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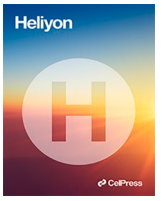

Research article

The use of biological catalyst (enzyme) for enhanced oil recovery in Niger Delta

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ABSTRACT

This study is aimed at using bio-catalyst (enzymes) for enhanced oil recovery in Niger Delta. Three different enzymes produced from microbial isolates with code ID; LPE1, LPE2 and AME were use in analyzing enzymes effect on the rock-fluid and fluid-fluid interaction test to simulate the conditions in the reservoir. The tests carried out include; wettability, interfacial tension (IFT) and adhesion test. The results from these tests show that addition of enzymes to rock-fluid interface has the potential of enhancing recovery of crude oil. From the result, the use of enzyme caused an alteration in the wettability of the rock from oil-wet to water-wet with a 33° difference. The selected enzyme LPE1 showed a significant difference in reduction of interfacial tension by a factor of 4, while LPE2 and AME did not show any significant difference. In conclusion, the wettability and IFT tests results were the basis for choosing LPE1 for core flooding process. Enzyme (LPE1) flooding after waterflood was able to give an additional 11.5 % oil recovery. From the results, the percentage recovery is a pointer to the fact that when the primary and secondary oil recovery methods are no longer viable in terms of economics, the Enyme enhanced oil recovery is the best method of mobilizing trapped crude oil in the Secondly, there is no negative effect on the crude oil quality using the enzyme-EOR because the enzymes only increase the rate of the chemical reaction on the rock media without undergoing any permanent chemical change.

1. Introduction

Research has it that modern society is dependent on hydrocarbon as well as its derivative but the effectiveness/efficacy of extraction has not been maximized optimally and this has resulted in search for new techniques for improving the efficiency of hydrocarbon extraction. About one-third of the existing oil reserves' recovery has been mainly through application of primary and secondary oil recovery techniques [1].

There are factors that drive crude to the surface during primary mechanism. The factors are gas expansion, water encroachment, gravity force, rock expansion, connate water reduction, and oil/dissolved gas expansion. When the primary mechanism reaches a limit, where reservoir pressure is low and cannot push or drive oil to surface again, secondary mechanism is deploy to get more recovery from the remaining potential in reservoir at economic value [2].

The secondary recovery techniques involve gas/water flooding to improve reservoir pressure in order to mobilize the remaining oil.

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Two methods of secondary recovery exist; waterflooding and gasflooding. Waterflooding method of oil recovery has to do with injecting water through an injection well to the aquifer of the reservoir, to sustain reservoir energy and displace oil to production wells. The water flooding technique used depends on the injection design based on relative penetrability records in both directions, informed by better geometry and the reservoir crustal stress direction. The gas flooding has similar ideology as water flooding technique of secondary recovery process. Unlike water flooding, gas is injected into the reservoir to boost gas-cap pressure and pushes oil towards the production well [2].

During secondary recovery process, as the injected fluid (water or gas) begins to get produced at the production well, it is usually a clear indication or feedback signal that the (water or gas injection) cannot sustain oil production and has lost its economic viability. At this point, tertiary (Enhanced) oil recovery method is employed [3]. The unrecovered portion of the reserves maybe recovered through the technique called enhanced oil recovery (EOR) method. An oil-recovery method that has to do with injection of energy or foreign fluid in the reservoir to mobilize or cause the flow of the remaining oil is termed Enhanced Oil Recovery (EOR) [4]. EOR process affects properties of reservoir such as; interfacial tension, viscosity, wettability, density and miscibility [4]. The injection fluid for EOR must accomplish the following objectives; it must enhance reservoir energy and interrelate with oil/rock reservoir system in order to reduce residual oil saturation. These objectives are been achieved through several tactics like viscosity reduction, mobility control and variation of the innate reservoir rock wettability [5]. This method of oil recovery is further classified as; thermal flooding, chemical flooding, miscible gas flooding, microbial flooding and enzyme flooding [2].

Recently, several authors have suggested the use of enzymes for enhanced oil ([2,12–14]). Experiments on enzyme-EOR were performed by Khusainova et al and Elemuo et al [7,10] to study the compatibility of enzymes based on variations on temperature, salinity, and oil type. After that, a laboratory procedure was design for core flooding experiment. From the study, they established that at optimum conditions, a significant boost in average recovery was achieved. An increase in oil production and a decrease in produced water were the findings from this study [6]. Several enzymes have been screened by modern biotechnology industry and found to be able to withstand reservoir conditions. Some reports on Oil and Gas Industry application of enzymes for enhanced oil recovery has also been studied [7]. Some of their applications include, permeability modification, formation damage removal, pre-treatment of bio-polymers, breaker, and improved oil recovery.

