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(RESEARCH ARTICLE)

Experimental investigation of cassava and orange peel liquid derivatives as demulsifiers for crude oil emulsion treatment

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Abstract

The need for an efficient and cost-effective approach of separation of water from oil cannot be overemphasized. Effective and time-bound separation of emulsion is needed to ensure optimum production of hydrocarbons. This work investigates the effectiveness of cassava and orange peel liquid extract for demulsification. Cassava and Orange peel were processed and liquid extracted. The extracts were mixed and blended with camphor powder, liquid soap and heated at 40^{o}C for complete dissolution. Emulsion and formulated demulsifiers (Cassava peel liquid extract, orange peel liquid extract, and Xylene) were mixed in the ratio of 90:10,80:20,70:30,60:40 mls and the water separation was measured after 20 minutes up to 140 minutes for 20 minutes interval at room temperature. Results shows that for 10 mls demulsifiers, xylene demulsifier has the least water separation at forty minutes optimum separation time while cassava peel liquid extract demulsifier gave the highest water separation at an optimum time of one hundred minutes. All the three demulsifiers had an optimum separation time of one hundred and twenty minutes for 20 mls demulsifiers addition, but cassava peel liquid extract had the highest water separation while xylene and orange peel extract gave the least water separation. Also, cassava peel liquid extract gave the highest separation at optimum time of one hundred and twenty minutes while orange peel extract demulsifier had the least water separation level at the same optimum time for 30 mls of demulsifiers. One hundred and twenty minutes was the optimum separation time for 40mls demulsifiers with cassava peel liquid extract having the highest water separation while the orange peel extract gave the least water separation. Cassava peel liquid extract demulsifier had the best performance at room temperature among the demulsifiers and recommended for higher temperature condition to verify its performance.

Keywords: Demulsifier; Emulsion; Orange Peel; Cassava Peel; Extract; Xylene

1. Introduction

Crude oil production is often accompanied with produced water sometimes containing chlorides, sulfates, nitrates and other inorganic compounds (Dimitrov *et al.,* 2012, Abdurahman *et al.,* 2012). This water is produced in the form of free water or emulsion and increases in percentage towards the end of the life of the well. The amount of water that emulsifies crude oil in most production systems varies with production process and crude oil type, hence there could be water-in-oil or oil-in water emulsion or multiple emulsions (Murtada *et al.,* 2019). On the basis of kinetic stability, emulsions are classified as loose, medium tight emulsions separating free water within few minutes, tens of minutes, hours and days respectively (Auflem, 2002). Produced water has been identified to be affected by the type and location of wells, type of reservoir, perforation and completion type and other procedures such as coning, channeling, cresting and fractures (Murtada *et al.,* 2019).

Emulsions are undesirable because the volume of dispersed water occupies space in the processing equipment and pipelines, increased operating and capital costs. Moreover, the characteristics and physical properties of oil change

