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Efficacy of a Locally Formulated Demulsifier in the Treatment of Crude Oil Emulsions

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Abstract
Produced water that accompanies crude oil production has been a major challenge facing the petroleum industry. This produced water is associated with some constituents such as inorganic, organic, and some elements that are harmful to the environment. In these modern days, the negative impact it creates on the environment has been a serious concern, therefore, there is a need to mitigate /eliminate the impact. However, there are several techniques whereby the produced water can be treated. One of the techniques that have received attention in crude oil emulsion is a chemical method using demulsifiers. This paper captures a comparative analysis of imported demulsifiers and locally formulated demulsifiers to ascertain the rate of demulsifying ability at test temperatures of 80°F and 150°F; 0.2ml and 1.0ml of concentrations of demulsifiers were used. The result analysis obtained shows that the locally formulated demulsifier has a high demulsifying ability as compared to the imported one. Further investigations were carried out on the physical parameters such as pH, specific gravity, viscosity, API gravity, cloud point, boiling point, and pour point of the local and imported demulsifiers, and results showed that the local demulsifier performed better as compared to the imported demulsifier. Therefore, the paper has revealed that some local demulsifiers can perform better than some imported demulsifiers in resolving oil-water emulsions into their separate constituents. Furthermore, the experimental results obtained using the locally formulated demulsifier have proven the fact that locally formulated demulsifier substitutes for imported demulsifier, and this, in turn, will boost the Nigerian economy in terms of stopping capital flights used in importing crude oil demulsifying agents, thereby, creating job and enhance home-based technology.
Keywords: Demulsifier; specific gravity; emulsion; viscosity; cloud point

