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Prospects of Breaking Crude Oil Emulsions Using Demulsifier Formulated from *Nicotiana tabacum* Seed Oil, Leaf Extracts, and Stalk Ash Extracts

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Abstract: The presence of crude oil emulsions in oil production and processing systems has been a great concern to industry worldwide. Several methods are available for breaking crude oil emulsions; however, Chemical method is the common demulsification method. Fossil-based materials are mainly used to develop these demulsifiers. Given the recent environmental and sustainability concerns, focus has shifted to the use of bio-based materials like agricultural plant extracts as alternatives to fossil-based demulsifiers. In this study, the prospects of breaking crude oil emulsions using demulsifiers produced from *Nicotiana tabacum* seed oil, leaf extracts, and stalk ash were evaluated. The study is based on the need for local production of demulsifiers in Nigeria, the need for more environmentally friendly and sustainable operations; and the need to put *Nicotiana tabacum* into alternative use due to its associated health hazards when consumed and its massive cultivation. The results of the physiochemical properties of *Nicotiana tabacum* seed oil; the phytochemical analysis of Nicotiana tabacum leaf extracts, and the potash concentrations of *Nicotiana tabacum* stalk ash extract showed the presence of hydrophilic and hydrophobic components of demulsifiers. The properties of the formulated demulsifier are similar to those of the commercial demulsifiers. The bottle tests results showed that the formulated demulsifier is capable of breaking medium and high-density crude oil emulsions. Hence, the formulated demulsifier performed comparably to the commercial demulsifiers.

Keywords: Crude Oil Emulsions, Demulsifiers, *Nicotiana tabacum*, Physiochemical, Phytochemical, Bottle Tests

1. Introduction

Hardly does a reservoir yield almost pure crude oil. Crude oil is often produced with water and other contaminants. Typically, crude oil production consisted of 30–90% of oil, 30–70 percent of water, and 2–15 percent of solids by mass [1]. Under production conditions, some portions of water and crude oil can intimately be dispersed throughout one another as small droplets and be stabilized by naturally occurring surface-active molecules such as asphaltene and resins, solids such as clay and waxes [2-5], forming crude oil emulsions.

Crude oil emulsions are classified according to which phase is dispersed and which phase is continuous. According to the studies carried out by Nalco (2004), Manar El-Sayed Abdel-Raouf (2012), Wong *et al.* (2015), Saad *et al.* (2019), the different types of crude oil emulsions are as follows: [6-9].

a. Oil-in-water (O/W) for oil droplets dispersed in water
b. Water-in-oil (W/O) for water droplets dispersed in oil
c. Multiphase Emulsions - Oil-in-water-in-oil (O/W/O) and Water-in-oil-in-water (W/O/W). That is, both oil-in-water and water-in-oil emulsions occurring simultaneously.

Recent works carried out by Odisu and Salami (2010), Udonne (2012), Falode and Aduroja (2015) Ovuema and Okotie (2015), Saad *et al.* (2019), Sofiah *et al.* (2020), Victory *et al.* (2020), show that Emulsions are undesirable due to the following reasons: [5, 9-14]

a. Emulsion from sellable crude reduces its commercial value. For this, oil leaving the producing facility has to meet the low water and salt content specifications.
b. Emulsions cause flow assurance problems. A high level of emulsion in the oil would severely reduce pumping and other transport capacities.
c. The high salinity of the water would cause corrosion and scaling problems.
d. Emulsified water in crude oil increases the cost of pumping due to the larger volume and the higher viscosity of the oil resulting in higher oil production costs
e. Higher demulsifier and treatment costs.
f. Emulsions cause productivity decline in wells.
g. Oil in water disposal /injection system poses environmental concerns.

Hence, the breaking of crude oil emulsion into oil and water phases (demulsification) is, therefore, necessary for oil field production operations. Demulsification can be carried out using chemical, biological, mechanical, thermal, microwave, electrical, ultrasonic, and membrane techniques [15, 16, 9]. However, the chemical technique is the most common demulsification method used in both oil fields and refineries [17-21].

The application of chemicals has great advantages of being able to break an interfacial film effectively, without any need for new equipment or modifications of the existing equipment [22].