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significantly upon emulsification. The density of emulsion can increase from 800 kg/m^3 for the original oil to 1030 kg/m^3 for the emulsion. The most significant change is observed in viscosity, which typically increases from a few mPa.s or less to about 1000 mPa.s (Pensini, 2014). The process of breaking emulsions by weakening the viscoelastic films techniques surrounding the dispersed water droplets, thus enhancing coalescence is termed Demulsification. The breaking of emulsions is necessary in many applications such as environmental technology, painting, petroleum industry and waste-water treatments. An emulsifier at the interface is replaced with the demulsifier destroying the stable film surrounding the water droplets. The removal of impurities, salt and water is important in demulsification processes. Demulsifiers are surface active compounds which upon addition to emulsion, migrate to the oil-water interface and break rigid film thus resulting in coalescence of water droplets (Alwadani, 2000). The chemical additives migrate to the oil-water interface to destabilize the emulsifying agents. They are generally classified into polymeric, anionic, amphoteric, nonionic, cationic, bio surfactant and surfactant mixtures (Akbari et al., 2018). The fraction and concentration of surfactants such as asphaltenes and resins have been observed to undergo interplay of diffusion at the oil water interface thus contributing immensely to the mechanism of interfacial adsorption, emulsion formation, and stability (Zainab, 2015). Asphaltenic substances, however, make the interfacial films stronger than resinous substances thereby contributing to wettability alteration which yields a more stable emulsion. The hydrophilic functional groups consisting of both asphaltene and resin, their concentration and ratio in different crudes are also other important factors responsible for emulsion stability (Al sabagh, 2012). The impact of the production and processing of crude oil emulsion on the environment cannot be over emphasized. The extraction of poisonous produced water impacts the marine environment as a result of high molecular weight components such as benzene, toluene, ethylbenzene, and xylene (BTEX) which it contains. Emulsions also increase salinity, viscosity and density of crude oil produced, thus resulting in increased cost of transportation, pumping of crude oil and pipeline corrosion. Since the process of emulsification is quite inevitable in the production and field processing of crude oil, it is thus essential to carry out demulsification at minimum cost. Methods of demulsification are generally classified into three categories. These are physical, chemical and biological treatments (Saad *et al.,* 2019). Physical demulsification includes gravitational settling, centrifugation, pH adjustment, thermal treatment which includes conventional heating, microwave irradiation, freeze/thaw, hydroclone, flotation, filtration by adsorption and coalescing filters, electrical demulsification by electro-coalescence, membrane separation, ion-exchange and biological demulsification by reverse-osmosis, ultrasonic by inertial, centrifuge and ortho-kinetic by shear flow (Saad *et al.,* 2019). Physical treatments of emulsions have often been employed in conjunction with other separation methods to establish hybrid systems to improve the destabilization of emulsions up to satisfactory levels (Zhang *et al.,* 2012). The biological treatment involves the use of bio-demulsifier as a form of biosurfactant with a characteristic feature to bio-remediate contaminated soils and destabilizes crude oil emulsion. Biodemulsifier have however been noted to be environmentally friendly, higher biodegradability and its usage does not result in secondary pollution (Makkar *et al.,* 2011). Therefore, this work will compare liquid extracted from orange peel and cassava peel with xylene as demulsifiers for emulsion treatment.

2. Material and methods

2.1. Materials

The materials and equipment used for this experiment are crude oil emulsion sample, distilled water, sodium phosphate, Xylene, diesel, camphor powder, paraffin wax, sodium hydroxide, sulphuric acid, sodium carbonate, orange peel liquid(extract), cassava peel liquid(extract), 100ml measuring cylinder, micro-pipette, stop watch, speed mixer, thermometer, weighting balance, syringe, graduated bottles, 250 ml beakers.

2.2. Methods

- **Formulation of Demulsifiers**: 30grams of camphor powder was mixed with 50ml of cassava peel liquid and orange peel liquid at ambient temperature and heated at 40^{o}C for complete dissolution. 20 kg of paraffin wax with 20kg of cassava starch was mixed and stirred. The mixture of 30grams of camphor powder with 100ml of extract (orange peel liquid, cassava peel liquid) and mixture of 20kg of paraffin wax with 20kg of cassava starch were blended into 20grams of liquid soap solution at 40^{o}C.
- **Demulsification of Crude oil emulsion**: 90ml of crude oil emulsion sample was poured into a test tube and 10ml of demulsifiers (xylene, orange peel extract, cassava peel extract) were added for separate formulation and mixed with a speed mixer with emulsifier added at room temperature and separation of water from crude oil measured at time intervals of 20mns, and up to 140mins. Similarly, 80ml of crude oil emulsion sample was poured into a test tube and 20 ml of demulsifiers (xylene, orange peel extract, cassava peel extract) were added for separate formulation and mixed with a speed mixer with emulsifier added at room temperature and separation of water from crude oil measured at time intervals of 20mns, and up to 140mins. The same procedure was carried out for a decrease in the crude oil emulsion by 10ml and an increase in the demulsifiers

added by 10ml and stop at crude oil emulsion volume of 60ml with 40ml volume of the demulsifiers at room temperature condition. The sample volume design and identification is presented in Table 1.