After employing primary and secondary oil recovery methods, EOR via the use of Enzymes at the target payzone is employed, that is Enzymes Enhanced Oil Recovery (EEOR) [8].

Enzymes help to accelerate discharge of oil from grain areas of the reactions per second in the reservoir [6]. Interfacial tension can be reduced by the interaction of enzyme solution with the reservoir rock/fluid interface. It can also help in breaking down oil globules as well as oil-wet to water-wet rock wettability variation [10].

The mechanisms behind the success of enzyme EOR has been reported by numerous authors ([2,9,12]), which is based on laboratory experiment to elucidate the influence of enzymes on the recovery of oil from the reservoir. These mechanisms have to do with improving the rock surface wettability, reducing interfacial tension, crude oil viscosity reduction and breaking down oil globules into smaller oil droplets [11]. The mechanism which is primarily responsible for EEOR success is alleged to be through catalytic breaking of the bond between oil and rock [12]. The IFT between brine/oil/enzyme solutions is highly reduced by the presence of a stabilizer in the enzyme solution, which is based on the optimum salinity and solubility content in the enzyme solution [12]. A change in the properties of crude oil after applying enzymes as EOR process has been reported by some researchers [11]. Example of this change is the breakdown of carbon bonds and reduction of wax content which invariably reduces the viscosity of oil [13].

In the study by Nasiri [12], the influence of the selected enzymes on wettability and capillary forces was shown, but he was not able to explain how enzymes contribute to increase oil recovery.

The study on the use of enzymes for water flood improvement was done by Nasiri et al., [14]. From the study, it was shown that additional oil recovered was 11.0 % of the original oil in place after flooding the with enzymes solution. Base on the additional oil recovered by enzyme flooding, the concentration of enzymes injected for EOR practice was not defined.

The use of oil-brine-enzyme systems on calcite surfaces wettability for EOR application was carried out by Ref. [7]. In the study, the enzymes capable for enhancing oil recovery was identified, but the method for screening these selected enzymes are not defined.

Recent research have proven the effectiveness of enzymes as agent for enhanced oil recovery (EOR) in comparison with other methods of EOR. The recovery of crude oil using enzyme EOR is achieved by two (2) main mechanism; solid-fluid interaction via alteration of rock wettability from oil-wet to water-wet and fluid-fluid interaction via interfacial tension reduction between oil and brine. These mechanisms combine together to promote mobilization of capillary trapped oil. Enzyme EOR was evaluated firstly on the basis of its interfacial tension reduction abilities and also, evaluating oil recovery using micro-scale experimental approach [16].

The aim of this study is to demonstrate how biocatalyst activities will aid mobilization of additional crude oil by reducing the residual oil saturation of the reservoir rock. The study will also demonstrate the method for screening enzymes for the purpose of EOR activities. Finally, it will demonstrate how concentration of injected enzymes will affect the recovery of additional crude oil.

The objectives of this study are to; characterize the selected enzymes strain obtained from enzyme assay analysis; select enzyme-EOR agents based on the interaction of oil/water/rock; and determine the efficiency of the enzymes through flooding as well as establish a concentration for enzyme-EOR application.

2. Materials and methods

2.1. Materials

2.1.1. Fluids

All flooding were carried out by using light and heavy stock tank oil (X1 and X2) from two different fields in Niger Delta (Table 1).

The brine used for all flooding experiment was synthetic sea water. The chemical for the brine preparation was purchased from Fluka with a purification above 99.4 %.

2.1.2. Core samples

When carrying out laboratory experiments for enhanced oil recovery, it is a regular practice that a simulated rock media (a prepared core sample) is deployed to mimic the reservoir rock. In this study, a sandstone core plug was used (Table 2).

2.1.3. Enzyme solution

The microbiology phase comprises culturing the crude oil contaminated soil, counting of microbial cells in the sample, isolation of the microorganisms, identifying the isolates, screening the microbial isolates and broth production of the enzymes. The identification processes were based on several procedure, bacteria isolate were identify through Gram staining and biochemical test and the fungal isolates were identify by the use of microbiology fungal ATLAS. The screening of the microbial isolates were based on the type of substrates used for possible producers of the enzymes. For lipase microbial isolates, olive oil were used as the substrates both for bacteria and fungi, while for amylase starch was used for the enzyme screening.

