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Full Length Research Paper

Chemical treatment of emulsion problem in crude oil production

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Remediation of water in the course of crude oil production has been a costly process and it has hampered the production activities in many parts of the world. In this research work, effective separation of emulsion using demulsifiers (castor oil and sulphuric acid) in six separate formulations was accessed. The result shows that using sulphuric acid as a demulsifier in 500 and 1000 revolution per minute in the centrifuge, 1.25 and 2.5% basis sediments of water was obtained. The same process was conducted using castor oil as the demulsifier and 2.5%, 6.25% basis sediments of water was obtained. Conclusively, the resultant separation technique can be used for the separation of emulsion.

Key words: Demulsifiers, castor oil and sulphuric acid, emulsion, sediment.

INTRODUCTION

Whenever two immiscible liquids, such as oil and water contact each other, one liquid tend to disperse but not dissolve in the other, this dispersion of liquid typically in an aqueous medium is an emulsion. The presence of water in crude oil can cause such undesirable consequences as: corrosion, raise conductivity, leaching of additives etc (Hikmat and Ahmed, 2010). Methods currently employed in demulsification of crude oil are: heat, electrical, chemical and polymer methods. Emulsion breaking or de-emulsification is the separation of a dispersed liquid from the liquid in which it is suspended. All chemical and mechanical methods of emulsion breaking conform to Stoke's law. The objective of demulsification is to destroy the interface and drive the surfactant to either the oil side or the water side, allowing the oil particles and sediments to coalesce and rise to the surface as in creaming. Decreasing water phase viscosity or increasing oil viscosity can enhance demulsification. Increasing the diameter of oil droplets and lowering the density of oil to water also works. There are several strategies for counteracting emulsion:

(i) Decompose the emulsion; modifying or using dissolved air floatation, oxination or other oxidation process. This method however is expensive.
(ii) Chemically react the emulsion, modifying the surfactants change so that it no longer acts as an emulsifier. Ionic surfactant neutralization is often the simplest method using an acid base or ionizer if calcium or magnesium salt, such as CaCl or $MgSO_4$ is added to emulsion stability by sodium soap, which is less soluble in water because the interfacial film has changed.
(iii) Increase the solubility of the surfactant in either bulk phase. Alcohol or other polar solvents such as acetone can be used to increase solubility in the water phase and pull the emulsifier out of the oil phase. If the aqueous phase is brine, dilution with water may be all that is needed to achieve separation.
(iv) Disrupt the oriented structure of the emulsifier interfacial phase with de-emulsifier. Because these materials are not very soluble in either phase they concentrate at the interface.

THEORY

An emulsion is a dispersion of droplets of one liquid (oil) in another liquid (water) with which it is incompletely immiscible. In emulsion, the droplets often exceed the usual limits for colloids in sizes. Emulsion normally do not exist in the producing formation but are formed when oil and water are produced together with a great amount of agitation when water and oil in a reservoir enter the well bore through the perforations in the casing, comparatively large pressure differences are created which violently mix the produced oil and water together so that emulsion forms.

Emulsion consists of three phases: the internal or discontinuous phase of finely divided droplets. The external or continuous phase is the matrix that keeps droplets in suspension. The interphase consists of an emulsifier or stabilizer, that keeps the emulsion stable, binding the internal and external phase together and preventing droplets from approaching each other and coalescing. Usually, emulsifiers are surfactants and soaps present either by themselves or as part of the make up of a detergent formation. An emulsifier consists of a molecule with hydrophilic and hydrophobic ends. In the presence of immiscible liquids, the emulsifier migrates to the interface of the internal and external phases, forming a protective sheath round droplets of dispersed phase. While the hydrophobic ends of the molecule migrates or partitions into droplets, the hydrophilic ends stays in the water. Common examples of emulsion are: homogenized milk, shaving cream, mayonnaise, etc.

Treatment methods for emulsion in crude oil

Application of heat: This assist in reducing the viscosity of the oil thereby increasing the difference in density between the oil and the water.

Application of electricity: This promotes the coalescence of water droplets in emulsion treatment.

Application of chemicals: This also helps to cause coalescence of water droplets in emulsion treatment.

Polymers: These are used in demulsification process and surfactants that counteract the effect of asphaltenes.