Table 1 Sample design and composition

Sample No.	Sample Content	Ratio
1a	Emulsion: Xylene	90:10
1b	Emulsion: Orange peel liquid extract	90:10
1c	Emulsion: Cassava peel liquid extract	90:10
2a	Emulsion: Xylene	80:20
2b	Emulsion: Orange peel liquid extract	80:20
2c	Emulsion: Cassava peel liquid extract	80:20
3a	Emulsion: Xylene	70:30
3b	Emulsion: Orange peel liquid extract	70:30
3c	Emulsion: Cassava peel liquid extract	70:30
4a	Emulsion: Xylene	60:40
4b	Emulsion: Orange peel liquid extract	60:40
4c	Emulsion: Cassava peel liquid extract	60:40

3. Results

3.1. Volume of Water Separated for Emulsion (90ml): Demulsifier(10 ml)

The separation of water from water in-oil emulsions as a function of time for sample design of 90ml emulsion and 10ml of demulsifiers is presented in figure 1.

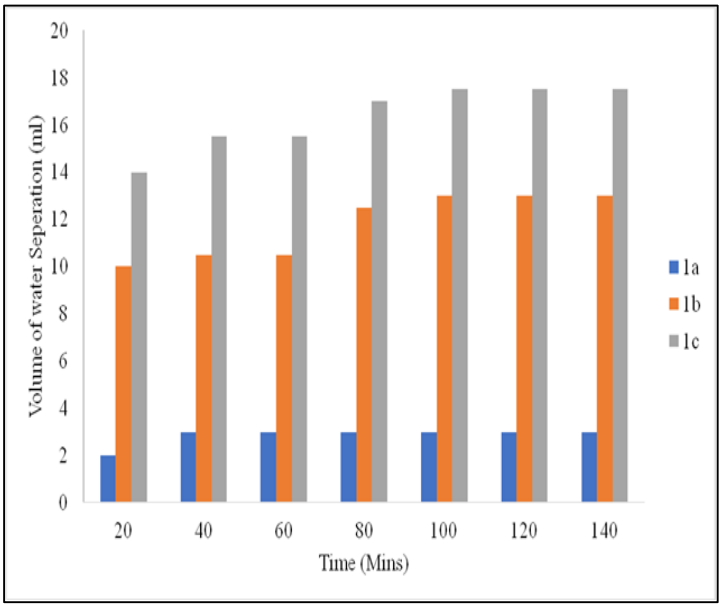

Figure 1 Volume of water separation for Emulsion (90ml):Demulsifier (10ml)

Result shows that xylene demulsifier has the least level of water separation, followed by the orange peel extract demulsifier and cassava liquid extract demulsifier with highest level of water separation. The level of water separation for the xylene demulsifier was not as high as that of the orange peel extract and cassava peel extract demulsifiers.

Increase in the allowed time for separation increases the level of water separation for all the demulsifiers up to 100minutes. The optimum time of separation was 100 minutes after which there was no separation for all the demulsifiers with the cassava peel liquid extract demulsifier having the highest water separation from the emulsion.

3.2. Volume of Water Separated for Emulsion (80 ml): Demulsifier (20 ml)

Figure 2 shows the separation of water from water in-oil emulsions as a function of time for sample design of 80ml emulsion and 20ml of demulsifiers. The xylene demulsifier only shows an increase in the level of water separation after 20minutes to 40 minutes of allowed time and further separation occurred after 40 minutes. Water separation from the emulsion started at 60minutes for the orange peel liquid extract demulsifier and increased uniformly to 120 minutes and remained the same at 140minutes allowed time. There was a continuous increase in the level of water separation with increased allowed time for the cassava peel liquid extract demulsifier. The optimum separation time for the xylene demulsifier, orange peel liquid extract demulsifier and cassava peel extract demulsifier was 40 minutes, 120 minutes and 140minutes respectively. The cassava peel liquid extract gave the highest water separation for 20ml demulsifier and 80 ml emulsion ratio.

