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Analysis of Diethylene Glycol and Decylamine as Demulsifiers for Treatment of Water-In-Oil Emulsions: Case Study of the Niger Delta, Nigeria

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Abstract:

Crude oil is made up of different hydrocarbon compounds. At different depths in the same reservoir, the properties of the crude oil differ from one another. During production of crude oil, emulsion is usually formed due interaction of water with emulsifying agents such as wax, as phaltenes, resins etc. present in crude oil. Water in oil emulsion (w/o) poses serious problems during production and pipeline transportation of crude oil. To separate water from crude oil, demulsifier is required. This research work seeks to evaluate two chemical demulsifiers (diethylene glycol and decylamine) on crude oil sample from the Niger Delta to ascertain the most effective in water separation. Demulsifier concentration used were 80% and 20% water. Water-in- oil emulsion was formulated in the ratio of 360ml:40ml of crude oil and distilled water respectively in the laboratory. The demulsification process was carried out at a temperature of 158°F. Demulsifier doses of 0.5, 1, 1.5, and 2mls were carried out at centrifugal speed of 300rpm, 600rpm, 900 rpm and separation time (10, 20, 40, 60,100, 150 sec). Volumes of water separated were recorded and water separation efficiencies were calculated. Results have shown that faster rate of water separation and performance efficiency can be achieved when diethylene glycol is used as demulsifier on crude oil from the Niger Delta region of Nigeria.

Keywords: Demulsifiers, emulsion, crude oil

1. Introduction

Production of oil is associated with water in oil reservoirs. During flow of oil from the reservoir through the tubing to the well head, emulsion is formed due to turbulent flow of oil and water. Emulsion consist of three types namely: (i) water- in- oil (w/o), water dispersing into the oil which is the continuous phase. (ii) oil-in-water (o/w), oil dispersing into the water which is the continuous phase. (iii) complex emulsions which is the combination of oil in water (o/w) and water in oil (w/o). The pre-requisites for stable emulsion to form include (i) Two immiscible liquids (ii) Emulsifying agent (iii) Agitation (Schuber and Armbruster, 1992). Emulsions are formed due to Asphaltene, resins, waxes otherwise known as emulsifying agents present in crude oil (Lee, 1999). Chemical demulsifiers used in the treatment of emulsions in the oil and gas industry are either polar (hydrophilic) or non-polar (hydrophobic) (Abdulkadir, 2006). Demulsifier molecules having equal partitioning between aqueous and oil phase are the most efficient demulsifiers (Al-Sabagh et al., 2011). Application of demulsifying agent for emulsion treatment depends on the properties of the crude oil which differ from one another (Hanapi, 2006). During demulsification process, temperature changes cause remarkable changes in the stability of emulsion; emulsions may be inverted or broken (Al-Sabagh et al., 2014). The aim of the study is to determine which of the demulsifiers (diethylene glycol and decylamine) generate better water separation efficiency.

2. Materials and Methods

2.1. Materials

The materials used are presented in Table 1 below

S/N	Material Name	S/N	Material Name
1	Clock timer	10	Diethylene glycol (demulsifier)
2	Water bath	11	Flat bottom flask
3	Centrifuge	12	Decylamine (demulsifier)
4	Thermometer	13	Hydrometer cylinder
5	Beakers (100 ml)	14	Xylene (solvent)
6	Funnel	15	Mixer
7	Syringe	16	Pipette
8	Centrifuge tube	17	Crude oil (from the Niger Delta)
9	Hydrometer	18	Distilled water

Table 1: Laboratory Equipment and Material

Properties of chemical demulsifiers used are shown in Table 2 below.

Properties	Diethylene Glycol	Decylamine
Molecular formula	C ₄ H ₁₀ O ₃	C ₁₀ H ₂₃ N
Physical Properties	Colorless liquid	Colorless liquid
Density	1.118 g/cm	0.73g/cm
Melting point	-10.45°C	17 °C
Boiling point	244-245°C	220.5 °C

Table 2: Properties of Demulsifiers (Diethylene Glycol and Decylamine)

Properties of crude oil samples used from the Niger Delta fields are as shown in Table 3 below

Crude Oil Properties	Values
Colour	Brown
Specific gravity, S.G	0.886
API gravity	28°

Table 3: Showing Properties of Crude Oil used

2.2. Methods

Emulsion preparation. Water-in-oil emulsion (w/o) was prepared in the laboratory at room temperature by mixing crude oil sample and distilled water in the ratio of 90%:10% or 360ml:40ml respectively. Hamilton beach electric mixer was used at a speed of 1000 rpm for one hour to obtain a stable emulsion.