I. Introduction

Crude oil is the world's main source of energy. In 2018, the world used approximately 99.3 million barrels per day of oil. This number is projected to rise to 100.8 million in 2019 (World Population Review, 2019). Crude oil is seldom produced alone because it generally is commingled with water. The water creates several problems and usually increases the unit cost of oil production. The produced water must be 1. Separated from the oil; 2. Treated and 3. Disposed of properly (Petrowiki, 2015), thus, all these steps increase costs. Furthermore, crude oil must comply with certain product specifications for sale, including the amount of basic sediment and water (BS&W) and salt, which means that the produced water must be separated from the oil to meet crude specifications. Produced water may be produced as "free" water (i.e., water that will settle out fairly rapidly), and it may be produced in the form of an emulsion. A regular oilfield emulsion is a dispersion of water droplets in oil. Emulsions can be difficult to treat and may cause several operational problems in wet-crude handling facilities and gas/oil separating plants. Emulsions can create high-pressure drops in flow lines, lead to an increase in demulsifier use, and sometimes cause trips or upsets in wet-crude handling facilities. The problem is usually at its worst during the winter because of lower surface temperatures. These emulsions must be treated to remove the dispersed water and associated inorganic salts to meet crude specifications for transportation, storage, and export and to reduce corrosion and catalyst poisoning in downstream processing facilities. Emulsions occur in almost all phases of oil production and processing: inside reservoirs, wellbores, and wellheads; at wet-crude handling facilities and gas/oil separation plants; and during transportation through pipelines, crude storage, and petroleum processing. Emuchay et al, (2013) stated that this mixture is a heterogeneous emulsion that consists of at least one immiscible liquid intimately dispersed in another in the form of droplets, making it difficult to separate pure clean crude from the emulsion. Recently, serious attention is placed on the environmental impact caused by this large quantity of produced water extracted from crude oil because produced water is associated with a mixture of several compounds, including inorganic, organic, and other elements. So, the primary objective of the oil production facility is the separation of water and other foreign materials from produced crude. Lee, (2008) defines crude oil as a complex mixture of saturates (paraffin/waxes) aromatics, naphthalene, asphaltenes, and resins. The viscosity of crude oil is a vital flow property in the industry which defines the resistance of the fluid to flow. An emulsion is a system with a dispersion of a liquid phase into another. Water is normally present in crude oil reservoirs or is injected to stimulate oil production and pipelines, and they include water-in-oil (W/O), oil-in-water (O/W), and more complex oil-in-water-in-oil (O/W/O) emulsions. Hence, such emulsion is detrimental to oil production since oil viscosity raises increased corrosion issues and is difficult to break in desalting and dehydrating units before refining. An oil-in-water emulsion is a mixture of two immiscible liquids where the oil phase is dispersed into the water continuous phase. Oil-in-water emulsions are very rare, deliberately produced to reduce the viscosity of highly viscous crude oil so that they can be transported easily through pipelines (Zaki, 1997). The oil-in-water emulsion reduces the viscosity of heavy crude oils and bitumen and may provide an alternative to the use of diluents or heat to reduce viscosity in pipelines (Langevin et al., 2004). Hanapi et al. stated that water-in-oil crude oil emulsions may be encountered at all stages in the petroleum production and processing industry. With the presence of water, they are typically undesirable and can result in high pumping costs and pipeline corrosion and increase the cost of transportation. Espinoza and Kleinitz (2003) affirmed that special handling equipment is needed to reduce the water also contributes to the plugging of gravel pack at the sand phase, and affects oil spill cleanup (Merv and Ben, 2003). Stability is a consequence of the small droplet size of water and the presence of an interfacial film on the droplets in an emulsion, which makes stable dispersions. Emulsion stability is considered in three different processes which are creaming, aggregation, and coalescence. Two main factors affect the stability of crude oil emulsion and they are viscosity and density. A crude oil emulsion can be stable, unstable, and meso-stable (Lee, 1999). There is a stage it will reach in the productive life of an oil field when water will be co-produced in unacceptable quantities with hydrocarbons. This water which co-exists with the hydrocarbon in reservoirs gradually infiltrates into the hydrocarbon production region of the formation. Eventually, water becomes part of the product regardless of the method of recovery. Sometimes water is produced early in the life of a field. Some wells drilled at higher levels in reservoirs still produce water later. Sometimes the amount of water produced is controlled by plugging back the lower part of the wellbore with cement and perforating intervals high up in formations. This can at least delay water encroachment for a time. Secondary or tertiary recovery methods are another cause of water encroachment. Some techniques employed to improve oil recovery also involve the use of water. Viscous fingering in the formation and early water breakthrough in these processes all contribute to introducing water into produced crude. Some surfactants stabilize water-oil emulsions. Oil leaving the producing facility has to meet a low water content specification. Too high a level of produced water in the exported oil could severely reduce pumping and transport capacity it is therefore necessary to prevent water encroachment during hydrocarbon production but the technique to efficiently achieve the goal has not yet been found and so presently, effective breaking oil-water emulsion is the most viable option. The relative stability of oil-waterer mixtures depends upon many factors such as water-cut, the nature of salts present, and the viscosity of the fluids involved. Sometimes, water does not mix with the oil to give a stable mixture because this “free water” readily separates from the oil but most times the conditions of production are such that a stable mixture is formed. Such a mixture is called an emulsion and must be specially treated before separation can occur. Demulsification is a process of breaking emulsions to separate water from oil, which is also one of the first steps in processing crude oil after transportation from the reservoir. The quality of crude oil is highly dependent on the residual contents of water and water-soluble contaminants which will be problematic for the water treatment part of the processes (Lee, 1999). Chemical demulsification is the most widely used method to treat crude oil-in-water (O/W) and water-in-crude oil (W/O) emulsions. Demulsifiers are surface-active compounds that when added to the emulsion migrate to the oil/ water interface rupture or weaken the rigid film and enhance water droplet coalescence. Over the years there has been an over-dependence on the use of foreign demulsifiers this is not quite effective in most cases due to incompatibility with the nature of some kinds of crude. From a process point of view, the oil producer is interested in three aspects of demulsification which are the rate at which this separation takes place, the amount of water left in the crude oil after separation, and the quality of separated water for disposal. It has also led to the quest for locally formulated demulsifiers for improved efficiency and cost-effectiveness, hence local demulsification shall be carried out in this study using locally produced demulsifiers from cocoa oil, cassava starch, candle wax, camphor, and liquid soap, and its effectiveness compared to that of imported commercial demulsifiers.

II. Materials and Methods

This study comprises different phases such as the production of local demulsifiers; raw material obtained locally and commercial demulsifiers. Thus, emulsions were subjected to different temperatures thereafter, the outcome properties of samples formulated with local and imported demulsifiers were systematically analyzed and compared.

