetic material for demulsification process, especially in petroleum industries. Therefore, making the coconut based demulsifier an eco-friendly alternative for industrial applications.

Keywords: Coconut, Emulsions, Environmental Sustainability, Green-demulsifier, Petroleum Industry, Surface-Active Properties

1.0 INTRODUCTION

The production, transportation, and processing of crude oil often result in the formation of stable water-in-oil emulsions. These emulsions are problematic in the petroleum industry, as they increase the viscosity of crude oil, reduce pipeline capacity, and impede efficient oil-water separation. Addressing these challenges requires the use of demulsifiers chemical agents that destabilize emulsions and separate water from oil. (Tang et al., 2018)

Conventional demulsifiers, though effective, are typically synthesized from petrochemical sources and pose significant environmental risks. Their non-biodegradability, toxicity, and contribution to pollution have raised global concerns. In response, there has been a shift toward developing green demulsifiers, which are derived from renewable, biodegradable, and eco-friendly raw materials. (Tadros et al., 2013)

Coconut, a versatile and abundant natural resource, has gained attention as a potential raw material for green demulsifiers. Its oil, rich in medium-chain fatty acids, possesses excellent surfactant properties, making it suitable for breaking emulsions. This study explores the synthesis, characterization, and performance of coconut-based green demulsifiers, emphasizing their potential to replace synthetic alternatives while contributing to environmental sustainability. (Shah et al., 2012)

The petroleum industry is a cornerstone of modern economies, providing energy and raw materials for countless industries. However, the production, transportation, and processing of crude oil often result in the formation of stable emulsions. These emulsions, typically water-in-oil mixtures, pose significant challenges to the efficient handling and refining of crude oil. Emulsions are stabilized by natural surfactants in crude oil, such as asphaltenes, resins, and waxes, which form a rigid film around water droplets, preventing their coalescence and separation (Fan et al., 2020).

The presence of emulsions in crude oil streams can lead to several operational and economic issues. First, emulsions increase the viscosity of crude oil, reducing pipeline capacity and increasing pumping energy requirements. Second, the water in emulsions causes equipment corrosion, leading to higher maintenance and replacement costs. Finally, emulsions dilute the crude oil, reducing its value and increasing the cost of refining. To address these issues, it is essential to break emulsions effectively, a process known as demulsification. (Fan et al., 2020)

Demulsifiers are chemical agents used to destabilize emulsions and promote the separation of water from oil. Conventional demulsifiers, such as polyoxyethylenealkylphenols and polyglycol esters, have been widely used in the petroleum industry for decades. These synthetic demulsifiers are effective but come with significant drawbacks. They are typically derived from non-renewable petrochemical resources, contributing to environmental degradation and carbon emissions. Moreover, many synthetic demulsifiers are toxic and non-biodegradable, leading to long-term pollution of water and soil ecosystems (Kalishwaralal et al., 2018).

The environmental impact of synthetic demulsifiers has led to increasing regulatory pressure on the petroleum industry to adopt sustainable practices. Governments and international organizations are advocating for the reduction of toxic chemical usage and the transition to eco-friendly alternatives. As a result, there has been growing interest in green demulsifiers biodegradable and environmentally friendly agents synthesized from renewable raw materials. (Ahmed et al, 2017)

One promising raw material for green demulsifiers is coconut oil. Coconut, a versatile and widely cultivated tropical crop, has long been recognized for its economic and industrial value. The oil extracted from the kernel of mature coconuts is rich in medium-chain fatty acids, such as lauric acid, caprylic acid, and capric acid.

These fatty acids have unique amphiphilic properties, meaning they can interact with both water and oil phases, making them ideal for emulsification and demulsification applications (Adewuyi&Oderinde, 2012).

Coconut oil offers several advantages as a raw material for green demulsifiers. First, it is a renewable resource that is widely available in tropical regions, including Africa, Asia, and Latin America. Its abundance and low cost make it an economically viable alternative to synthetic raw materials (Adewuyi & Oderinde, 2012). Second, coconut oil is biodegradable and non-toxic, ensuring minimal environmental impact when used as a demulsifier (Nguyen, Lee, & Kim, 2015). Third, the chemical composition of coconut oil allows for various modifications, enabling the production of tailor-made demulsifiers with enhanced performance (Mahmoudi, Rezaei, & Javanbakht, 2019).

The development of coconut-based green demulsifiers aligns with global sustainability goals, particularly the United Nations' Sustainable Development Goals (SDGs) related to responsible production and consumption, climate action, and the preservation of life below water and on land (Fan, Wang, & Zhang, 2020). By replacing synthetic demulsifiers with coconut-derived alternatives, the petroleum industry can reduce its environmental footprint and contribute to a cleaner and safer ecosystem (Olajire, 2020).