Preparation of Demulsifier. Eighty percent (80%) solution of the chemical demulsifiers (diethylene glycol and decylamine) was prepared as follows:

- Xylene was added into 50ml graduated flat bottom flask up to 10ml level.
40ml of demulsifier was added to the 50ml graduated cylinder to make up the total volume.
- The mixture was vigorously agitated with the flask closed and labelled.
- Steps 1,2, and 3 were repeated for the other demulsifier (decylamine).

Summary of Mixture

Xylene volume used = 10ml.

Concentrated demulsifier volume used = 40ml.

Total volume of solution = (40+10) = 50ml.

Percentage of xylene in solution = $10/50 \times 100 = 20\%$.

Percentage of demulsifier in solution = $40/50 \times 100 = 80\%$

2.2.1. Analytical Procedure

- Emulsion samples in centrifuge tube were placed into centrifuge at a temperature of 158oF and set to spin at a given time.
- The volume of water separated is measured in time 10,20,40,60,100, and 150 sec.
- Steps a-b are repeated at various speeds of the centrifuge 300rpm,600rpm and 900rpm for demulsifier doses of 0.5ml,1.0ml,1.5ml and 2.0ml respectively.
- The above procedures were performed on the two chemical demulsifiers.
- Calculation of water separation efficiency is as follows: % Water separated (e) = Volume of water separated ml / Original volume of water in emulsion ml * 100. Results and Discussion

3. Results

The results of the test performed are shown in the tables below. Tables 3.1 to 3.12 shows volume of water separated from 10 sec. to 150 sec, while tables 3.13 to 3.24 shows water separation efficiency of diethylene glycol and decylamine for the same range of time.

Demulsifier	Time (s)					
	10	20	40	60	100	150
Decylamine separated water (ml)	0.1	0.1	0.1	0.1	0.1	0.1
Diethylene glycol (DEG) separated water (ml)	0.3	0.3	0.3	0.3	0.3	0.3

Table 4: Demulsification Process Result of 300 Rpm for 0.5 MI Demulsifier Dose

Demulsifier	Time (s)					
	10	20	40	60	100	150
Decylamine separated water (ml)	0.15	0.15	0.15	0.15	0.15	0.15
Diethylene glycol (DEG) separated water (ml)	0.35	0.35	0.35	0.35	0.35	0.35

Table 5: Demulsification Process Result of 300 Rpm for 1.0 MI Demulsifier Dose

Demulsifier	Time (s)					
	10	20	40	60	100	150
Decylamine separated water (ml)	0.1	0.1	0.1	0.1	0.1	0.1
Diethylene glycol (DEG) separated water (ml)	0.3	0.3	0.5	1.0	1.5	2.0

Table 6: Demulsification Process Result of 300 Rpm for 1.5 MI Demulsifier Dose

Demulsifier	Time (s)					
	10	20	40	60	100	150
Decylamine separated water (ml)	0.05	0.05	0.15	0.20	0.20	0.20
Diethylene glycol (DEG) separated water (ml)	0.1	0.15	0.25	0.5	1.0	1.5

Table 7: Demulsification Process Result of 300 Rpm for 2.0 MI Demulsifier Dose

Demulsifier	Time (s)					
	10	20	40	60	100	150
Decylamine separated water (ml)	0.1	0.1	0.1	0.1	0.1	0.1
Diethylene glycol (DEG) separated water (ml)	0.3	0.3	0.3	0.3	0.3	0.3

Table 8: Demulsification Process Result of 600 Rpm for 0.5 MI Demulsifier Dose

Demulsifier	Time (s)					
	10	20	40	60	100	150
Decylamine separated water (ml)	0.15	0.15	0.15	0.15	0.15	0.15
Diethylene glycol (DEG) separated water (ml)	0.35	0.35	0.35	0.35	0.35	0.35