Figure 1. *Pour point Tester*

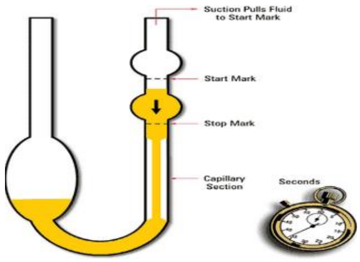

Figure 2. *Capillary U-Tube Viscometer*

Extraction of coconut oil

Coconut oil can be extracted through dry or wet processing, however, the coconut oil was extracted by wet process. The oil was extracted using wet processing as described by *(Kurian; 2007).* The fresh coconut was extracted, then it was grated with domestic blended. The milk was squeezed and left for some time for sedimentation and then sieved to remove impurities. The milk was cooked for 3 hours with low heat till it became brownish. It was then removed and allowed to cool and then the cooled thickened milk in a muslin cloth and the oil was squeezed out.

The percentage of oil recovered was calculated as follows:

$$\% \text{ of oil recovered} = \frac{weight\ of\ oil}{weight\ of\ ground\ sample} \times 100 \qquad 1$$

Production of liquid soap from locally sourced materials

Sodium Hydroxide (NaOH) of 130 grams was soaked in 150 g of distilled water for 24 hours in a container. A mixture of a solution of 510 g of Sulphonic acid, 187g of Sodium Laureen Sulphate (SLS), and 270g of Sodium Trioxocarbonate (iv) (Na_2CO_3) was prepared in another container. The solution of sodium hydroxide and distilled water was then added to the solution of sodium laureen sulphate, sodium trioxocarbonate (iv), and sulphuric acid. The mixture was gently stirred and more distilled water was added to produce a homogeneous mixture of 10 liters with a pH of 9.0.

Production of local starch from cassava

Some quantity of dry cassava starch was purchased from a local market around mile three in Port Harcourt. 300g of the dry cassava starch was dissolved in 300g of cold distilled water to form a solution. Again, some quantity of distilled water was made to boil on a gas burner at 212^0F. 310.9g of the boiled distilled water was added to the starch solution and gently stirred to form a paste-like solution.

Production of Local Demulsifier

30g of camphor powder was measured and poured into a beaker containing 20g of Coconut oil, placed on a heated hot plate at a regulated temperature of 104^oF, and gently stirred to completely dissolve the camphor. 15g of paraffin wax was then added to the hot camphorated coconut oil. Thereafter, 25g of prepared cassava starch was added to the mixture while stirring continued. Furthermore, 25g of prepared liquid soap was added to the entire mixture and stirred gently for 60 minutes on the heated hot plate to obtain a homogenous blend of local demulsifier.

Procedure for Treatment of Crude Oil Emulsion

Prepare treated water of 5% HCL. Set up 3 portions of 50ml. to each, add 0.2 ml and 1.0 ml of demulsifier respectively, and allow to stand. In turn, mix each of the portions with 50ml of crude oil in a ratio of 50:50. Allow to stand and check separation after 0, 5, and 10mins at 80^0F. Record observation. Repeat the same at 150^0F for all the 3 portions and observation recorded.

Procedure for Cloud Point

The samples were poured into the chamber test tube with a thermometer inserted in it thus, the samples were transferred into the Cloud point chamber and it was allowed to cool. The temperature continued to drop. The body of the chamber test tube was observed for cloud at an interval of 3 degrees drop in temperature.

Procedure for Pour Point

The pour point of the coconut oil and local and imported demulsifiers was carried out in accordance with ASTM D97. Immediately after the cloud point has been taken, the samples in the chamber test tube were allowed to cool further. Thereafter, each check at an interval of 3 degrees drop in temperature, the temperature at which the specimen does not flow is added +3ºC to get the pour point.

Procedure for pH

The pH meter of Hanna HI9811-5 was placed in each sample and allowed to stand until stabilized. Reading was taken and recorded to indicate the pH of each of the samples.

Procedure for API Gravity

It is expressed as: [(141.5 ÷ S.G) - 131.5] 2

Procedure for Specific Gravity

Samples were poured into a 100ml cylinder. Hydrometer was inserted and allowed to suspend. The lower meniscus was observed before the reading was taken and recorded at the lower meniscus.

Boiling Point

50ml of the sample was poured into a beaker inserted with a thermometer and placed on a heater at constant heating until it boil. The boiling point was recorded with the aid of the thermometer.