Natural treatment: Emulsion are treated naturally by means of storage in tanks or pits. During this period the liquid with higher density will settle first.

METHODOLOGY

Emulsion that is (oil + water) was obtained from different wells that is, 2 wells, having different samples to work upon. The first experiment was carried out without any emulsion breaker as shown in Tables 1 and 2. This was to certify that there was no natural demulsifier available in the crude. The second experiment was carried out by using sulphuric acid (H_2SO_4) as its demulsifier as shown in Tables 3 and 4. Before the commencement of the second experiment, there were available 6 test tubes with calibrations as follows: 2, 4, 6, 8 and 10 ml respectively. After calibration, crude with water were added to a level of 4, 8 and 6 ml for all the three experiments. Emulsion breakers of 1, 2, 3, 4 and 6 drops respectively, were added to the different test tubes in the centrifuge machine. The test tubes were later inserted into the machine for spinning and for separation. The time of rotation and the number of revolutions per minute (rpm) were recorded. After the time of rotation had elapsed, the test tubes in the centrifuge were measured and the separation of oil from water recorded. The experiment for another demulsifier was recorded, which was castor oil. The procedure was also repeated for all the samples and the results recorded.

RESULTS

The experiment show that both sulphuric acid and castor oil perform well as demulsifiers. For example at 500 and 1000 rpm, both varied in the levels of separation of oil from water when compared with the same experiment without emulsifiers. Figures 1 and 2 show the amount of sulphuric acid droplets required for a given level of separation.

The results indicate that there is better level of separation when using castor oil than when sulphuric acid is used. For example, at centrifuge spin of 1000 rpm and 2 drops of H_2SO_4 (Tables 5 to 7), the level of separation achieved was 3.5%, while 5 drops produced 12.5%. Castor oil produced a separation level of 3.3% with 2 drops and 15% with 5 drops at the same level of spin of 1000 rpm. The different levels of degree of separation could be attributable to similarity between crude oil and castor oil; both are oils From literature (Afanasev et al. 1993), before the demulsifier can achieve film breaking, it has to set to the interface between the oil and H_2O droplets. It then starts to gather sufficient droplets together prior to coalescence. This gathering together is called flocculation. Figures 3 to 5 show the amount of castor oil required for a given amount of separation.

It has been shown that the addition of de-emulsifier cause a change in colour in the reagents. Different oil from wells gives varying change in colour. Colour is also an indicator, but it may not be definitive. These findings have been confirmed by a number of researchers including Sjoglom (2001) and Fingas et al. (2000). Emulsion stability is also a factor, which is needed to be analyzed during this experiment; which defines four water in oil states; stable emulsions, meso-stable emulsion, unstable emulsion (or simply water and oil) and entrained water. These four states are distinguished by perseverance through time, visual appearance and by rheological measurements (Kawanaka et al., 1991). Meso-stable have properties between stable and unstable emulsions. All stable emulsions are usually reddish, although some meso-emulsions also have the colour of the starting oil. Water contents are not an indicator of stability because excess water may be present.

The experimental work has shown that demulsifier must not be much because it tends to affect the emulsion. As a result, the emulsion breaker must be added in little quantity efficient and cost effective. 98% of water was removed from the crude oil leaving the remaining percentage to gravity or the remaining de-emulsifier to work upon. Emulsification is the process of formation of various state of water in oil, often called “chocolate mousse” or “mousse” among oil spill workers.

These emulsions significantly change the properties

Table 1. Emulsion without demulsifier (RPM 500).

Sample	RPM	Time (min)	Emulsion (ml)	Water level (ml)	Crude + water level (ml)
A	500	5	4	-	4
B	500	5	4	-	4
C	500	5	4	-	4
D	500	5	4	-	4
E	500	5	4	-	4
F	500	5	4	-	4

Table 2. Emulsion without demulsifier (RPM 1000).

Sample	RPM	Time (min)	Emulsion (ml)	Water level (ml)	Crude + water level (ml)
A	1000	5	4	-	4
B	1000	5	4	-	4
C	1000	5	4	-	4
D	1000	5	4	-	4
E	1000	5	4	-	4
F	1000	5	4	-	4

Table 3. Emulsion with demulsifier – sulphuric acid (RPM 500).