The biochemistry phase of this study is the enzyme assaying process. It comprises of firstly, harvesting day of the broth enzymes at which the optimum activities is reach. Secondly, the optimum pH of the various microbial isolates. Thirdly, the optimum temperature before denaturing of the enzymes; the effect of substrate concentration on the enzymes produced and finally, the thermo-stability effect of the enzymes to know how much the enzymes can react to lower the activation energy for a reaction to start. See Refs. [2,15] for more details.

The enzyme solution was prepared under a clean and calm condition of ambient temperature of 25–27 °C. 10 ml of the broth media for enzymes production was collected at different time interval of 24hrs with a syringe. The collected samples were then used in measuring lipase and amylase activities on the isolated microbial strains (isolated fungal). The samples collected were centrifuged at 3000 rpm for 10min before using it for enzyme assay analysis [2,15]. Three enzyme solutions belonging to the classes of lipases and amylase investigated in this study are both isolates of fungi [15], and it is been presented in Table 3.

3. Method

This study was carried out in different phases. The first phase of this study was the selection of the enzyme strains that might have the potential of EOR application. Tests such as wettability for measuring the contact angle, adhesion for determination of the adhesion behaviour, and interfacial tension test (IFT) which determines the rate of reduction or increase in IFT between brine/crude interface were carried out using the enzymes. For the microbiology phase, the hydrocarbon contaminated soil was cultured, then the sample microbial cells counting, micro-organism isolation, isolates identification, isolates screening and formulation of broth for enzymes production (enzymes assay). The process of identifying the organisms involved several procedures like Gram staining and biochemical test which was used in identifying the bacteria isolate, while microbiology fungal ATLAS was used for the identification of fungal isolates. The Screening of microbial isolates was dependent on the type of substrates used as possible enzyme producers. The substrate for bacteria and fungal lipase enzyme isolates was olive oil while starch was the substrate for amylase enzyme.

Biochemistry part of this study is the process of enzyme assay. The steps are as follows.

(1) harvesting day of cultured broth solution which is the day when the optimal activities is achieved
(2) Determination of optimum pH and temperature of the enzyme solution before denaturing sets in.
(3) Determination of the effect of substrate concentration and thermo stability of the enzymes solution to know when low activation energy can be reached in order for the reaction of the enzymes to start. (See [10; 15] for more details).

3.1. Wettability test

Wettability measurements in this study was done using KSV-camera 200. The equipment measures the water-oil-enzyme angle of contact on slide (solid) surface that uses the principle of sessile drop. Droplets of the liquid solutions were deposited via Hamilton

Table 1
Characteristics of the study's crude oil samples.

Crude ID	Field	Description	API gravity	Viscosity, cSt	Density, g/cm3
X1	Agbami	Light, low sulphur crude oil	47.9°	5.3	0.8673
X2	Ogini	Relatively heavy	19°	25.5	0.9440

Table 2
Physical properties of sandstone core samples used in this study.

Core ID	Length, cm	Diameter, cm	PV, ml	Porosity,%	S_{wi}	S_{oi}	K_w	$K_o@S_{wi}$
B1	5.8	3.73	14.13	22.3	0.18	0.82	913	946
B2	5.9	3.73	12.5	20.0	0.13	0.87	898	921

Table 3
Enzyme solution samples used.

Sample	Enzyme Type	Enzymatic action
LPE1	Lipase EC3.1.1.3	Hydrolysis of ester bonds in a lipid (activity: 100 klu/g)
LPE2	Lipase EC3.1.1.3	Hydrolysis of ester bonds in a lipid (activity: 50 klu/g)
AME	Amylase EC3.2.1.1	Hydrolysis of starch (activity: 120 klu/g)

syringe which was used to add droplets of enzyme-water-oil solution on solid media (glass slide). The experiments were all carried out under ambient condition. The enzyme solutions were measured as aqueous/heavier phase while the crude oil was taken as the oleic/lighter phase (crude X1 and X2). They were measured in concentrations ranging from 0.0 to 2.0 wt percentage. Droplets of crude oil were dropped on the slide using a micro-syringe and then the enzymes solutions surrounded the oil droplets. The enzymes on the slide surface were displaced by the oil droplets, giving rise to a condition called dynamic water receding.