Table 9: Demulsification Process Result of 600 Rpm for 1.0 MI Demulsifier Dose

Demulsifier	Time (s)					
	10	20	40	60	100	150
Decylamine separated water (ml)	0.0	0.05	0.05	0.05	0.05	0.05
Diethylene glycol (DEG) separated water (ml)	0.0	0.05	0.1	0.5	1.4	3.0

Table 10: Demulsification Process Result of 600 Rpm for 1.5 MI Demulsifier Dose

Demulsifier	Time (s)					
	10	20	40	60	100	150
Decylamine separated water (ml)	0.05	0.10	0.10	0.15	0.20	0.20
Diethylene glycol (DEG) separated water (ml)	0.10	0.10	0.50	1.0	1.5	1.5

Table 11: Demulsification Process Result of 600 Rpm for 2.0 MI Demulsifier Dose

Demulsifier	Time (s)					
	10	20	40	60	100	150
Decylamine separated water (ml)	0.1	0.1	0.1	0.1	0.1	0.1
Diethylene glycol (DEG) separated water (ml)	0.3	0.3	0.3	0.3	0.3	0.3

Table 12: Demulsification Process Result of 900 Rpm for 0.5 MI Demulsifier Dose

Demulsifier	Time (s)					
	10	20	40	60	100	150
Decylamine separated water (ml)	0.15	0.15	0.15	0.15	0.15	0.15
Diethylene glycol (DEG) separated water (ml)	0.35	0.35	0.35	0.35	0.35	0.35

Table 13: Demulsification Process Result of 900 Rpm for 1.0 MI Demulsifier Dose

Demulsifier	Time (s)					
	10	20	40	60	100	150
Decylamine separated water (ml)	0.05	0.08	0.10	0.15	0.20	0.20
Diethylene glycol (DEG) separated water (ml)	0.1	0.20	0.35	0.5	1.5	2.5

Table 14: Demulsification Process Result of 900 Rpm for 1.5 MI Demulsifier Dose

Demulsifier	Time (s)					
	10	20	40	60	100	150
Decylamine separated water (ml)	0.05	0.10	0.15	0.20	0.20	0.20
Diethylene glycol (DEG) separated water (ml)	0.5	1.0	1.5	1.5	1.5	1.5

Table 15: Demulsification Process Result of 900 Rpm for 2.0 MI Demulsifier Dose

Time	10	20	40	60	100	150
Decylamine (e)	0.25	0.25	0.25	0.25	0.25	0.25
Diethylene glycol (DEG) (e)	0.75	0.75	0.75	0.75	0.75	0.75

Table 16: Water Separation Efficiency Result of 300 Rpm for 0.5 MI Demulsifier Dose

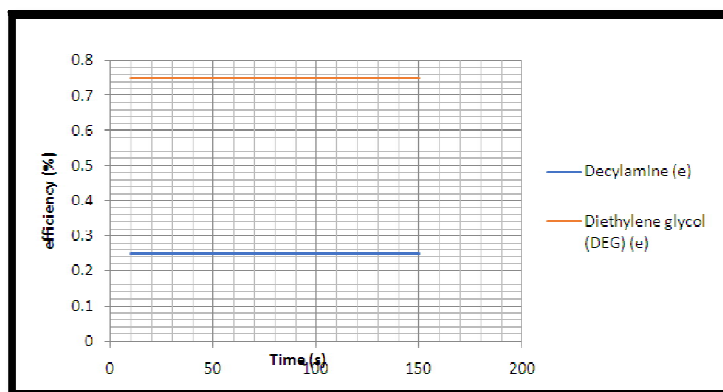


Figure 1: Plot of Water Separation Efficiency for 300rpm in 0.5 MI Demulsifier Dose

Time	10	20	40	60	100	150
Decylamine (e)	0.375	0.375	0.375	0.375	0.375	0.375
Diethylene glycol (DEG) (e)	0.875	0.875	0.875	0.875	0.875	0.875

Table 17: Water Separation Efficiency Result of 300 Rpm for 1.0 MI Demulsifier Dose