The procedures for the formulation of chemical demulsifiers are quite complex. However, emulsifiers and demulsifiers use the same class of chemical substances called "surfactants" [23, 24, 16, 9]. They consist of polymeric surfactants and amine substances such as copolymers, ethylene oxide, propylene oxide, a polymeric chain of EO/PO of alcohols, ethoxylated phenols, nonylphenols, alcohols, amines, resins, and sulphuric acid salts, etc. [25, 11, 12, 5, 26, 27]. Previously, fossil-based materials have been mainly used to develop these demulsifiers [28, 16]. Although, soaps, fatty acids, fatty alcohols, amines, resins obtained from plant materials can be used in the production of demulsifiers [28-32, 25, 16]. Because of the recent environmental and sustainability concerns, the focus has shifted to the use of bio-based materials like agricultural plant extracts as an alternative to fossil-based demulsifiers.

Among the agricultural plants that need to be put into alternative use is Nicotiana *tabacum,* also known as Tobacco, this is due to its associated health hazards when consumed [33-35] and its massive cultivation [35, 36]. *Nicotiana tabacum* is a stout herbaceous plant in the Solanaceae (nightshade family) that is indigenous to the Americas, Australia, South Africa, West Africa, and the South Pacific [37, 38]. Tobacco is a plant product containing mainly nicotine, cellulose, ammonia, protein, and other phytochemicals [37, 39-44, 38, 36].

In this study, the prospects of breaking crude oil emulsions using demulsifier produced from *Nicotiana tabacum* seed oil, leaf extracts and stalk ash were evaluated. The study is based on the need for local production of demulsifiers in Nigeria [45]; the need for more environmentally friendly and sustainable operations, and the need to put tobacco into alternative use due to its associated consumption and health hazards and it is also based on the fact that it is cultivated massively. Breaking crude oil emulsions using demulsifiers produced in Nigeria will drastically reduce the cost of demulsification as well as improve the economy of Nigeria through the local content initiative. Producing demulsifiers using *Nicotiana tabacum* will provide other alternative uses for the plants, thereby providing an alternative to redirect its human consumption without affecting the income of the farmers. Producing demulsifiers using *Nicotiana tabacum* plant will lead to more environmentally stable and sustainable operations.

2. Materials and Methods

The study encompassed:

a) Sourcing of *Nicotiana tabacum* plant materials.
b) Extraction and characterization of *Nicotiana tabacum* seed oil.
c) *Nicotiana tabacum* leaf extract preparation and phytochemical analysis
d) *Nicotiana tabacum* stalk ash extract preparation and determination of potash and alkali contents.
e) Formulation of demulsifiers using *Nicotiana tabacum* leaf extract, seed oil, and stalk ash extract.
f) Performance evaluation of the formulated demulsifier.

2.1. Sourcing of Nicotiana tabacum Plant Materials

Nicotiana tabacum seeds were obtained from Emu Unor in Ndokwa West Local Government Area of Delta State. The seeds were then planted in improvised nursery plastic plant pots in Petroleum Engineering Laboratory, Igbinedion University, Okada. At maturation, the leaves, seeds, and stalks were harvested for the study (Figure 1).

Figure 1. *Plant materials (Nicotiana tabacum seeds, leaves, and stalks).*

2.2. Extraction and Characterization of Nicotiana tabacum Seed Oil

Extraction of Nicotiana tabacum Seed Oil: Oil from *Nicotiana tabacum* seeds was extracted using the Soxhlet method with hexane as solvent. *Nicotiana tabacum* seeds were air-dried until fully dried. The dried seed was crushed in a mortar and pulverized with the aid of an electric blender. 100 g of the pulverized *Nicotiana tabacum* seeds were packed into a porous thimble and placed in a soxhlet extractor. 500 ml of hexane were placed in a round bottom flask and the soxhlet extractor was assembled. Extraction solvent (hexane) was heated in the bottom flask to 70°C and vaporized into the sample thimble. It condensed in the condenser and dripped back. When the liquid content reached the siphon arm, it emptied into the bottom flask again and the process was continued [46]. The procedures were repeated until all pulverized *Nicotiana tabacum* seeds were used up.

Oil Yields: Oil yields were calculated using equation (1)

$$Yield\% = \frac{W_1 - W_2}{W_1} \times 100 \quad (1)$$

Where: W_1=sample weight before extraction and W_2= sample weight after extraction.