Sample	RPM	Time (min)	Emulsion (ml)	Sulphuric acid (drops)	Water level (ml)	crude oil (ml)	Basis % sediment of water (%)
A	500	5	8	1	0.1	7.9	1.25
B	500	5	8	2	0.2	7.8	2.5
C	500	5	8	3	0.3	7.7	3.75
D	500	5	8	4	0.3	7.7	3.75
E	500	5	8	5	0.3	7.7	3.75
F	500	5	8	6	0.3	7.7	3.75

Table 4. Emulsion with demulsifier- sulphuric acid (RPM 1000).

Sample	RPM	Time (min)	Emulsion (ml)	Sulphuric acid (drops)	Water level (ml)	Crude oil (ml)	Basis % sediment of water (%)
A	1000	5	8	1	0.2	7.8	2.5
B	1000	5	8	2	0.3	7.7	3.75
C	1000	5	8	3	0.5	7.5	6.25
D	1000	5	8	4	0.6	7.4	7.5
E	1000	5	8	5	1.0	7.0	12.5
F	1000	5	8	6	1.0	7.0	12.5

and characteristics of spilled oil. Stable emulsions contain between 60 and 85% properties and characteristics of spilled oil thus expanding the volume of the spilled material (Kaufmann 1983, Speight 1999). If aromatic solvents are in abundance, the emulsions are not as readily formed. The amount of asphaltenes and resins were very important as the ratios between these compounds.