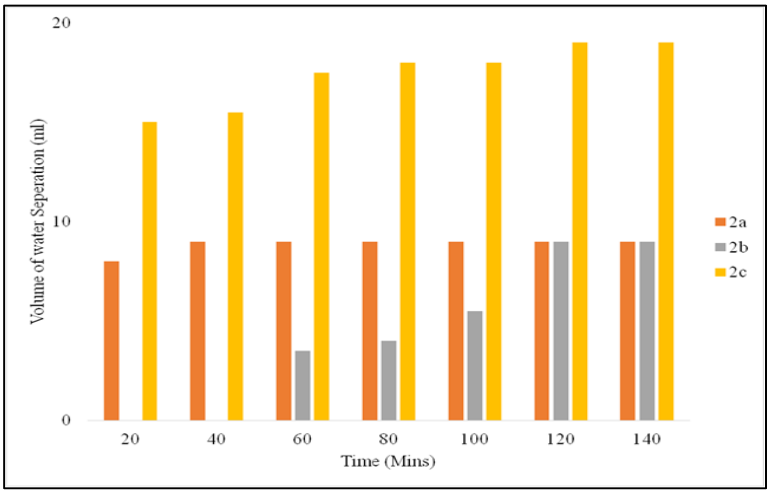

Figure 2 Volume of water separation for Emulsion (80 ml): Demulsifier (20 ml)

3.3. Volume of Water Separated for Emulsion (70ml): Demulsifier(30ml)

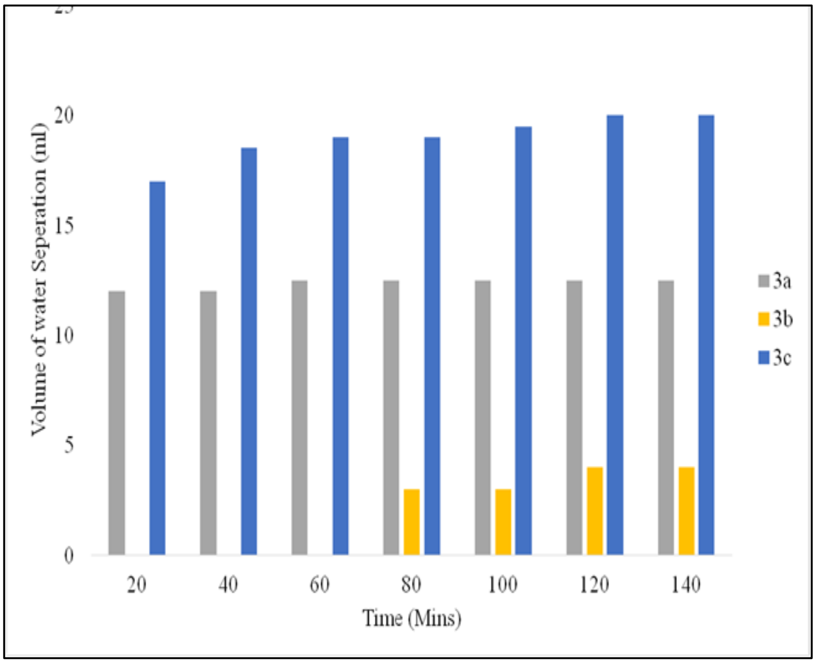

Figure 3 Volume of water separation for Emulsion (70 ml): Demulsifier (30 ml)

The separation of water from water in-oil emulsions as a function of time for sample design of 70ml emulsion and 30ml of demulsifiers is presented in figure 3. The water separation for the xylene demulsifier increased gradually with the allowed time up to 80minutes(optimum) after which there was no further separation. Water separation started after 80minutes and increased up to 120 minutes (optimum) for the orange peel liquid extract demulsifier. The cassava peel liquid extract demulsifier started water separation from 20minutes and increased gradually up to 120 minutes (optimum). Cassava peel liquid extract had the highest water separation for the duration of separation considered.

3.4. Volume of Water Separated for Emulsion (60 ml): Demulsifier (40 ml)

Figure 4 shows the separation of water from water in-oil emulsions as a function of time for sample design of 60ml emulsion and 40ml of demulsifiers. The xylene demulsifier started water separation from 20minutes to 80 minutes (optimum time) of the allowed time after which there was no further separation. The orange peel liquid extract demulsifier did not separate water from the emulsion up to 60minutes of the allowed time after which there was a gradual increase in level of separation till 120 minutes (optimum time) and no further separation. The cassava peel liquid extract demulsifier had the highest water separation and was increasing in separation with the allowed time. 120 minutes was the optimum separation time for both the orange peel liquid extract and cassava peel liquid extract demulsifiers.