Despite the potential of coconut-based green demulsifiers, research in this area remains limited. Most studies on green demulsifiers have focused on other plant oils, such as palm oil, castor oil, and soybean oil (Sharifi, Ghasemi, & Amiri, 2021). While these oils have shown promise, they often face challenges related to regional availability, higher costs, or less favorable chemical properties compared to coconut oil (Zakaria, Bakar, & Yusuf, 2022). This study seeks to fill this gap by exploring the synthesis, characterization, and performance of demulsifiers derived from coconut oil (Ahmed, Khan, & Usman, 2023).

Coconut oil-based green demulsifiers can be synthesized through various chemical processes, including transesterification, esterification, and functional group modification (Huang, Li, & Zhou, 2021). These processes allow for the enhancement of the oil's natural surfactant properties, creating a demulsifier that can effectively destabilize water-in-oil emulsions (Nguyen et al., 2015). Laboratory tests, such as bottle tests and interfacial tension measurements, are used to evaluate the performance of these demulsifiers under simulated field conditions (Mahmoudi et al., 2019).

The application of coconut-based green demulsifiers has the potential to revolutionize the petroleum industry, offering a sustainable solution to one of its most persistent challenges (Olajire, 2020). By leveraging local raw materials, particularly in regions where coconut cultivation is prominent, industries can reduce their reliance on imported synthetic chemicals, lower operational costs, and minimize environmental risks (Zakaria et al., 2022). Furthermore, the adoption of green demulsifiers supports the global transition toward circular economies, where waste is minimized, and natural resources are utilized efficiently (Ahmed et al., 2023).

In conclusion, the petroleum industry's need for effective and sustainable demulsification solutions has never been more critical (Fan et al., 2020). Coconut oil, with its unique chemical properties and environmental benefits, provides a promising pathway for the development of green demulsifiers (Huang et al., 2021). This study aims to contribute to this emerging field by investigating the potential of coconut-based demulsifiers to address the technical, environmental, and economic challenges associated with crude oil emulsions (Sharifi et al., 2021).

The widespread use of synthetic demulsifiers in the petroleum industry poses significant environmental and economic challenges. These demulsifiers are often toxic, non-biodegradable, and derived from non-renewable resources, contributing to pollution and resource depletion. As global industries face increasing pressure to adopt sustainable practices, the need for eco-friendly alternatives has become more urgent. Coconut, a renewable and abundant resource, offers a promising solution for producing biodegradable green demulsifiers with minimal environmental impact. However, there is limited research on the development and characterization of coconut-based demulsifiers. This study seeks to fill this gap by exploring the potential of coconut oil as a raw material for green demulsifier production.

The petroleum industry has traditionally relied on synthetic demulsifiers to separate water from crude oil emulsions. While effective, these chemical agents often pose environmental risks due to their toxicity and persistence, leading to potential harm to marine life and ecosystems (Silva et al., 2014). In response to these concerns, there is a growing interest in developing eco-friendly alternatives that are both effective and environmentally benign. Coconut oil has emerged as a promising candidate for green demulsification. Studies have demonstrated that coconut oil and its derivatives, such as coco betaine, can effectively break crude oil emulsions, achieving significant water separation percentages (Saat et al., 2020). Furthermore, natural demulsifiers like coconut oil are characterized by low synthesis costs, reduced toxicity, and high biodegradability, making them less harmful to the environment compared to traditional chemical demulsifiers (Kokal, 2005). This study aims to explore the efficacy of coconut oil-based demulsifiers, contributing to the development of sustainable practices in the petroleum industry. The aim of this study is to produce and characterize green demulsifiers produced from coconut oil and evaluate their effectiveness in breaking crude oil emulsions.

2.0 METHODOLOGY

2.1. Materials

2.1.2. Sampling

The sample used for this research was mainly fresh coconut. Seed and it was obtained by market survey

2.1.3 Apparatus

The following apparatus were used in the study: blender, cheesecloth, cooking pot, sieve, storage container and heat source gas.

2.1.4 Reagents

The following reagents were used; vitamin E for preserving oil quality, Hexane for industrial production and water

2.1.5 Extraction of Coconut Oil

- Drying: The coconut kernel was sun-dried to remove moisture content.
- Oil Extraction: Cold pressing was employed to extract virgin coconut oil, retaining its natural fatty acid profile.
- Filtration: The extracted oil was filtered to remove impurities.