Physiochemical Characterization of the Nicotiana Tabacum Seed Oil: The physiochemical properties of *Nicotiana tabacum* seed oil such as specific gravity, viscosity, pH, pour point, flash point, fire points, free fatty acid, acid value, iodine value, peroxide value, and saponification value, etc. were carried out according to standard methods. The specific gravity of the oil was determined at 25°C using a hydrometer. The viscosity of the oil was determined by the Ostwald viscometer. The pH of the oil was determined by a portable pH Meter (Model: PH-02). The cloud and pour points were determined in accordance to ASTM D2500 (2011) and ASTM D97 (2016) procedures respectively [47, 48]. The flash and fire points of the oil were determined in accordance to ASTM D92-18 (2018) procedures [49]. The chemical properties (free fatty acid acid value, iodine value, peroxide value, and saponification value, etc.) were determined in accordance to the Association of Official Analytical Chemists (2000) standard [50] as described by Banji *et al.,* (2016) [51]. The color characteristics of the oils were determined by sighting and correlation using colour charts.

2.3. Nicotiana Tabacum Leaves Extracts Preparation and Phytochemical Analysis

Nicotiana Tabacum Leaves Extracts Preparation: The soxhlet method of extraction was adopted based on Azwanida (2015) and Gopalasatheeskumar (2018) reports [46, 52]. Mature and healthy leaves of *Nicotiana tabacum* were plucked, washed in dechlorinated water, shade dried, pulverized with the aid of an electric blender, and sieved. 1 kg of the powdered leaves was extracted with two different solvents (methanol and distilled water) to obtain reasonable results from the phytochemical evaluation. The leaf extracts were then stored in airtight amber-colored bottles at 4°C for further usage (phytochemical evaluation and demulsifier formulation).

Phytochemical Analysis of Nicotiana Tabacum Extracts: Standard analytical procedures described by Debela (2002), Sahira and Cathrine (2015), Vishnu *et al.* (2019), [53, 54, 55] were used in the phytochemical analysis of methanol and aqueous leaf extracts of *Nicotiana tabacum*. The procedures are presented in Table 1.

Table 1. *Procedure for phytochemical tests.*

SN	Metabolites	Procedures	Confirmation
1	Alkaloids *(Mayer's Test)*	To 2 ml of extract, 2 ml of concentrated hydrochloric acid was added. Then a few drops of Mayer's reagent were added.	The presence of green color or white precipitates indicates the presence of alkaloids.
2	Carbohydrates	2 ml of extract was treated with 1 ml of Molisch's reagent and few drops of concentrated sulphuric acid	Formation of purple or reddish color
3	Flavonoids	To 2 ml of extract, 1 ml of 2N sodium hydroxide was added.	The presence of yellow color indicates the presence of flavonoids.
4	Glycosides	To 2 ml of extract, 3ml of chloroform, and 10% ammonia solution were added.	The formation of pink color indicates the presence of glycosides.
5	Oils (Spot test)	A small quantity of extract was pressed between two filter papers	Oil stain on the paper indicates the presence of fixed oils
6	Phenol	2 ml of distilled water followed by a few drops of 10% ferric chloride was added to 1ml of the extract.	The formation of blue or green color indicates the presence of phenols
7	Polypeptides	2 ml of filtrate + 1 drop of 2% copper sulphate solution+ 1 ml of ethanol (95%) + excess of potassium hydroxide pellets	The pink colour ethanolic layer indicates the presence of protein
8	Quinones	To 1 ml of extract, 1 ml of concentrated sulphuric acid was added.	The formation of red color indicates the presence of quinones.
9	Reducing sugars	1ml extract + 5ml HCL + 2ml NaOH	Brick red precipitate
10	Saponins	5ml extract + 5ml H_2O + heat 5ml extract + Olive oil (few drops)	Froth appears Emulsion forms
11	*Soluble Starch*	Few quantities of the extract were boiled with 1 ml of 5% KOH, cooled, and acidified with H_2SO_4.	A yellow colouration indicates the presence of soluble starch
12	Steroid	2ml extract + 2ml $CHCl_3$ + 2ml H_2SO_4 (conc.)	A reddish-brown ring at the junction
13	Tannins *(Braymer's Test)*	2ml extract + 2ml H_2O + 2-3 drops $FeCl_3$ (5%).	The formation of dark blue or greenish-black indicates the presence of tannins.
14	Terpenoids	0.5 ml of the extract was treated with 2 ml of chloroform and conc. sulphuric acid.	The formation of red-brown colour at the interface indicates the presence of terpenoids.