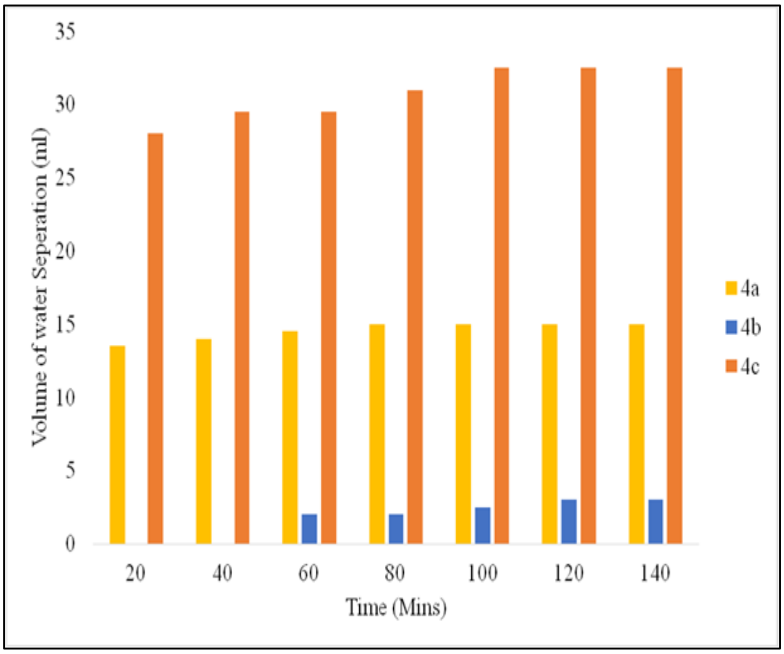

Figure 4 Volume of water separation for Emulsion(60 ml):Demulsifier (40 ml)

3.5. Volume of Water Separated by Xylene Demulsifier at different dosage

The volume of water separated by xylene demulsifier at different dosages is presented in figure 5. Increase in the volume of the xylene demulsifier increases the water separation. 10ml of the xylene demulsifier gave the least water separation while 40ml xylene demulsifier gave the highest water separation.10 ml has its optimum separation at 40minutes, 20 ml has its optimum at 40minutes, 30ml has its optimum separation at 60 minutes and 40ml gave the highest water separation with its optimum separation at 80minutes for the xylene demulsifier.