Procedure for Kinematic Viscosity

The kinematics of the coconut oil, local and imported demulsifiers were carried out in accordance with ASTM D445 ISO 3448 kinematic viscosity grading system, making it the international standard. The kinematic viscosity in cSt at 40°C is the basis. The samples were poured into the capillary U-Tube viscometer as shown in Figure 2. The time was taken when the samples travelled through the orifice of a capillary under the force of gravity.

III. Results

Comparative analyses of local and imported demulsifiers were carried out to ascertain the rate of the treatment of crude oil emulsion under temperature and time concerning demulsifier dosage. However, different results obtained are analyzed and discussed below:

The Efficiency of Separation of Local and Imported Demulsifiers

The Efficiency of separation as a function of the time of emulsion separation at the different dosages of Known commercial demulsifiers and locally formulated demulsifiers are represented in Figure 3 to Figure 9 respectively.

The experimental results have shown that the imported demulsifier took a longer time to break the emulsion completely when compared with the local demulsifier as shown in Figure 3 to Figure 9.

At demulsifiers 0.2 ml and 1.0 ml of local and imported demulsifiers. Upon 0.2 ml of local demulsifiers at 80ºF in zero minutes, it was observed that the slow rate of separation and the interface were not clear. At 80ºF in 1 minute (Figure 3), it was seen that there was a 60% rate of separation of crude oil, 40% water, and 0% sludge and the interface was not clear.

For 0.2 ml of imported demulsifiers at 80ºF in zero minutes (Figure 3), it was observed that the slow rate of separation and the interface were not clear. At 80ºF in 1 minute, it was observed that there was a 96% rate of separation of crude oil, 4% water, and 0% sludge and the interface was not clear.

For 0.2 ml of local demulsifiers at 80ºF in 2 minutes

(Figure 4), it was observed that there was a 50% rate of separation of crude oil, 50% water, and 0% of the sludge and the interface was not clear, Whereas at 80ºF in 2 minutes for the imported demulsifiers, it was observed that there was a 90% rate of separation of crude oil, 10% water and 0% of the sludge and the interface was not clear. It was at 10 minutes that 50% crude oil and 50% water rate of separation were achieved.

Upon 1.0 ml of local demulsifiers at 80ºF in zero minutes (Figure 5), it was noted that separation started and the interface was not clear. At 80ºF in 1 minute it was seen that there was an 80% rate of separation of crude oil, 20% water, and 0% of the sludge and the interface was not clear. Whereas at 80ºF in 2 minutes (Figure 6), it was recorded that there was a 50% rate of separation of crude oil, 50% water, and 0% of the sludge and the interface was not clear.

For the 1.0ml of imported demulsifiers at 80ºF in zero minutes (Figure 5), it was seen that separation started and the interface was not clear. But at 80ºF in 1 minute, it was recorded that there was an 87% rate of separation of crude oil, 13% water, and 0% of the sludge and the interface was not clear. Whereas at 80ºF in 2 minutes (Figure 6), it was observed that there was a 64% rate of separation of crude oil, 36% water, and 0% of the sludge and the interface was clean. 50% crude oil and 50% water rate of separation were achieved in 4 minutes.

With 0.2 ml of local demulsifiers at 150ºF in zero minutes (Figure 7), it was seen that there was a separation of crude oil emulsion and the interface was clean. At 150ºF in 1 minute, it was observed that there was a 90% rate of separation of crude oil, 10% water, and 0% of the sludge and the interface was clean. Whereas at 150ºF in 2 minutes (Figure 8), it was noted that there was a 50% rate of separation of crude oil, 50% water, and 0% of the sludge and the interface was clean.

Upon 0.2 ml of local demulsifiers at 150ºF in zero minutes it was observed that there was the separation of crude oil emulsion and the interface was clean; at 150 ºF in 1 minute, it was observed that there was a 72% rate of separation of crude oil, 27% water and 0% of sludge and interface was clean. Whereas at 150ºF in 2 minutes it was observed that there was a 64% rate of separation of crude oil, 36% water, and 0% of the sludge and the interface was clean. 50% crude oil and 50% water rate of separation were achieved in 7 minutes.

Similarly, In Figure 9 with 1.0 ml of local demulsifiers at 150ºF in zero minutes, it was observed that separation started and the interface was clean; at 150ºF in 1 minute it was also observed that there was a 50% rate of separation of crude oil, 50% water and 0% of sludge and interface was clean.