2.4. Nicotiana tabacum Stalk Ash Extracts Preparation and the Determination of the Potash and Alkali Contents

Stalks of *Nicotiana tabacum* plants were collected and dried to constant weight in an oven (Haier HRDH-71) set at 80°C. The dried stalks were placed in a porcelain crucible and combusted to ash in a muffle furnace. 0.15 Kg of ash was extracted with 2 liters of distilled water until all ashes have been used. The potash and alkali contents of the extracts were determined following the procedures described by Babayemi *et al*. (2010), and Umeh-Idika and Maduakor, (2013) [56, 57]. The *Nicotiana tabacum* stalk ash extracts were kept in bottles at 5°C in the laboratory for the subsequent experimental formulation of demulsifiers.

2.5. Preparation of the Demulsifiers Using Nicotiana Tabacum Leaves Extracts, Seed Oil, and Stalk Ash (NTLESESAD)

10 g of the *Nicotiana tabacum* stalk ash extract residues were added to the solution containing 40 g of *Nicotiana tabacum* seed oil and 20 g of *Nicotiana tabacum* leaf extract. The mixtures were placed on the magnetic stirrer- heater at a regulated temperature of 40°C to dissolve the residues. The mixtures were homogeneously mixed to form the demulsifier and later cooled to room temperature. The physical properties were then determined. The specific gravity of the demulsifier was determined at 25°C using a hydrometer. The viscosity of the demulsifier was determined by the Ostwald viscometer. The pH of the demulsifier was determined by portable pH Meter (Model: PH-02).

2.6. Performance Evaluation of the Formulated Demulsifier (NTLESESAD)

The purpose of the evaluation is to determine the effectiveness of the breaking ability of the formulated demulsifier on crude oil emulsions and to compare the performance with compared to commercially available demulsifiers. The formulated demulsifier was termed the acronym "*NTLESESAD*"

2.6.1. Sourcing of Commercial Demulsifier

Two common Commercial Demulsifiers were sourced. The properties of the commercial demulsifiers are shown in Table 2.

Table 2. *Properties of Commercial Demulsifiers.*

S/NO.	Parameter	EO/PO Block Copolymer	SDS (Sodium dodecyl sulphate) solution (10%)
1	Physical State	Liquid	Liquid
2	Appearance / colour	Hazy liquid	Clear, colourless.
3	Specific gravity@60F	1.005 - 1.025	0.9
4	viscosity (cp) or mPa.s	338 @ 40°C	284.3@ 40°C
5	pH	5 - 7 (1% aqueous sol.)	8.7 @ 20°C

2.6.2. Sourcing of Crude Oil Samples

Two crude oil samples were sourced from Nigerian Oil fields designated as Field X and Field Y, Delta State, Nigeria. The Crude oil properties are shown in Table 3.

Table 3. *Properties of Crude Oil.*

S/NO.	Parameter	Field X	Field Y
1	Appearance/colour	Dark Brownish Liquid	Brownish Liquid
2	Specific gravity@60F	0.929	0.8811
3	API gravity (°API)	20.8	29.1
4	Kinematic viscosity (CST) @60F	76.21	36.4
5	Dynamic viscosity (cp) @60F	70.8	32.07
6	pH	5. 4	7.8
7	Resins (wt%)	15.1	13.5
8	Asphaltenes (wt%)	1.6	0.3

2.6.3. Crude Oil Emulsion Preparation

Water in crude oil emulsions was prepared in the laboratory by adding 30 vol% of water containing 0.3% sodium chloride by mass to the oil at room temperature and emulsified by SPAN 80 (Polysorbate 80). The contents were homogeneously mixed in the Hamilton bench mixer at 1200 rpm for 15 minutes.

2.6.4. Bottle Test

The bottle test method was used to evaluate the effectiveness of crude oil emulsion breaking ability of the formulated demulsifier and to compare the performance with that of the commercially available demulsifiers. Equal concentrations of the formulated demulsifier and the commercial demulsifiers were added to the different bottles. The bottles were placed in a centrifuge and shook for 1 min to ensure thorough mixing of the crude oil emulsions and demulsifiers. The amount of water separated by each of the demulsifiers at 30 minutes intervals was read and recorded.

The demulsifier's efficiency is calculated as follows:

$$Demulsifier's\ Efficiency = Water\ Separation\ Efficiency = \frac{Volume\ of\ Separated\ Water\ (ml)}{Original\ Volume\ of\ Water\ in\ the\ Crude\ Oil\ Emulsion} \times 100 \quad (2)$$

Demulsifier concentrations of 100 ppm, 200 ppm, and 300 ppm were used to evaluate the effectiveness of the breaking ability of the formulated demulsifier on crude oil emulsions. The performance of the formulated demulsifier was compared with that of the commercial demulsifiers at 300 ppm. Bottle tests were conducted at room temperature (27°C) for 6 hours.