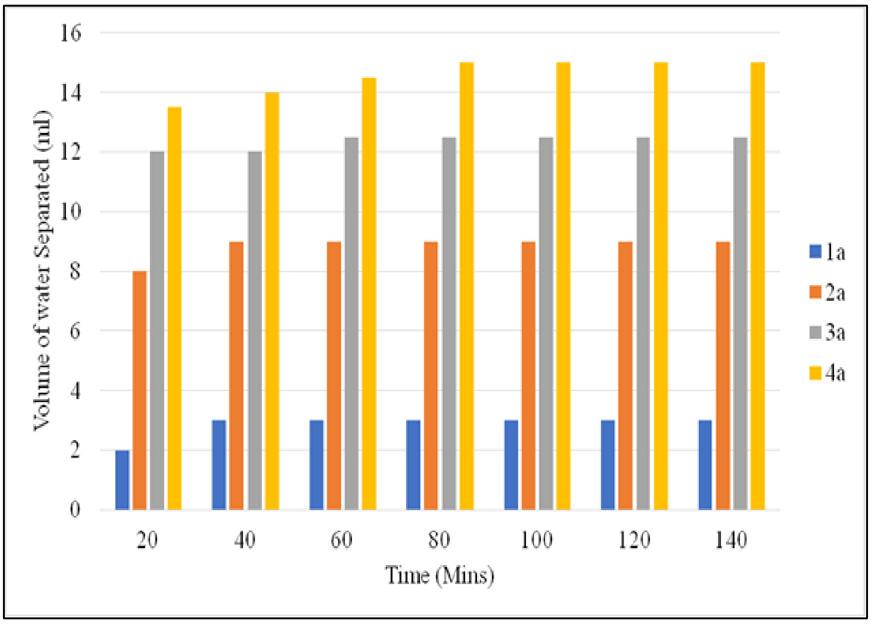

Figure 5 Volume of water separated at different dosage of xylene demulsifier

3.6. Volume of Water Separated by Orange peel liquid extract demulsifier at different dosages

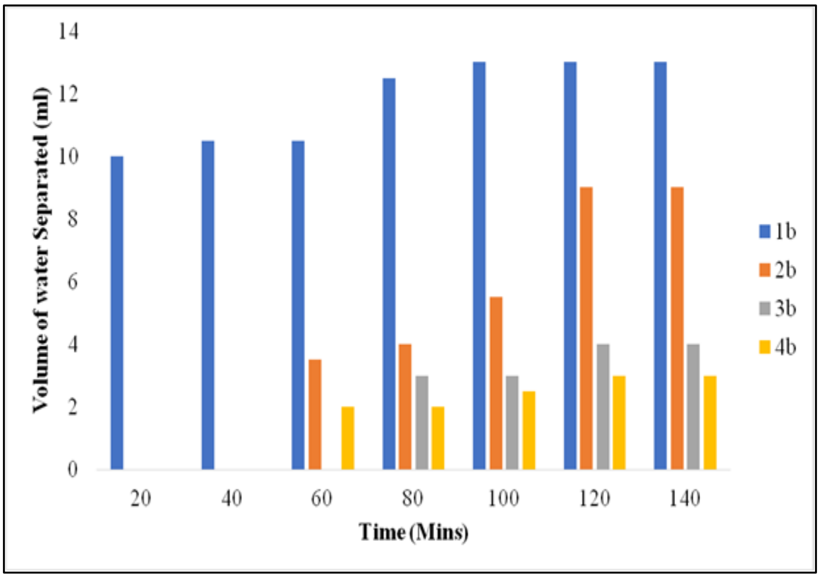

Figure 6 Volume of water separated at different dosage of orange peel liquid extract demulsifier

Figure 6 shows the volume of water separated for orange peel liquid extract demulsifier at different dosages. Result reveals that 10ml orange peel liquid extract demulsifier had water separation at 20minutes allowed time and was increasing gradually till optimum separation at 100 minutes. 20ml of the extract demulsifier started separation at 60minutes and optimum separation at 120minutes. Water separation started at 80minutes allowed time for the 30ml orange peel liquid extract demulsifier and optimum water separation at 120 minutes. 40 ml of the orange peel liquid extract started water separation at 60mls and was optimum at 120minutes. 10 ml of the orange peel liquid extract demulsifier gave the highest water separation and optimum at 100minutes.

3.7. Volume of Water Separated by Cassava peel liquid demulsifier at different dosage

The volume of water separated at different allowed time for different dosage of the cassava peel liquid extract demulsifier is presented in figure 7. 30 ml of the cassava peel liquid extract demulsifier gave the least water separation with optimum separation at 80 minutes while 40 ml of the cassava peel liquid extract demulsifier gave the highest water separation with optimum separation at 100minutes of the allowed time. Increase in the volume of the demulsifier increases the water separation up to optimum separation for the cassava peel liquid extract demulsifier.