For the second phase of the wettability test experiment, a soaked or aged slide surface was used. The slides were soaked in crude X1 and X2 for an interval of 15 days with a temperature value of 80 °C. After the day 15 of soaking; the slides were then removed from the oil samples and toluene was used to rinse off the crude oil stains. Again the slides were soaked in the decant for 2 minutes and then rinsed off with distilled water. It is worthy to note that for the purposes of this study, the soaked and unsoaked slides were used to represent solid surfaces. In wettability calculation, a dimensionless term ($\Delta\theta/\theta Ref$) was defined; θRef being the contact angle values that are measured at reference point where enzymes are kept separate from the brine solution while $\Delta\theta$ represents the contact angle difference measured at reference point and point where enzymes was added to solution of brine ($\theta Ref - \theta Enzyme$). See Ref. [10] for more details.

3.2. Adhesion test

A volumes of Crude X1 and X2 were collected using a micro syringe with inverted needle and dispersed to form oil droplets in the enzyme-brine solution on a solid surface (slide). The oil droplets were submerged in the brine solution (with the selected enzyme) and then allowed to come in contact a smooth solid surface. Two minutes after droplets contacted the solid surface, the oil droplet was withdrawn into the inverted needles (when oil droplets start to move towards non-adhesion or destabilize). There were three (3) different observed behaviour during the experiment, which are; non-adhesion, adhesion and temporary adhesion behaviors respectively. For more details, see Ref. [10].

The study was conducted on both clean and aged solid surface. The aged slide was soaked for 120 h at a temperature of 80 °C. The KSV-Camera 200 was used for this study to enhance/simplify the observation of oil-water droplet on the slide/solid surface contacts. HCl (NaCl or common salt) and NaOH were the salts used in the adjustment of the P^H of the aqueous solution.

The reproducibility/repeatability and intermediate precision studies are yardsticks used to determine the precision of this method. For detailed explanations, see Ref. [10].

3.3. Interfacial tension (IFT) test

The effect of three (3) enzymes AME, LPE1 and LPE2) on interfacial activity between the enzyme-brine solution (heavy/aqueous) and crude X1 (light/oleic) was observed. The enzymes were mixed into brine (aqueous) phase at different concentrations and then allowed to contact crude X1. The oleic and aqueous phase were equilibrated at a ratio of 1:1 vol and allowed to stand for 3 days after centrifuging for stability. KSV-camera 200 pendant-drop instrument was used for the measurement of IFT between aqueous and oleic interface. The shape of the oil drop that hung from the needle tip was used to analyse or measure the IFT. The Young-Laplace Equation was used to fit the drop image and then Hansen and Rodsrud 1991 equation (see Eqn (1)) was applied for the measurement of the IFT

$$IFT = \frac{\Delta\rho^* g^* R_o^2}{\beta} \quad \text{(Eq.1)}$$

Where; $\Delta\rho$ is the difference in density between fluids (oleic-aqueous phase) at interface; g is gravitational constant; R_o is radius of drop curvature at apex and β is shape factor which defined through the Young-Laplace Equation. See Ref. [10] for more details.

Another aspect of this study is the actual core flood experiments or processes. Two core samples label B1 and B2 were washed to remove formation water and residual hydrocarbon using Toluene and Methanol before using for the experiment. Properties of the core samples were determined when the core samples were dried and saturated with brine (NaCl) and stock tank oil.

Porosity (Ø) of the core plugs (core samples) were measured using porosi-meter and calculated using Equation (2). The method

involved extracting air from the core plugs using a vacuum, after which the bulk volume of the core plug was measured. The expression used to calculate the porosity value is:

$$\% \, \emptyset = \frac{pore\ volume}{bulk\ volume} \times 100 \quad \text{(Eq.2)}$$