3. Results and Discussions

3.1. Physiochemical Properties of the Extracted Nicotiana Tabacum Seed Oil

Table 4 shows the Physiochemical Properties *of Nicotiana tabacum* seed oil extracted. The Physiochemical Properties *of Nicotiana tabacum* seed oil extracted are shown in Table 4. The saponification value (184 mgKOH/g) favoured (demulsifier) production and soap/ surfactant production. High saponification values are favourable for soap/surfactant production because soaps/surfactants *are* demulsifiers [16, 9]. In addition, the pH of the oil was not favorable for stable emulsion formation; hence, the oil can easily break the water in the oil emulsion. The oil yield of 32.1% was an added advantage.

3.2. Phytochemicals of the Nicotiana tabacum Leaf Extracts

The results of the phytochemical analysis of the *Nicotiana tabacum* leaf extracts are shown in Table 5. Some of the phytochemicals present in the extracts are components of demulsifiers.

Table 5. *Phytochemicals of Nicotiana tabacum Leaf Extracts.*

SN	Metabolites	***Nicotiana tabacum* Leaf Extracts**	
		Methanol	**Aqueous**
1	Alkaloids (Mayer's Test)	+	+
2	Carbohydrates	+	+
3	Flavonoids	+	+
4	Glycosides	+	+
5	Oils (Spot test)	+	+
6	Phenol	+	-
7	Polypeptides	-	+
8	Quinones	+	-
9	Reducing sugars	+	±
10	Saponins	+	-
11	*Soluble Starch*	+	+
12	Steroid	+	+
13	Tannins (Braymer's Test)	+	+
14	Terpenoids	+	-

Key: + (Positive); ± (Trace); - (Negative).

3.3. Potash Concentration of the Nicotiana Tabacum Stalk Ash Extracts

The potash concentrations of *Nicotiana tabacum* stalk ash extracts are shown in Table 6. The value was lower than plantain peel but higher than that of cassava peel reported by [57]. The *Nicotiana tabacum* stalk ash extracts were alkaline with a pH of 9.6. The concentration of KOH and pH values are shown in Table 6 favouring soap/surfactant (demulsifier) production.

Table 6. *Potash Concentration of the Nicotiana Tabacum Stalk Ash Extracts.*

Samples	Concentration of KOH	pH value
Nicotiana tabacum stalk ash extracts	18.2g/dm^3	9.8

3.4. Properties of Formulated Demulsifier (NTLESESAD) from Nicotiana Tabacum Leaves Extracts, Seed Oil, and Stalk Ash

The physiochemical properties of *Nicotiana tabacum* seed oil, the results of the phytochemical analysis of tobacco leaf extract and potash concentrations of *Nicotiana tabacum* stalk ash extract showed the presence of hydrophilic and hydrophobic components of demulsifiers (Tables 4-6).

The properties of the formulated demulsifier are shown in Table 7. The properties are similar to those of the commercial demulsifiers (Table 2). Thus, the formulated demulsifier *known as NTLESESAD* is favourable for breaking crude oil emulsion.

Table 7. *Properties formulated demulsifier (NTLESESAD).*

S/NO.	Parameter	Formulated Demulsifier (NTLESESAD)
1	Physical State	Liquid.
2	Appearance / colour	Brownish.
3	Specific gravity@60F	1.02
4	viscosity (cp) or mPa.s	326
5	pH	7

3.5. Performance Evaluation of the Formulated Demulsifier (NTLESESAD)

3.5.1. Effectiveness of the Breaking Ability of the Formulated Demulsifier on Crude Oil Emulsions

Figure 2 and Figure 3 showed the effects of the formulated demulsifier (NTLESESAD) on Field X and Field Y crude oil emulsion samples. The results showed that the formulated demulsifier is capable of breaking the two crude oil emulsions. However, the demulsifier is more effective on Field Y's crude oil emulsion samples. The emulsion breaking performance of a demulsifier is a function of the crude oil emulsion stability and the demulsifier's properties [58, 13]. The stability of crude oil emulsions depends on the physicochemical properties of the crude constituents, their interrelationships, and interactions with each other [59, 19, 60, 13].