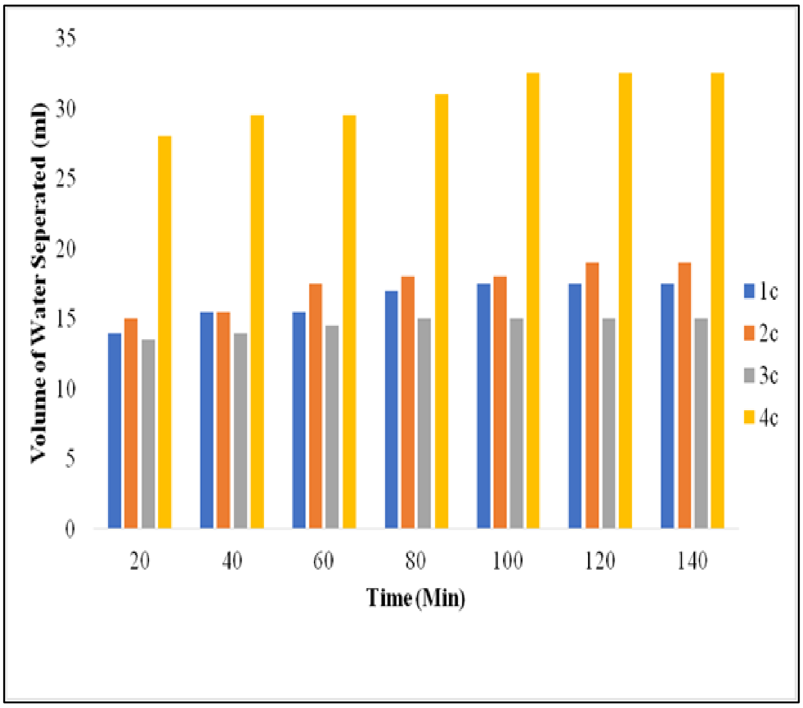

Figure 7 Volume of water separated at different dosage of cassava peel liquid extract demulsifier

3.8. Demulsifiers performance for volume of water separated

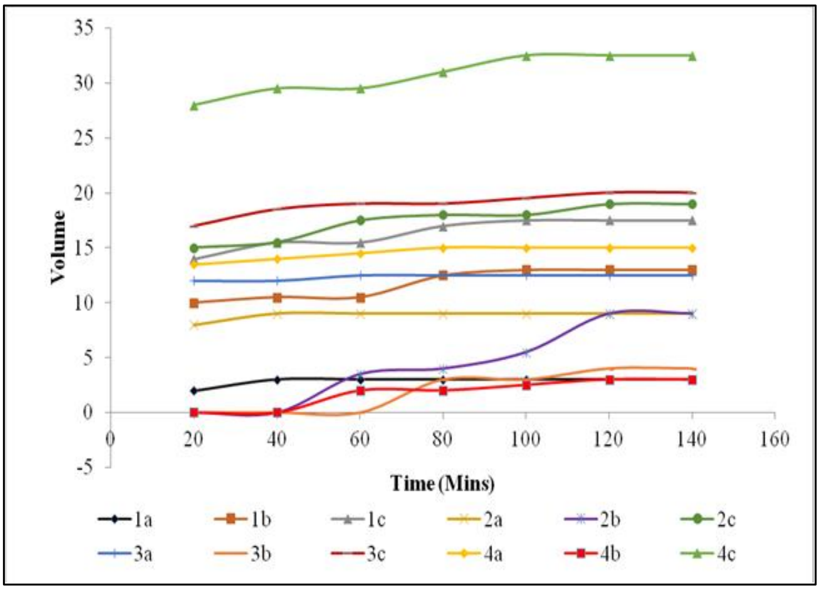

Figure 8 Demulsifiers performance

The performance of the three demulsifier at different dosage is presented in figure 8. The cassava peel liquid extract demulsifier has the highest water separation for 40ml and has its optimum separation at 100mimutes while the orange peel extract demulsifier has the least water separation with its optimum separation for 10ml at 100minutes.

4. Conclusion

This study evaluated the performance of three formulated demulsifier (xylene base, orange peel liquid extract base, and cassava peel liquid extract base). The demulsifiers were formulated and tested for emulsion treatment at varying ratio and different dosage at room temperature condition. The analysis results to the following conclusions;

- Increase in the volume of demulsifiers increases the water separation with the allowable time but some were uniform than others.
- Orange peel liquid extract demulsifier has the least water separation with respect to the dosage and time.
- Cassava peel liquid extract demulsifier have the highest water separation with dosage and the allowable time.
- Cassava peel liquid extract demulsifier have the best optimum separation time with respect to the volume of water separated.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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