Upon 1.0 ml of imported demulsifiers at 150ºF in zero minutes it was observed that separation started and the interface was clean; at 150ºF in 1 minute it was observed that there was a 68% rate of separation of crude oil, 32% water and 0% of sludge and interface was clean; at 2 minutes 55% of crude oil and 45% water rate of separation was achieved. Whereas at 3 minutes 50% of crude oil and 50% of water rate of separation was achieved as shown in Tables 4 and 7.

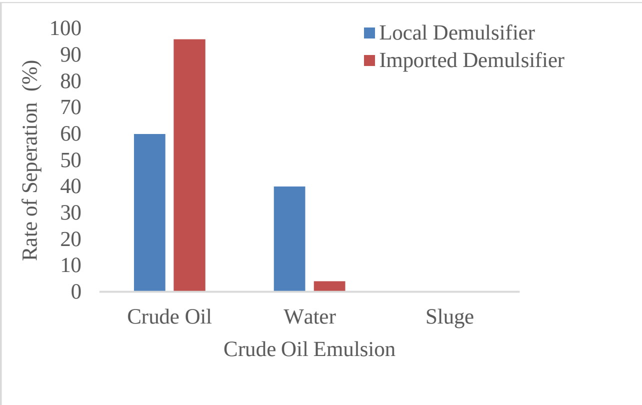

Figure 3. Rate of separation of an emulsion of 0.2 ml of demulsifiers in 1 minute @ 80ºF

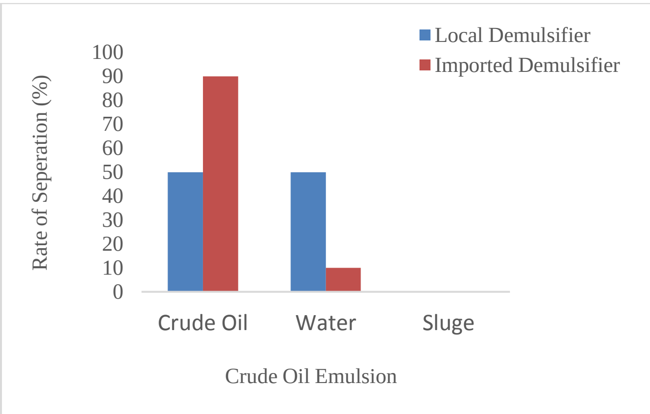

Figure 4. Rate of Separation of Emulsion of 0.2 ml of Demulsifiers in 2 minutes @ 80ºF

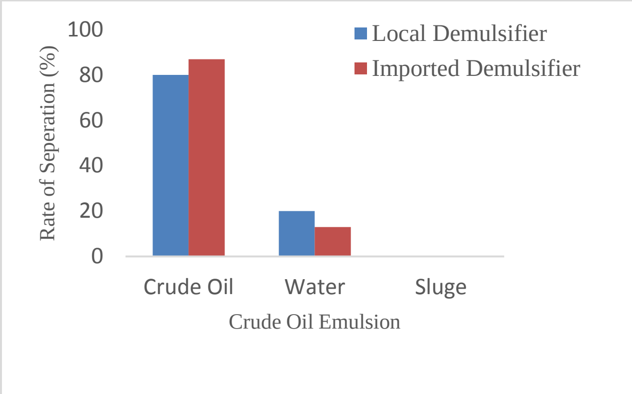

Figure 5. Rate of Separation of Emulsion of 1.0 ml of Demulsifiers in 1 minute @ 80°F

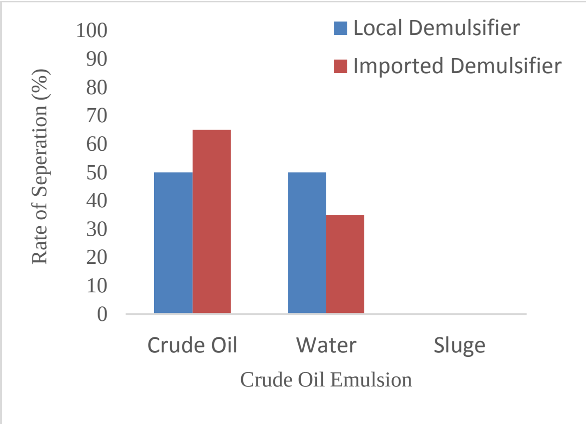

Figure 6. Rate of Separation of Emulsion of 1.0 ml of Demulsifiers in 2 minutes @ 80°F