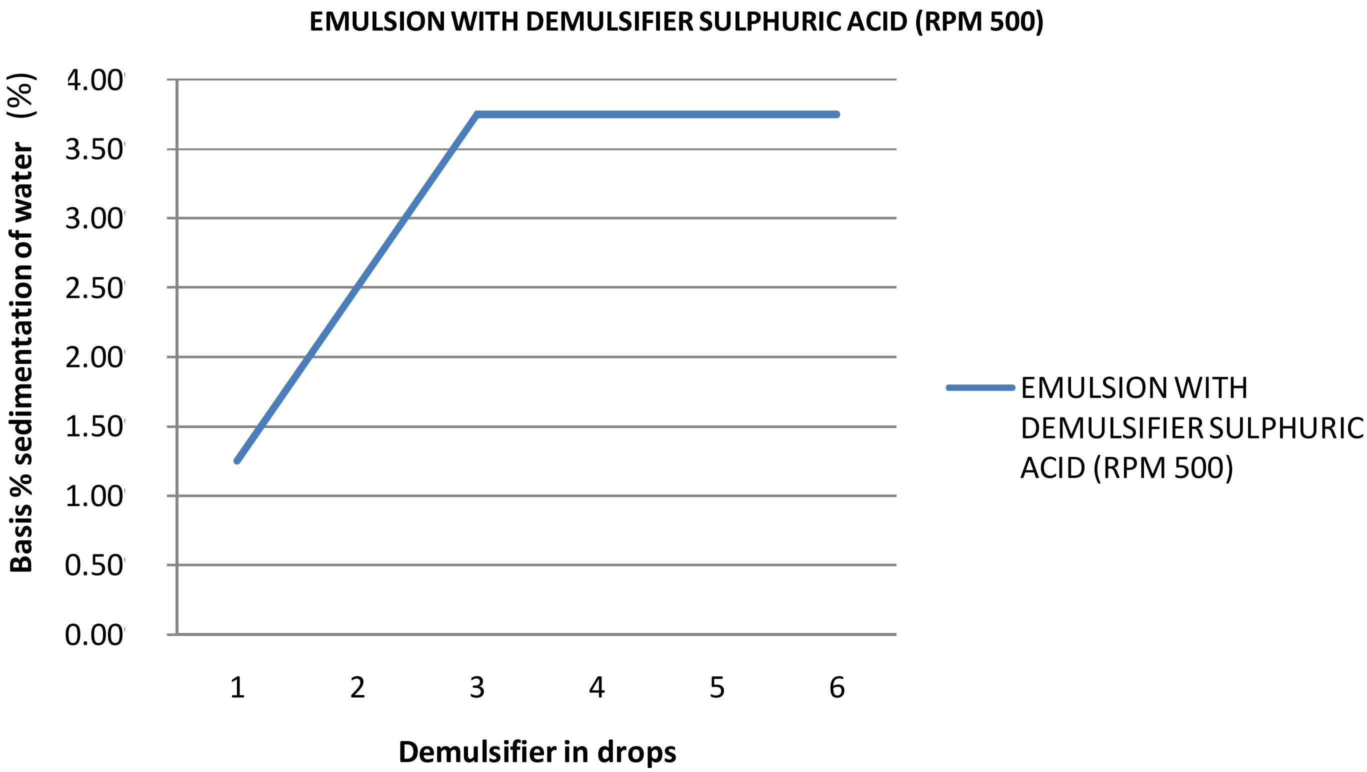

Figure 1. Amount of sulphuric acid droplets versus extent of separation of crude oil from water (RMP 500).

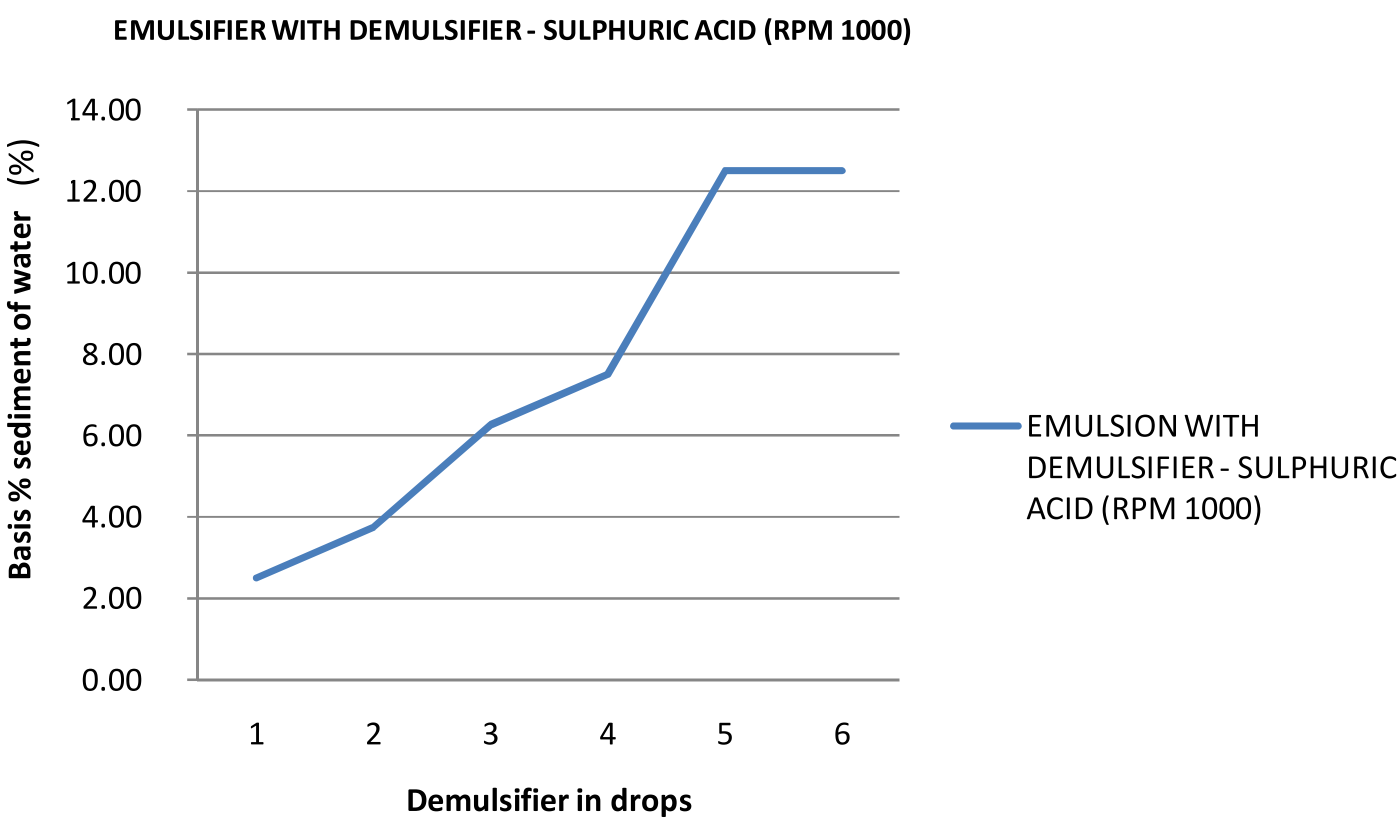

Figure 2. Amount of sulphuric acid droplets versus extent of separation of crude oil from water (RMP 1000).