The crude oil of Field X has higher specific gravity, viscosity, resin, and asphaltene but lower pH compared to the crude oil of Field Y (Table 2).

(a) *Influence of density:* The density difference between oil and water may affect the rate of flocculation and demulsification [13]. The higher the density of the crude oil emulsion, the more the difficulty encountered in breaking the emulsion. Consequently, the formulated demulsifier (NTLESESAD) was more active on Field Y's crude oil emulsion with lower density (Table 2 and Figures 2-3)

(b) *Influence of viscosity:* Higher crude viscosity causes low crude oil emulsion separation. The higher the viscosity of the continuous phase, the lower the diffusion coefficient and collision frequency of the drops. While the decreased in the continuous phase (oil) viscosity enhanced the kinetic motion of the dispersed water droplets, causing increased bombardment, resulting in film relaxation, film rupture, and coalescence. [61] stated that crude oil with higher viscosity and higher asphaltene/ resin contents negatively reduces the diffusion coefficient of the demulsifier molecules, thus inhibiting the demulsification process. Consequently, as shown in Table 2 and Figures 2-3, the formulated demulsifier (NTLESESAD) is less efficient on Field X's crude oil emulsion with higher viscosity.

(c) *Influence of pH:* pH strongly affects the interfacial properties of asphaltene at the oil/water interface. At high or low pH, asphaltene's functional groups become charged, enhancing its surface activity and thereby increasing the stability of the crude oil emulsion [62]. That is, water-in-oil emulsion becomes more stable at very high and at very low pH [63, 18]. As a result, the formulated demulsifier (NTLESESAD) is more efficient in Field Y's crude oil emulsion with suitable pH (Table 2 and Figures 2- 3).

(d) *Influence of asphaltene and resins:* Asphaltenes and resins pose problems in oil-water separation. At a given pH, the higher the amounts of resin and asphaltene, the more stable the crude oil emulsion [62]. Higher Asphaltene/ Resin contents negatively decrease the diffusion coefficient of the demulsifier molecules, thereby decreasing the demulsification efficiency (Table 2 and Figures 2-3). Consequently, as shown in Table 2 and Figures 1-2, the formulated demulsifier (NTLESESAD) is less efficient on crude oil emulsion in Field X with higher Asphaltene / Resin contents (Table 2 and Figures 2-3).

(e) *Effect of demulsifier concentration:* Demulsifier concentration is one of the major variables that can either decrease or improve emulsion stability, and thus the demulsification efficiency [9, 64]. In this study, an increase in demulsifier concentration increased the demulsification efficiency (Figures 2-3).

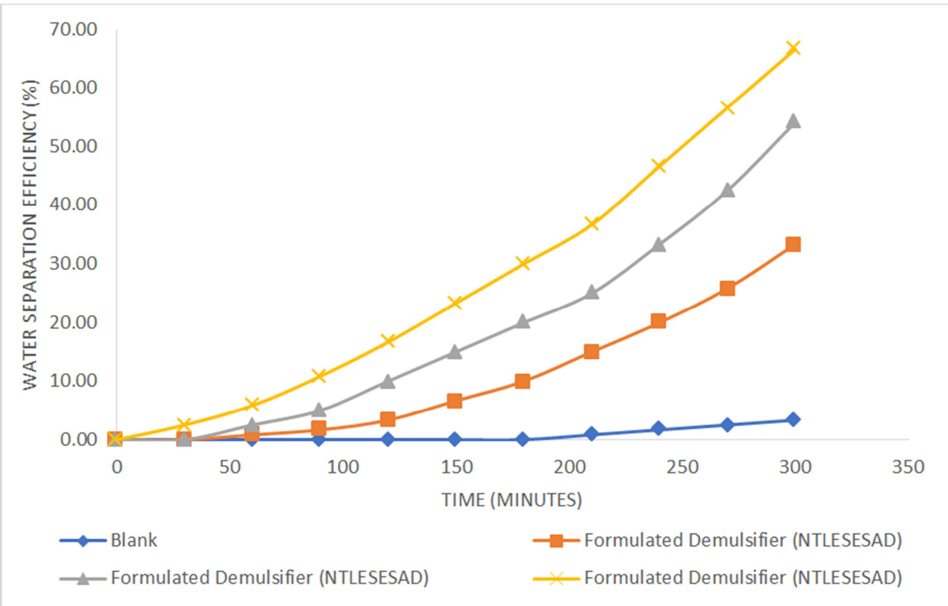

Figure 2. *The effect of the formulated demulsifier (NTLESESAD) on Field X crude oil emulsion sample.*