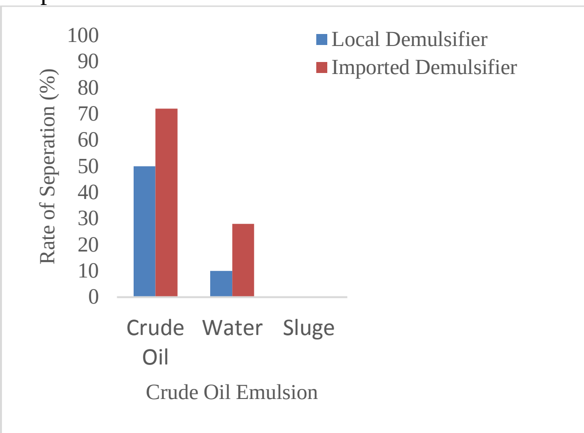

Figure 7. Rate of Separation of Emulsion of 0.2 ml of Demulsifiers in 1 minute @ 150°F

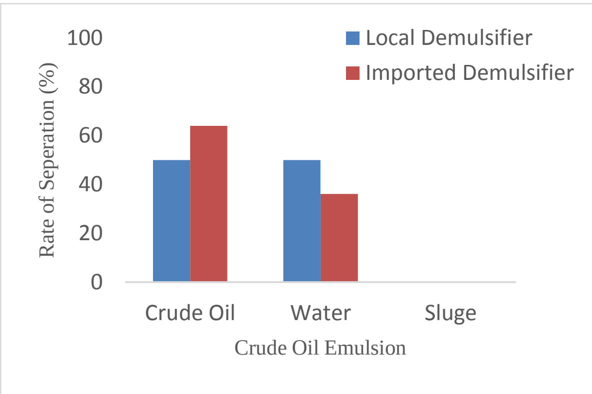

Figure 8. Rate of Separation of Emulsion of 0.2 ml of Demulsifiers in 2 minutes @ 150°F

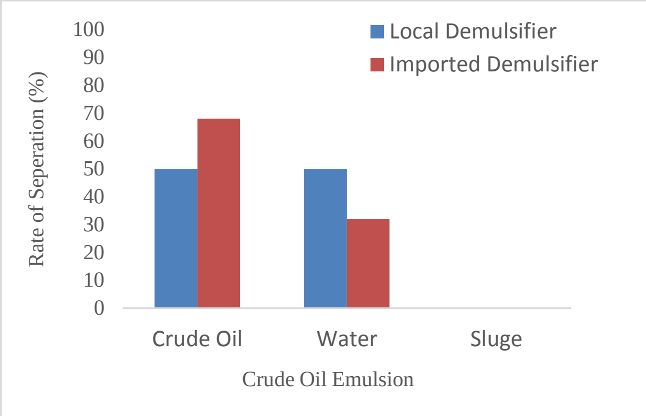

Figure 9. Rate of Separation of Emulsion of 1.0 ml of Demulsifiers in 1 minute @ 150ºF

Characterization of Physical Properties of Coconut Oil as a Based Oil for Local Demulsifier and Imported Demulsifier

The parameters such as pH, specific gravity, viscosity, API gravity, cloud point, boiling point, and pour point of the coconut oil, and local and imported demulsifiers were analyzed to ascertain their performance as shown in Table 3. Similarly, Table 4 and Table 7 also shows the established degree of compatibility assessment were also established as for local and imported demulsifier.

However, further experimental analyses were carried out on the physical properties of coconut oil, and local and imported demulsifiers to ascertain the quality before usage. The pH of the local demulsifier was 7.2 whereas the imported one was 3.0 meaning the local demulsifier was basic whereas the imported demulsifier was acidic. Thus, the pH of the local demulsifier contributed to the excellent performance of the emulsion break as compared to the imported demulsifier and this is in line with the findings of Mitchell, and Speight, (1973) which state that pH affects demulsifier performance. Furthermore, basic pH promotes oil-in-water emulsions and acidic pH produces water-in-oil emulsions. High pH, therefore, helps in destabilizing water-in-oil emulsions. The specific gravity of the local demulsifier was 0.99 whereas the imported demulsifier was 0.81 meaning the local demulsifier is neutral and that is the reason why the pH is 7.2.