A **permeameter** was used to determine the permeability of the core samples**.** The permeameter determines the difference pressure drop ($p_1 - p_2$) from a known fluid viscosity (μ) at a flow rate (Q) with a cross-sectional area (A) of length (L). Darcy's law (Equation (3)) gives the mathematical expression used for calculating permeability:

$$K(Darcy) = \frac{Q\mu L}{A(p_1 - p_2)} \quad \text{(Eq.3)}$$

Pore volume (PV) of the core samples was calculated using Equation (4), through the dissimilarity principle of weight. Saturated weight of core, (W_s) and dry weight of core, (W_d) divided by the density of brine, ρ_s. The mathematically expressed is;

$$PV = \frac{W_s - W_d}{\rho_s}(cc) \quad \text{(Eq.4)}$$

Initial water saturation (S_{wi}) of the saturated core plug (with water) is determined after desaturating the core with crude oil (XI) as the original oil in place (OOIP). Equation (5) was used in calculating initial water saturation mathematically:

$$\%, S_{wi} = \frac{PV - OOIP}{PV} * 100 \quad \text{(Eq.5)}$$

With the assumption that initial gas saturation is zero ($S_{gi} = 0$), initial oil saturation (S_{oi}) is thus calculated using Equation (6).

$$S_{oi} = 100 - S_{wi}(\%) \quad \text{(Eq.6)}$$

The flooding process was done in two phases. First phase involved flooding with brine (water flooding) after saturating the core samples with stock tank oil. The second phase is the process were enzymes solutions, were added to water (brine) and then injected into the cores to enhance the recovery by supporting the water flooding process.

3.4. Waterflooding

After saturating the core samples with crude oil, brines with salinity of 21,000 ppm was injected into core samples for the process of waterflooding the core samples. Waterflooding was performed for improve recovery by displacing the oil with brine until water cut was up to 90.5 %. The injection rate throughout the flooding was constant at 0.1 ml/min. The effluents from the core were collected in graduated test tubes and their volumes recorded. The injection rate was then varied from 0.1 ml/min to 1.0 ml/min to determine the influence of injection rate on recovery. The volumes of oil and water produced during the flooding process were measured and recorded. The effective permeabilities to water were also calculated with respect to residual oil saturation.

3.5. Enzymes-brine flooding

After flooding the cores with brine solution, different concentrations of enzyme-brine solution was injected into the core samples at different injection rates in order to recover more oil. The additional oil recovered by the enzyme flooding was collected and recorded. The injection of the enzyme solution continued until a water-cut of 90.5 % was reached.

4. Results and discussion

Figs. 1 and 2 are plots of $\Delta\theta/\theta_{Ref}$ versus concentration of enzymes. It shows the effect of liquid contact angle measurement from solid surface when enzymes are introduced in brine solution for non-aging and aging slide at 80 °C slide.

From the experimental results, contact angle measurement shows a favourable wettability on the solid surface when an enzyme solution is injected. This is one of the main mechanism that demonstrates the effect of enzymes in EOR. The change in wetting phase is caused by the molecules of the enzymes that convert the oil-wet media to water-wet. From the result, the contact angle change ($\Delta\theta$) was visibly noticed to be in the range 14° to 33° as a result of enzyme concentration increase and the fraction $\Delta\theta/\theta$Ref increases from 0.14 until a plateau of 0.46 is reached (for the case of glass slide without aging as shown in Figs. 1 and 2).

The effect of enzymes on core plug wettability is shown in Fig. 3. (Plot of Contact angle, θ versus Time, t). Fig. 3 shows the effect of exposure time of enzyme on contact angle measurement. The contact angle values decreased from 49° at a time zero (0) time to 34° after 8 min.

Fig. 4 is the plot of IFT versus Aqueous solution. It shows the effect of different aqueous solution on interfacial tension at different concentration after 2–4 weeks equilibration.

Selected enzymes LPE1, LPE2 and AME that have been proven to have active interfacial tension were used to see their effect on the interfacial tension between brine and crude oil. From the result (Fig. 4), it was observed that LPE2 and AME did not show any significant difference in the interfacial tension of crude oil/brine solution and that of crude oil/enzyme-brine solution while LPE1 showed

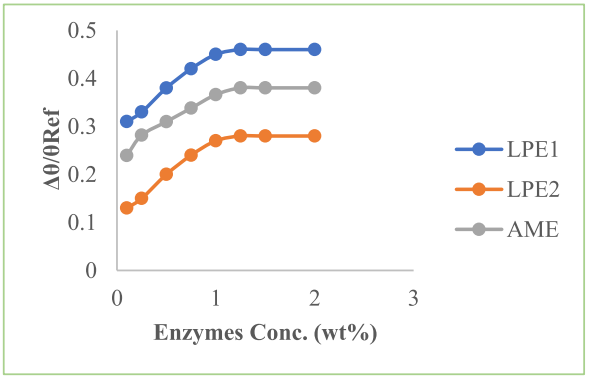

Fig. 1. Plot of $\Delta\theta/\theta_{Ref}$ versus enzyme concentrations without aging.