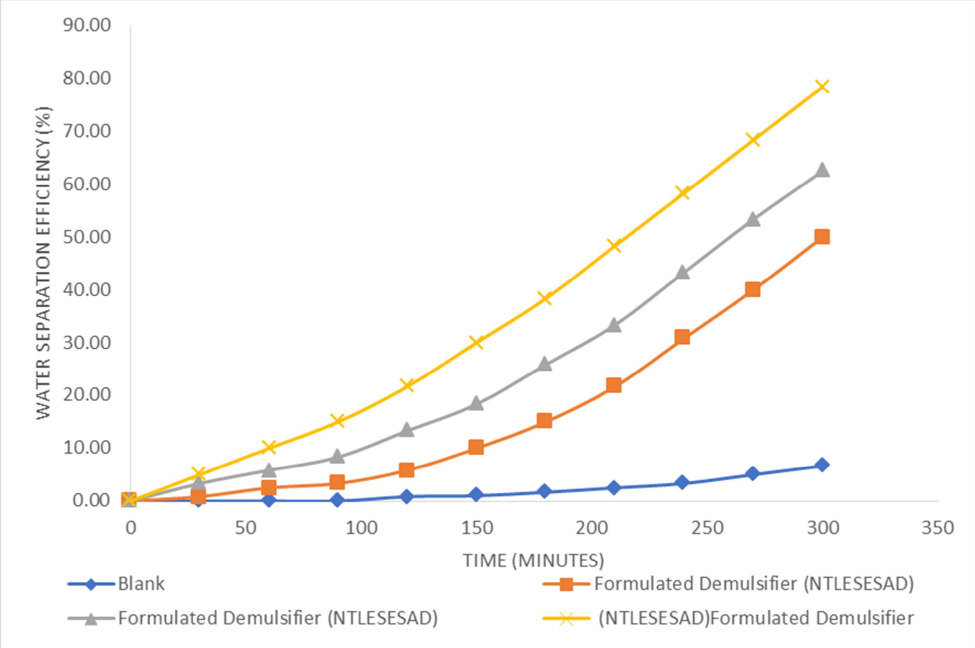

Figure 3. *The effect of the formulated demulsifier (NTLESESAD) on Field Y crude oil emulsion sample.*

3.5.2. Comparison of the Performances of the Formulated Demulsifier (NTLESESAD) and the Commercially Demulsifiers

The emulsion breaking performance of a demulsifier is a function of the stability of the crude oil emulsion and the properties of the demulsifiers [58, 13]. The properties of the formulated demulsifier (Table 7) are similar to those of the commercial demulsifiers (Table 2).

The bottle test results (Figures 4-5) showed that the formulated demulsifier performed comparably to the commercial demulsifiers (EO/PO Block Copolymer and Sodium dodecyl sulphate). The six hours demulsification efficiency of the crude oil emulsion from Field X was 66.67% for NTLESESAD, 73.33% for EO/PO Block Copolymer, and 61.67% for Sodium dodecyl sulphate. While the six hours demulsification efficiency of crude oil emulsion from Field Y was 78.33% for NTLESESAD, 86.67% for EO/PO Block Copolymer, and 65.83% for Sodium dodecyl sulphate. This implies that the formulated demulsifier (NTLESESAD) is better than Sodium dodecyl sulphate.