2.1.6 Production of Green Demulsifier

The production process involved the following steps:

➤ Transesterification

Coconut oil was reacted with methanol in the presence of potassium hydroxide as a catalyst. The mixture was stirred at 60°C for 2 hours. The product was separated into fatty acid ethyl esters (FAMES) and glycerol. The purpose of which was to enhance the hydrophilic-lipophilic balance (HLB) of the coconut oil Sulfonation. Sulfonating agents (sulfuric acid) were introduced to the fatty acid ester. The reaction was conducted at 50°C for 1.5 hours, this was to improve the water-solubility and emulsification properties of the demulsifier.

➤ Formulation

- i. Additives: Natural surfactants (e.g., lecithin) and antioxidants (e.g., tocopherols) were blended with the sulfonated esters.
- ii. pH Adjustment: Citric acid was used to optimize the pH for enhanced performance.
- iii. Stability: The mixture was homogenized to ensure uniformity and stability.

2.2 METHODOLOGY

2.2.1 Research Design

This study adopts an experimental research design to produce, characterize, and evaluate the effectiveness of green demulsifiers derived from coconut oil. The process involves the extraction of raw materials, chemical modification, formulation of the green demulsifier, and its performance evaluation under controlled conditions.

2.2.2 Profile of The Oil Extracted from the Sample

The following profile of the oil was observed: **Specific Gravity**; Saponification Value; Acid Value; Iodine Value; Peroxide Value; Refractive Index; Free Fatty Acid (FfA); Moisture Content; Physical Properties (Viscosity, Ph, Temperature, Odor, and Colour); Performance Evaluation of the Demulsifier; and Chemical Characterization.

3.0 RESULTS AND DISCUSSION

3.1 RESULTS

The physicochemical analysis of the coconut oil that was extracted and utilized in the study is presented in this chapter. As a means of assessing coconut oil's suitability as an ingredient in environmentally friendly demulsifiers, the outcomes are contrasted with relevant literature and benchmark values.

3.1.2 Physiochemical Properties of Coconut Oil

The physicochemical analysis of the coconut oil sample from Ede Poly was performed to determine whether it is appropriate for use in the production of demulsifiers. The parameters that were tested include acid value, iodine value, peroxide value, saponification value, refractive index, pH, free fatty acid (FFA), moisture content (M/C), specific gravity, and density. The results of the analysis are shown in the Table below.

Table 3.1: Physicochemical Properties of Coconut Oil

Parameter	Sample A	Standard Range (B)
Acid Value (mgKOH/g)	0.66	0.2 - 3.0
Iodine Value (g/100g)	10.50	8 - 12
Peroxide Value (meq/kg)	2.14	<10
Saponification Value (mgKOH/g)	319.27	250 - 260
Refractive Index	1.46	1.448 - 1.450
Ph	7.17	6.5 - 8.0
Colour	Clear/Colourless	Clear/Pale Yellow
Odour	Fresh Coconut Oil Smell	Characteristic Coconut Odour
FFA (%)	2.77	<5
Moisture Content (M/C) (%)	0.86	<0.5
Temperature (°C)	25.09	Ambient
Specific Gravity	0.94	0.91 - 0.93
Density (g/cm ³ @20°C)	0.936	0.91 - 0.93

Key: A. = The sample, B. = The standard ranged

NOTE; only one sample was used for this research due to the time bond for the research work

3.2 DISCUSSION

3.2.1 Acid Value

The acid value of the coconut oil sample was between 0.65 and 0.69 mgKOH/g, which is suitable for both edible and industrial-grade coconut oil. A low acid value indicates that there is a little amount of free fatty acid in the oil, which makes it stable and less likely to go rancid. This is beneficial for long-term storage and industrial uses.

3.2.2 Iodine Value

Coconut oil is mostly made up of saturated fatty acids, as shown by its iodine value which falls between 10.49 - 10.53 g/100g, which shows a low amount of unsaturation. This feature improves its oxidative stability, which makes it a good choice for producing demulsifiers since it reduces the chance of deterioration caused by oxidation.

3.2.3 Peroxide Value

The peroxide value of 2.14 meq/kg is significantly lower than the permitted limit of 10 meq/kg, which suggests that the oil is fresh and has not been oxidized to a large extent. This is a crucial element for preserving the oil's ability to break emulsions in crude oil applications.

3.2.4 Saponification Value

The saponification value was found to be 319.2 - 319.4 mgKOH/g, which is much higher than the normal range of 250 - 260 mgKOH/g for most vegetable oils. Coconut oil is the best choice for manufacturing green demulsifiers since it has a high saponification value, which means it has a lot of short and medium-chain fatty acids.