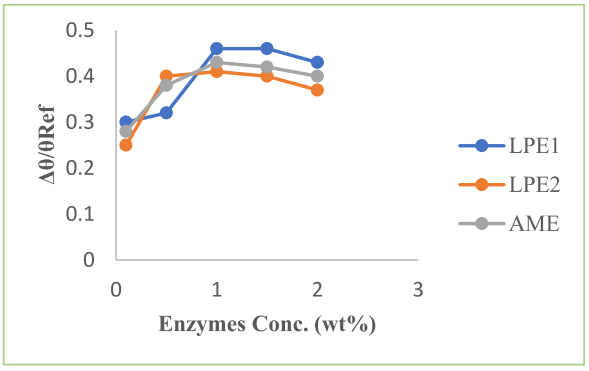

Fig. 2. Plot of $\Delta\theta/\theta_{Ref}$ versus enzyme concentrations with aging at 80 °C.

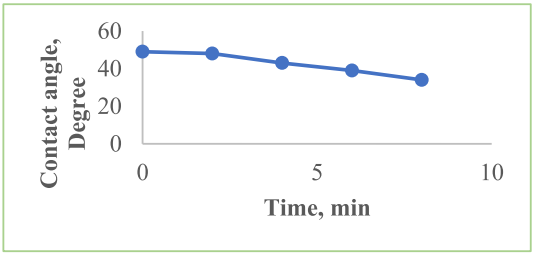

Fig. 3. Plot of contact angle θ versus time.

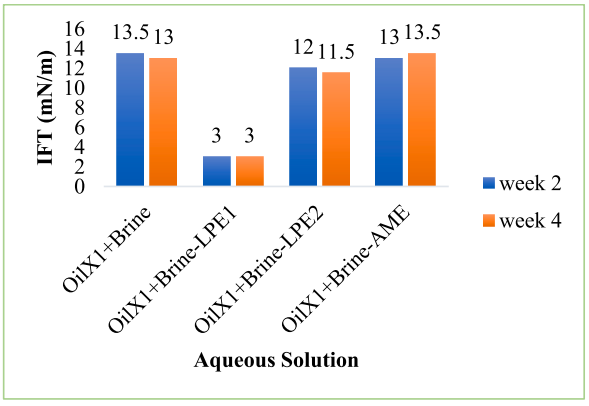

Fig. 4. Plot of IFT versus aqueous solution.

a significant difference, which decreases from 13.5 mN/m to 3.0 mN/m. The decrease in IFT by LPE1 enzyme tells that LPE1 contains both enzymes and stabilizer (surfactant). The presence of this stabilizer makes the enzyme more stable and active (Nasiri, 2011). With decrease in IFT, LPE1 enzyme was then selected as potential EEOR agent for core flooding experiment.

Figs. 5 and 6 are plots of oil production versus injection rates after core B1 and B2. It tells the effect of enzymes on oil recovery during EEOR flooding process at different injection rates for cores B1 and B2 for LPE1 enzymes.

Two core samples (B1 and B2) were used to assess the effect of the selected enzyme strain on the recovery of oil in sandstone simulated reservoir. After waterflooding the cores (B1 and B2) to produce oil, it was then flooded with brine-enzyme solution (LPE1). Oil recovery by enzyme flooding shows an increasing trend on oil production which is (Figs. 5 and 6).

Fig. 7 is the plot of total oil recovery versus core B1 and B2. It highlights the effect of waterflooding and enzyme-brine flooding for both cores on total oil recovery.

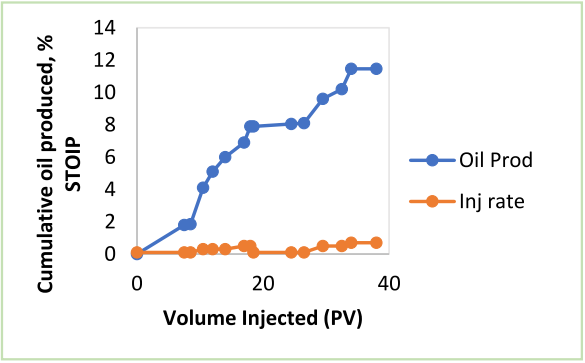

Fig. 5. Plot of cumulative oil production and injection rates (PV) for 1wt% LPE 1 for core B1.