Table 5. Emulsion with demulsifier–castor oil (RPM 1500).

Sample	RPM	Time (min)	Emulsion (ml)	Castor oil (drops)	Water level (ml)	Crude oil (ml)	Basis % sediment of water (%)
A	1500	5	8	1	0.21	7.79	2.6
B	1500	5	8	2	0.35	7.65	4.5
C	1500	5	8	3	0.50	7.5	6.3
D	1500	5	8	4	0.65	7.35	8.1
E	1500	5	8	5	1.0	7.0	12.5
F	1500	5	8	6	1.0	7.0	12.5

Table 6. Emulsion with demulsifier-castor oil (RPM 500).

Sample	RPM	Time (min)	Emulsion (ml)	Castor oil (drops)	Water level ml)	Crude oil (ml)	Basis % sediment of water (%)
A	500	5	6	2	0.15	5.86	2.5
B	500	5	6	3	0.25	5.75	4.2
C	500	5	6	4	0.6	5.4	10
D	500	5	6	5	0.75	5.25	12.5
E	500	5	6	6	0.75	5.25	12.5
F	500	5	6	7	0.75	5.25	12.5

Table 7. Emulsion with demulsifier-castor oil (RPM 1000).

Sample	RPM	Time (min)	Emulsion (ml)	Sulphuric acid (drops)	Water level (ml)	crude oil (ml)	Basis % sediment of water (%)
A	1000	5	6	2	0.2	5.8	3.3
B	1000	5	6	3	0.4	5.6	6.7
C	1000	5	6	4	0.8	5.2	13.3
D	1000	5	6	5	0.9	5.1	15
E	1000	5	6	6	2.0	4.0	33.3
F	1000	5	6	7	2.0	4.0	33.3

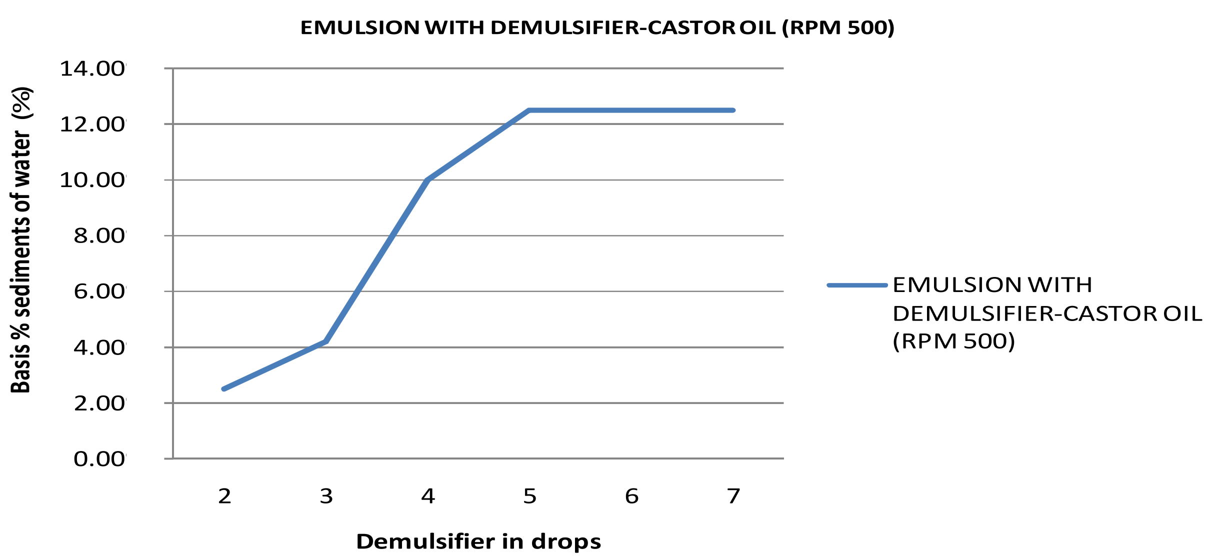

Figure 3. Amount of castor oil droplets versus extent of crude oil separation from water (RMP 500).