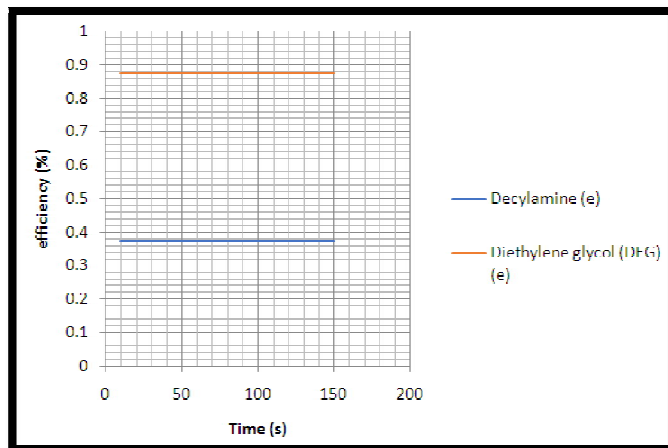


Figure 2: Plot of Water Separation Efficiency for 300rpm in 1.0 MI Demulsifier Dose

Time	10	20	40	60	100	150
Decylamine (e)	0.25	0.25	0.25	0.25	0.25	0.25
Diethylene glycol (DEG) (e)	0.75	0.75	1.25	2.5	3.75	5

Table 18: Water Separation Efficiency Result of 300 Rpm for 1.5 MI Demulsifier Dose

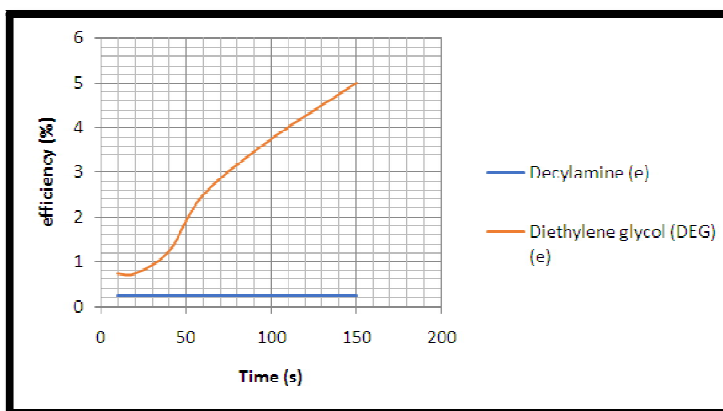


Figure 3: Plot of Water Separation Efficiency for 300rpm in 1.5 MI Demulsifier Dose

Time	10	20	40	60	100	150
Decylamine (e)	0.125	0.125	0.375	0.5	0.5	0.5
Diethylene glycol (DEG) (e)	0.25	0.375	0.625	1.25	2.5	3.75

Table 19: Water Separation Efficiency Result of 300 Rpm for 2.0 MI Demulsifier Dose

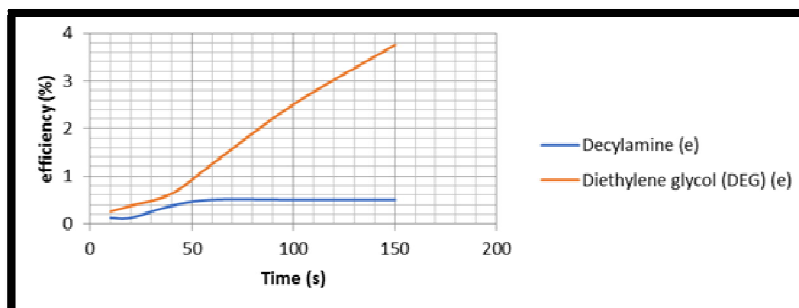


Figure 4: Plot of Water Separation Efficiency for 300rpm in 2.0 MI Demulsifier Dose

Time	10	20	40	60	100	150
Decylamine (e)	0.25	0.25	0.25	0.25	0.25	0.25
Diethylene glycol (DEG) (e)	0.75	0.75	0.75	0.75	0.75	0.75

Table 20: Water Separation Efficiency Result of 600 Rpm for 0.5ml Demulsifier Dose