The boiling point of the local demulsifier was 212^0C whereas the imported demulsifier was 106^0C meaning the local demulsifier tends to withstand external pressure more than the imported demulsifier, thus, it could be highly inflammable as compared to the imported demulsifier. The cloud point of the local demulsifier was 27^0C while the imported demulsifier was 15^0C. It means the temperature regime for wax appearance temperature (WAT) and wax precipitation temperature (WPT) to develop in the local demulsifier will be high as compared to the imported demulsifier and that makes it better and contributed to the faster destabilization of the emulsion.

The pour point of the local demulsifier was 21^0C whereas the imported demulsifier was -3ºC. That means the imported demulsifier loses its flow characteristics in cold weather whereas cold weather has little or no effect on the local demulsifier, therefore, these flow characteristics make it better than the imported demulsifier. The API gravity of the local demulsifier was 11.43^0 whereas the imported demulsifier was 43.19^0 meaning there is light and can float on water easily since they are greater than 10. The kinematic viscosity @ 40 ºC of the local demulsifier was 31 whereas the imported demulsifier was 11 meaning the imported demulsifier has high resistance to flow than the imported demulsifier. This may be a result of the hydrophilic ingredient (cassava starch) of the local demulsifier as well as the lipophilic ingredient (coconut oil).

IV. Conclusions

A comparative analysis of the effect of demulsifiers in the treatment of crude oil emulsion has been carried out in the laboratory. However, based on the results obtained, the following conclusion is drawn as follows:

- Experimental results have shown that local demulsifiers can be highly effective with low separation time in separating oil from water in oil-water emulsions.
- Imported and local demulsifiers spontaneously resolved the emulsion in the crude oil sample producing nearly 100% dry crude oil with trace elements.
- Local demulsifiers exhibited better physical characteristics as compared to imported demulsifiers.
- Some local demulsifiers can perform better than some imported demulsifiers in resolving oil-water emulsions into their separate constituents.

Acknowledgments
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S/N	Name of Equipment	Description/Model	Function
1	Thermometers	Pyrex, England	For measuring temperature
2	Electronic balance	A&D/FX-5000i	To weigh materials
3	Standard CTC constant speed mixer	OFITE 2000	To obtain homogeneity
4	Centrifuge machine	Pyrex, England	For centrifuging
5	Graduated bottles	Pyrex, England	For mixing demulsifiers and emulsion
6	Beakers	Pyrex, England	For weighing/blending
7	Stop Watch	Quartz, China	For timing
8	Syringe	Axojet syringe set China	For suction
9	Water bath	Lindberg/Blue M	For indirect heating at constant
10	Digital pH meter	Hanna HI9811-5	To test acidic or basic of aqueous solution
11	Hydrometer	Brewing America	To obtain specific gravity
12	Pour point tester		To obtain pour point
13	Refrigerator	Thermocol	For cooling
14	Capillary U-Tube Viscometer		To obtain kinematic viscosity

Table 1. List of Equipment

Table 2. *Materials for local demulsifier production and their importance*

S/N	Materials	Source	Location	Importance
1	Cocoa nut		Port Harcourt	Edible cream oil that acted as solvent for oil camphor and also increased the lipophilic properties of the crude oil
2	Camphor powder	Conifer/Pinene tree (Turpene)	Port Harcourt	This formed the lipophilic end of the local demulsifier produced
3	Paraffin Petroleum	Petroleum Wax	Port Harcourt	This served as the bulking agent in the locally formulated produced
4	Starch	Cassava	Port Harcourt	This formed the hydrophilic end of the locally Produced demulsifier because of its strong affinity for water
5	Distilled water	Steam	Port Harcourt	This was used as solvent for the starch solution
6	Liquid Soap	Saponification of fatty acids and alkaline	Port Harcourt	This served as the binder for the demulsifier produced from locally sourced materials to bind the lipophilic and the hydrophilic end

Table 3. *Characterization of Physical Parameters of Coconut Oil as a Based Oil for Local Demulsifier and Imported Demulsifier*

s/n	Parameters	Unit	Coconut oil	Local demulsifier	Imported demulsifier
1	Colour	-	Light Yellow	Light Yellow	Light Brown
2	Ph	-	5.7	7.2	3.0
3	Specific Gravity	-	0.95	0.99	0.81
4	Kinematic Viscosity @ 40 ºC	(cSt)	20	31	11
5	API Gravity	º	17.45	11.43	43.19
6	Boiling Point	ºC	198	212	106
7	Cloud Point	ºC	23	27	15
8	Pour Point	ºC	17	21	-3

.