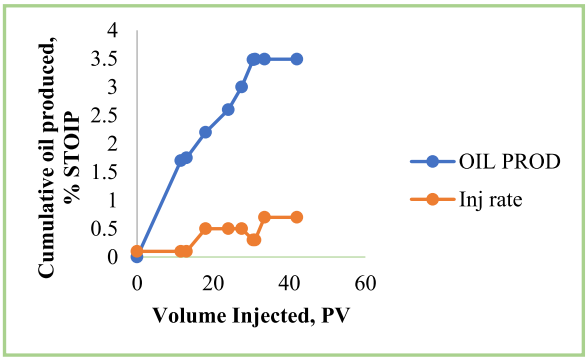

Fig. 6. Plot of cumulative oil production and injection rates (PV) for 1 wt% LPE1 for core B2.

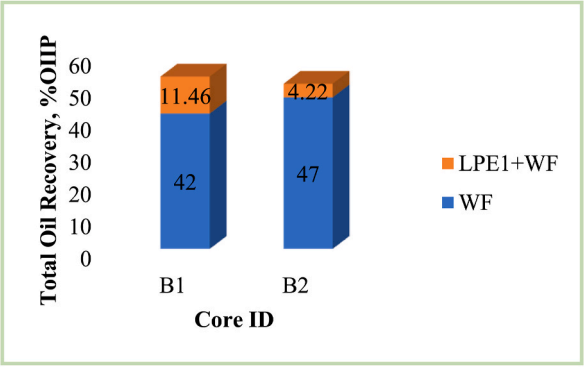

Fig. 7. Plot of total oil recovery versus core B1 and B2.

The potential of enzymes in improving oil recovery were also examined through core flooding using sandstone core model. As presented in Fig. 7, LPE1-brine flooding was successful because it was able to recover some remaining oil in the porous media after waterflooding took place. The additional oil recovered during the period of LPE1-brine flooding is 11.46 % for core B1 and 4.22 % for core B2.

5. Conclusions

The highlight of this study is the fact that injection of enzymes in water (brine) flooding gives an increase in recovery of oil from sandstone core plugs. Enzymes are known to have the ability to change the wettability of glass slide from oil-wet to a strong water-wet condition.

contact angle change is much higher in LPE1 than in LPE2 and AME as shown from the study.

The study has shown that the effect of enzyme solution on petroleum rock is a function of time, that is, as time increases, enzymes effect on wettability gets weaker.

It was observed that only LPE1 had a significant difference on IFT reduction because it contained both enzyme and stabilizer (surfactant), while LPE2 and AME have no significant difference in IFT reduction.

Additional oil recovery from enzyme-brine flooding is a function of the core plug (porous media) properties based on the result from cores B1 and B2.

This study showed that addition of enzymes to brine changes the wettability of a porous media from oil-wet to water-wet state and when used for enhanced oil recovery, it mobilizes the remaining oil that was bypassed during waterflooding. It also showed how the selected enzymes influenced the wettability and interfacial tension of oil/brine/rock interaction and the possible contribution to enhanced oil recovery. This research also showed that, to induce mobilization of residual oil, the reduction in interfacial tension is not enough to create additional recovery.

Enzymes are affordable because they can be got from several sources. For the purpose of this study, the enzyme sources were contaminated hydrocarbon soil and crude oil sludge which were got at little or no cost. The storage of the collected samples and the production of the enzymes for the EOR process attracts less cost due to availability of equipment and materials for the production.

Enzymes EOR does not pose a threat to the environment or the reservoir itself. This is advantageous in the sense that reservoir treatment or environmental pollution costs are eliminated. Although, the economic analysis was not part of this study, the produced enzymes can be multipled by a factor of 100 and still be produced at same cost. The economic analysis will be considered for further study where it will be extensively discussed.

Further study should be carried out to know if it is the protein nature or enzyme nature that contributes to the alteration in wettability of the reservoir rock, and also check the economic viability of enzymes-EOR.

CRediT authorship contribution statement

Ndubuisi Gabriel Elemuo: Writing – original draft, Validation, Methodology, Investigation, Conceptualization. **Sunday Sunday Ikiensikimama:** Supervision. **Virtue Urunwo Wachikwu-Elechi:** Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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