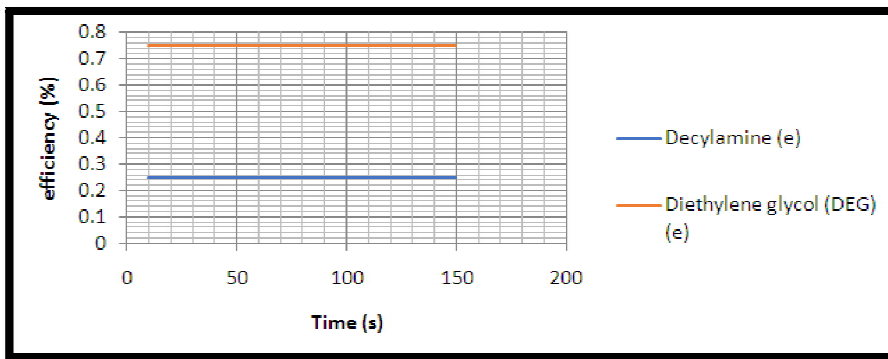


Figure 5: Plot of Water Separation Efficiency for 600rpm in 0.5 MI Demulsifier Dose

Time	10	20	40	60	100	150
Decylamine (e)	0.375	0.375	0.375	0.375	0.375	0.375
Diethylene glycol (DEG) (e)	0.875	0.875	0.875	0.875	0.875	0.875

Table 21: Water Separation Efficiency Result of 600 Rpm for 1.0 MI Demulsifier Dose

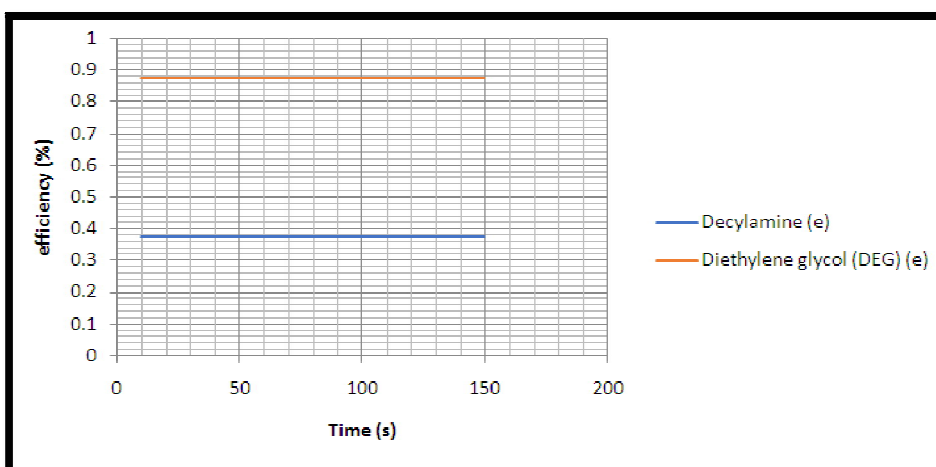


Figure 6: Plot of Water Separation Efficiency for 600rpm In 1.0 MI Demulsifier Dose

Time	10	20	40	60	100	150
Decylamine (e)	0	0.125	0.125	0.125	0.125	0.125
Diethylene glycol (DEG) (e)	0	0.125	0.25	1.25	3.5	7.5

Table 22: Water Separation Efficiency Result of 600 Rpm for 1.5 MI Demulsifier Dose

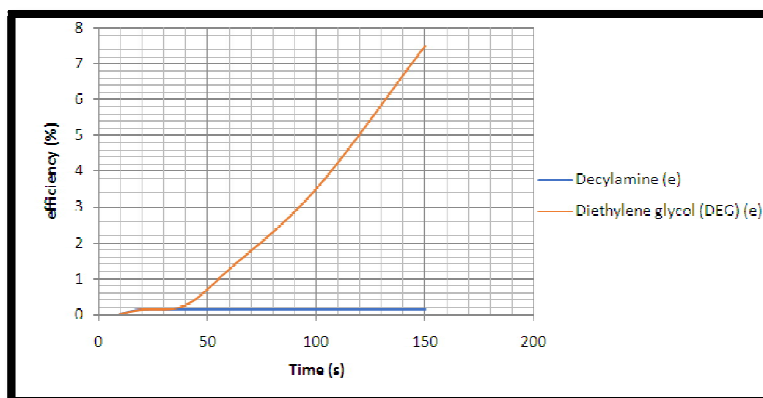


Figure 7: Plot of Water Separation Efficiency for 600rpm in 1.5 MI Demulsifier Dose