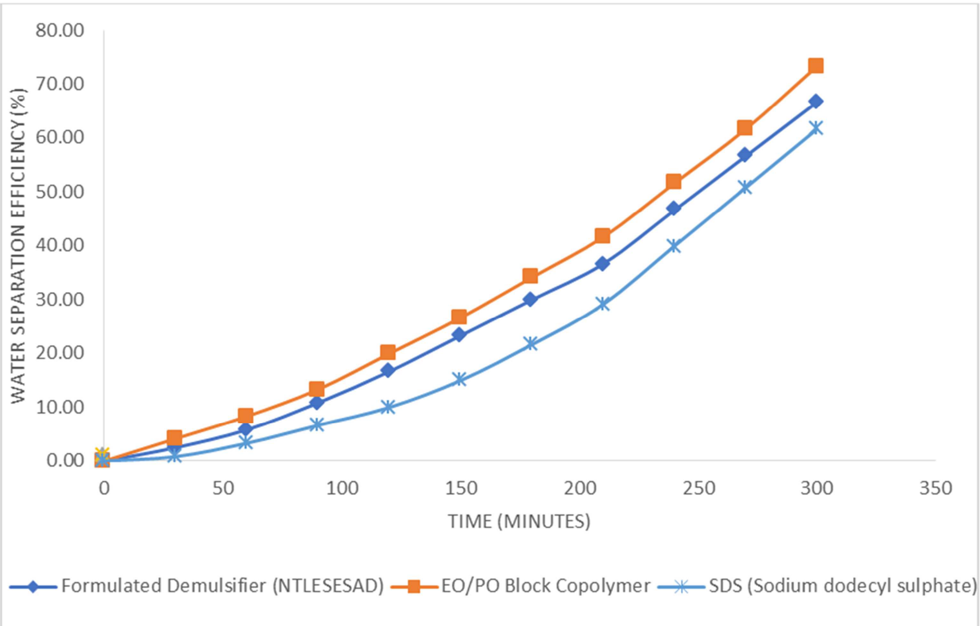

Figure 4. *Comparison of the performances of the formulated demulsifier (NTLESESAD) and the commercial demulsifiers on Field X crude oil emulsion sample.*

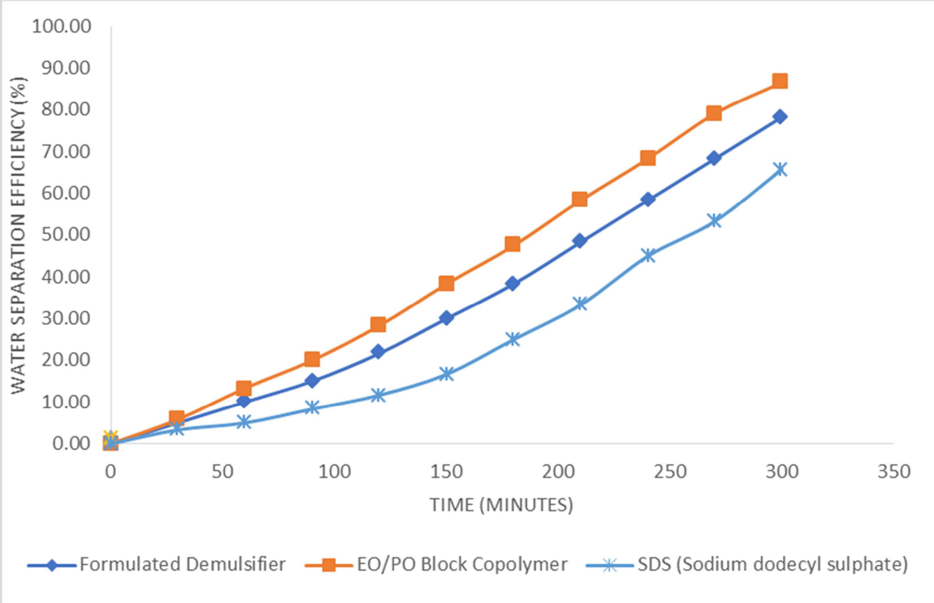

Figure 5. *Comparison of the performances of the formulated demulsifier (NTLESESAD) and the commercial demulsifiers on Field Y crude oil emulsion sample.*

4. Conclusions

Based on the results of the study, the following conclusions were drawn:

(a) The results of the physiochemical properties of *Nicotiana tabacum* seed oil; the phytochemical analysis of tobacco leaf extracts, and the potash concentrations of *Nicotiana tabacum* stalk ash extract showed the presence of hydrophilic and hydrophobic, components of demulsifiers.

(b) The properties of the formulated demulsifier (NTLESESAD) are similar to those of the commercial demulsifiers.

(c) The bottle tests results showed that the formulated demulsifier is capable of breaking medium and high-density crude oil emulsions.

(d) The emulsion breaking performance of the demulsifier is a function of the physicochemical properties of the crude oil emulsion constituents, their inter-relationships, and interactions with each other.

(e) The bottle tests showed that the formulated demulsifier performed comparably to the commercial demulsifiers.

(f) Optimum demulsification conditions should be evaluated based on the field conditions.

Declaration of Competing Interests

The authors declare that there are no competing interests (financial or personal influencing the work reported in this paper.

Nomenclature

Demulsifier formulated from Nicotiana Tabacum Leaves Extracts, Seed Oil, and Stalk Ash.

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