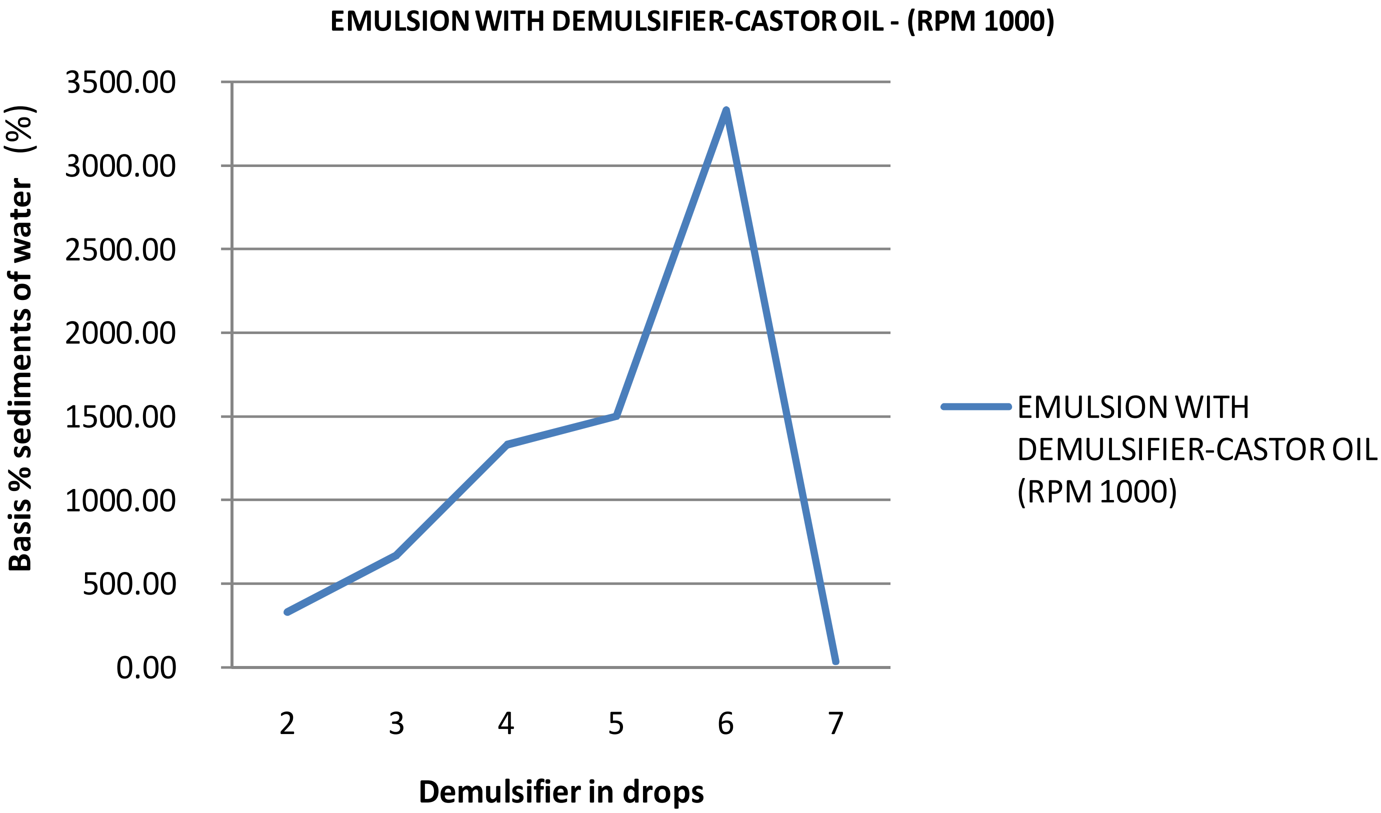

Figure 4. Amount of castor oil droplets vs extent of crude oil separation from water (RMP 1000).