Time	10	20	40	60	100	150
Decylamine (e)	0.125	0.25	0.25	0.375	0.5	0.5
Diethylene glycol (DEG) (e)	0.25	0.25	1.25	2.5	3.75	3.75

Table 23: Water Separation Efficiency Result of 600 Rpm for 2.0 MI Demulsifier Dose

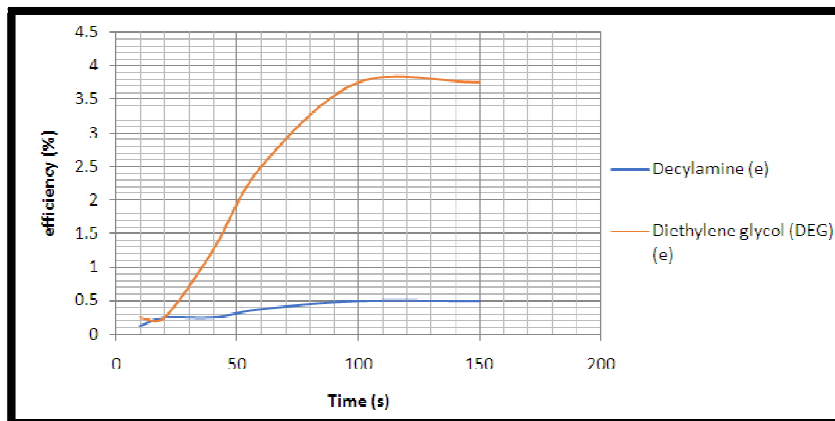


Figure 8: Plot of Water Separation Efficiency for 600rpm in 2.0 MI Demulsifier Dose

Time	10	20	40	60	100	150
Decylamine (e)	0.25	0.25	0.25	0.25	0.25	0.25
Diethylene glycol (DEG) (e)	0.75	0.75	0.75	0.75	0.75	0.75

Table 24: Water Separation Efficiency Result of 900 Rpm for 0.5 MI Demulsifier Dose

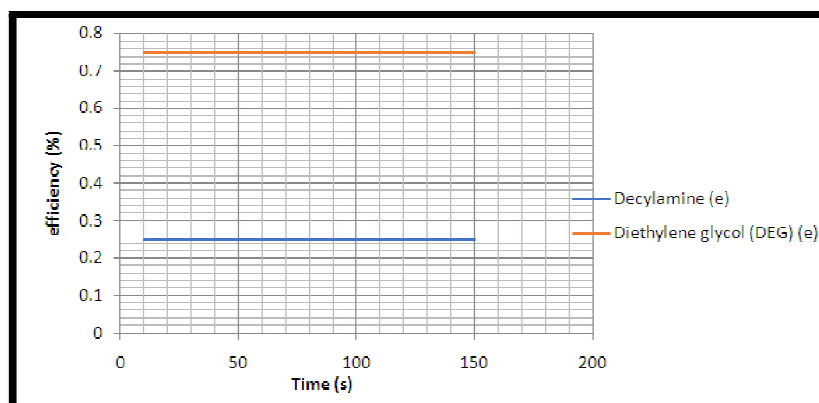


Figure 9: Plot of water separation efficiency for 900rpm in 0.5 ml demulsifier dose

Time	10	20	40	60	100	150
Decylamine (e)	0.375	0.375	0.375	0.375	0.375	0.375
Diethylene glycol (DEG) (e)	0.875	0.875	0.875	0.875	0.875	0.875

Table 25: Water Separation Efficiency Result of 900 Rpm for 1.0 MI Demulsifier Dose

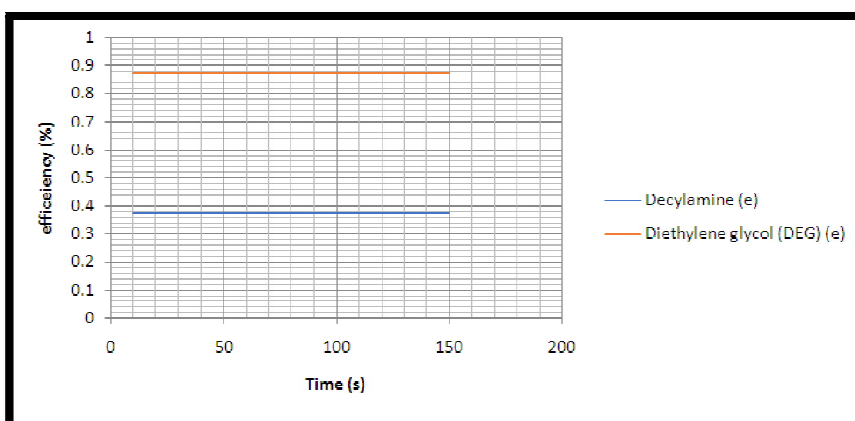


Figure 10: Plot of Water Separation Efficiency for 900rpm in 1.0 MI Demulsifier Dose