Table 4. *Treatment of Crude Oil Emulsion with Local Demulsifier*

S/N	Surfactants (ml)	Temp (ºF)	Time (mins)	Observation	Break	Interface	Compatibility	Sediment
1.	0.2	80	0	Separation begins slowly	Not clear	Not clear	Compatible	None
			1	Oil =60mls Water =40mls Sludge =0ml	Not clear	Not clear		None
			2	Oil =50mls Water =50mls Sludge = 0ml	Not clear	Clear	Compatible	None
	1.0	80	0	Separation starts	Not clear	Not clear	Compatible	None
			1	Oil =80mls Water =20mls Sludge = 0	Not clear	Not clear	Compatible	None
			2	Oil =50mls Water =50mls	Not clear	Clear	Compatible	None
2.	0.2	150	0	Separation begins	Clean	Clean	Compatible	None
			1	Oil =90mls Water =10mls Sludge = 0	Clean	Clear	Compatible	None
			2	Oil =50mls Water =50mls	Clean	Clear	Compatible	None
	1.0	150	0	Separation starts	Clean	Clean	Compatible	None
			1	Oil =50mls Water =50mls Sludge=0mls	Very clean	Very clear	Compatible	None

Table 5. *Treatment of Crude Oil Emulsion with Imported Demulsifier*

s/n	Demulsifier (ml)	Temp (ºF)	Time (mins)	Observation	Break	Interface	Compatibility	Sediment
1.	0.2	80	0	Separation begins slowly	Not clear	Not clear	Compatible	None
			1	Oil =96mls Water =4mls Sludge =0ml	Not clear	Not clear		None
			2	Oil =90mls Water =10mls Sludge = 0ml	Not clear	clear	Compatible	None
			3	Oil =85mls Water =15mls Sludge = 0ml	Not clear	clear	Compatible	None
			4	Oil =69mls Water =11mls Sludge = 0ml	Not clear	clear	Compatible	None
			5	Oil =54mls Water =46mls Sludge = 0ml	Clear	clear	Compatible	None

			10	Oil =50mls Water =50mls Sludge = 0ml	Clear	clear	Compatible	None
	1.0		0	Separation starts	Not clear	Not clear	Compatible	None
			1	Oil =87mls Water =13mls Sludge = 0	Not clear	Not clear	Compatible	None

Table 6. *Treatment of Crude Oil Emulsion with Imported Demulsifier*

S/N	Surfactant (ml)	Temp (ºF)	Time (mins)	Observation	Break	Interface	Compatibility	Sediment
			2	Oil =65mls Water =35mls Sludge = 0	Not clear	clear	Compatible	None
			3	Oil =59mls Water =41mls Sludge = 0ml	Clear	clear		None
			4	Oil =50mls Water =50mls Sludge = 0ml	Clear	clear	Compatible	None
2.	0.2	150	0	Separation begins	Clean	clean	Compatible	None
			1	Oil =72mls Water =28mls Sludge = 0	Clean	clear	Compatible	None
			2	Oil =64mls Water =36mls	Clean	clear	Compatible	None
			3	Oil =62mls Water =38mls Sludge = 0ml	Clean	clear	Compatible	None
			4	Oil =60mls Water 40=mls Sludge = 0ml	Clean	clear	Compatible	None
			5	Oil 56=mls Water 44=mls Sludge = 0ml	Clean	clear	Compatible	None

Table 7. *Treatment of Crude Oil Emulsion with Imported Demulsifier*

S/N	Surfactant (ml)	Temp (ºF)	Time (mins)	Observation	Break	Interface	Compatibility	Sediment
			6	Oil =52mls Water =48mls Sludge = 0ml	Clean	clear	Compatible	None
			7	Oil =50mls Water =50mls Sludge = 0ml	Clean	clear		None
	1.0	150	0	Separation starts	Clean	clear	Compatible	None
			1	Oil =68mls Water =32mls Sludge=0mls	Clean	clear	Compatible	None
			2	Oil =55mls Water =45mls Sludge = 0ml	Clean	clear	Compatible	None
			3	Oil =50mls Water =50mls Sludge = 0ml	clean	clear	Compatible	None

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