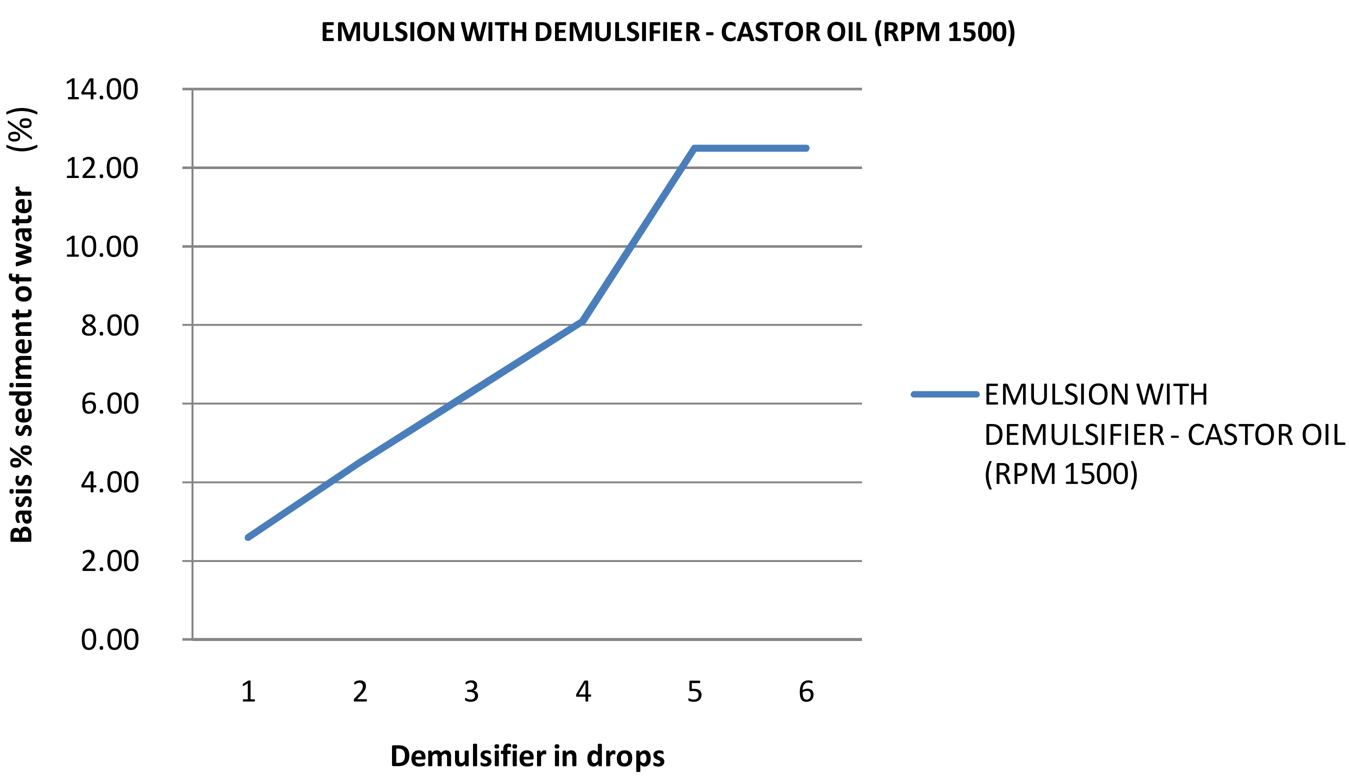

Figure 5. Amount of castor oil droplets vs extent of separation of crude oil from water (RMP 1500).

CONCLUSION AND RECOMMENDATION

Results from this research were compared favourably with other previous work done (Anderson and Birdi, 1991) and can be put for practical application in crude oil production. According to the results, one can estimate the amount of demulsifier that will be used in large scale production of crude oil, which has water content when produced. Demulsifier are not needed to be added into the oil wells because emulsion is not formed in the well when oil is been produced (Fry, 1984). Additionally, different oil well with crude oil + water (emulsion) needs different types of separation. Vigorous universal solution to the chemical treatment of emulsion is to know different stability, pH and to know different type of surface active surfactant or natural surfactant in different oil wells. Some surfactant will not allow any chemical to separate but will separate the oil from the water by itself. Then one must also take note of desalter, if there is any form of salt present in oil well. More and more discovery on how to solve the problem of emulsion chemically has been the scientific quest to find a solution to the problem.

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