Time	10	20	40	60	100	150
Decylamine (e)	0.125	0.2	0.25	0.375	0.5	0.5
Diethylene glycol (DEG) (e)	0.25	0.5	0.875	1.25	3.75	6.25

Table 26: Water Separation Efficiency Result of 900 Rpm for 1.5 MI Demulsifier Dose

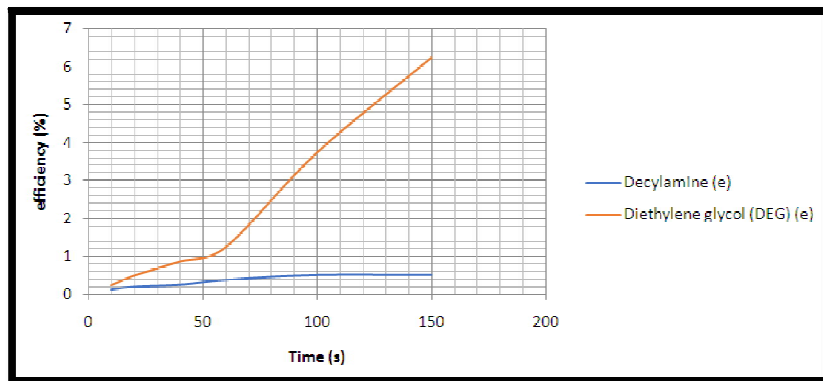


Figure 11: Plot of Water Separation Efficiency for 900rpm in 1.5 MI Demulsifier Dose

Time	10	20	40	60	100	150
Decylamine (e)	0.125	0.25	0.375	0.5	0.5	0.5
Diethylene glycol (DEG) (e)	1.25	2.5	3.75	3.75	3.75	3.75

Table 27: Water Separation Efficiency Result of 900 Rpm for 2.0 MI Demulsifier Dose

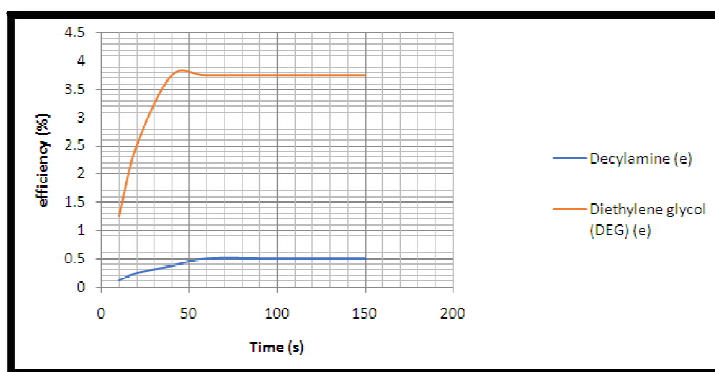


Figure 12: Plot of Water Separation Efficiency for 900rpm in 2.0 MI Demulsifier Dose

4. Discussion of Results

In Table 18 at centrifuge speed of 300rpm for 1.5 ml demulsifier dose, water separation efficiency was 5ml in 150sec with diethylene glycol and 0.5 in 150 sec with decylamine while in Table 22 at a speed of 600rpm for 1.5ml demulsifier dose, water separation efficiency was 7.5ml in 150sec with diethylene glycol and 0.125ml in 150sec with decylamine. In Table 26, at centrifuge speed of 900rpm for 1.5ml demulsifier dose, water separation efficiency was 6.25ml in 150sec with diethylene glycol and 0.5ml with decylamine.

5. Conclusion

Rate of water separation is quicker and efficiency in terms of performance can be realized when diethylene glycol is used as demulsifier on crude oil sample from the Niger Delta region of Nigeria.

6. References

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