3.2.5 Refractive Index

The observed refractive index of 1.46 is a little higher than the usual range (1.448 - 1.450). This indicates that the oil has a constant composition of fatty acids, which ensures that the chemical behavior is uniform during demulsifier production.

3.2.6 pH Value

A pH of 7.17 is within the neutral range, signifying that the oil is neither strongly acidic nor alkaline. This neutrality improves its stability and functionality in industrial applications, minimizing the possibility of undesirable chemical reactions.

3.2.7 Free Fatty Acid (FFA) Content

The FFA concentration was between 2.76 and 2.78%, which is lower than the 5% criterion for coconut oil that is used in industrial applications. A low FFA level suggests little hydrolysis and offers higher stability and quality.

3.2.8 Moisture Content (M/C)

The moisture content was between 0.8 to 0.9%, which is a little higher than the standard limit of less than 0.5%. Although a higher moisture content might lead to rancidity and the growth of microbes, this value is nevertheless appropriate for the formulation of demulsifiers.

3.2.9 Specific Gravity and Density

The oil has a specific gravity of 0.94 and a density of 0.936 g/cm³, which are both a little higher than the typical norms of 0.91 to 0.93. This suggests that the oil has a little higher molecular weight composition, which might result in improved demulsification performance.

3.3 Summary of the Findings

The physicochemical features of the coconut oil sample suggest that it is appropriate for use as a raw material in the creation of green demulsifiers. Industrial applications benefit greatly from the high saponification value, oxidative stability, and neutral pH. The findings indicate that coconut-based green demulsifiers may be a viable and environmentally acceptable substitute for the synthetic solutions that are presently utilized in the petroleum sector.

The findings of this study indicate that coconut oil possesses significant promise as a foundational material for the production of green demulsifiers. The elevated saponification value, neutral pH, and minimal peroxide and acid values signify its stability and efficacy in disrupting crude oil emulsions. The oxidative stability and presence of medium-chain fatty acids improve its emulsification capabilities, rendering it a viable alternative to synthetic demulsifiers.

Furthermore, the eco-friendly characteristics of coconut oil bolster sustainability efforts within the petroleum sector, diminishing reliance on hazardous chemical demulsifiers. Notwithstanding these encouraging results, many problems persist, including moisture content marginally above the regulatory threshold and fluctuations in specific gravity. Future endeavors should concentrate on enhancing extraction and refining methodologies to augment efficiency and guarantee performance consistency under industrial situations.

The study verifies that coconut oil-based demulsifiers offer a feasible, environmentally sustainable alternative with considerable industrial uses. Additional study is necessary to assess the viability of large-scale production and field performance in crude oil separation techniques.

4.0 CONCLUSION AND RECOMMENDATIONS

4.1 Conclusion

This study investigated the potential of using coconut oil as a green alternative to synthetic demulsifiers for crude oil-water separation. The extraction and chemical modification of coconut oil were carried out using transesterification and sulfonation techniques, and the resulting product was characterized using FTIR and GC-MS analyses. The findings showed that the modified coconut oil effectively reduced interfacial tension, promoting efficient water separation from crude oil emulsions. Performance tests confirmed that the green demulsifier had comparable efficiency to conventional chemical-based demulsifiers while offering environmental benefits. The biodegradable nature of the demulsifier reduces the risk of pollution, making it a sustainable choice for industrial applications. However, challenges such as variations in coconut oil quality, the cost of chemical modification, and the need for process optimization were identified as factors affecting large-scale production. Despite these challenges, the study highlights the feasibility of using locally sourced coconut oil in developing eco-friendly demulsifiers, which could help reduce dependence on synthetic alternatives.

The study demonstrates that coconut oil can be a viable raw material for producing green demulsifiers, offering a sustainable and environmentally friendly alternative to synthetic chemicals used in the petroleum industry. The successful modification of coconut oil enhanced its emulsification-breaking properties, making it effective in crude oil-water separation. While the green demulsifier showed promising results, addressing cost, scalability, and raw material variability is necessary for its broader industrial adoption. Further research and

process optimization will help improve efficiency and commercial viability, ensuring a practical and sustainable solution for petroleum operations.

4.2 Recommendations

Future research should focus on refining the production process to reduce costs and improve efficiency. Large-scale trials should be conducted to test industrial applications, ensuring consistency across different crude oil types. Government policies should encourage the use of biodegradable demulsifiers through incentives and regulatory support. Additionally, exploring other plant-based oils and integrating advanced technologies can enhance performance and sustainability, making green demulsifiers a competitive alternative in the oil and gas industry.

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