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Performance of Pineapple Peel Waste as Surfactant Flooding in Enhanced Oil Recovery

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Abstract**—***Oil and natural gas are still the dominant energy sources in Indonesia's energy use, so many efforts have been made to increase their reserves. One effort is to increase oil recovery by Enhanced Oil Recovery method, especially chemical flooding using surfactants. One of the raw materials that can be synthesized into surfactants is pineapple peel. Pineapple peel is processed into eco enzyme and used as EOR injection fluid. This process simultaneously overcomes wasted fruit peel waste. The method used was laboratory research with salinity variables, 20,000 ppm and 40,000 ppm, at surfactant eco enzyme concentrations of 20%, 30% and 40%. Characteristics of pineapple peel eco enzyme can reduce the IFT from 12.71 dyne/cm to 6.52 dyne/cm at 40,000 ppm salinity solution. The best results are obtained by mixing pineapple peel eco-enzyme at a concentration of 30% with a salinity of 40,000 ppm which can increase the recovery factor by 57.2%. The increase in oil recovery only occurred slightly, from water flooding to surfactant flooding there was only an increase of 3%. From this condition it can be concluded that the use of pineapple peel eco enzyme requires a co-surfactant in order to increase oil recovery.*

Keywords**—** *Enhanced Oil Recovery, interfacial tension, pineapple peel, surfactant eco enzyme.*

I. INTRODUCTION

Oil and natural gas are still dominantly utilized as energy sources in Indonesia. This is why, there are numerous efforts implemented to improve their reserves. One method to improve oil reserves is by enhancing oil recovery efforts. There are a number of efforts that can be implemented, namely short, middle, and long-term efforts. The short-term effort can be implemented through work over and well services, middle-term efforts can be conducted by applying enhanced oil recovery (EOR), and long-term through exploration. EOR is a method to improve oil reserves by draining previously unobtainable oil volumes. The process is divided into three phases, namely primary, secondary, and tertiary phases. In this study, the tertiary phase known as enhanced oil recovery method is implemented [1].

Chemical injection is one of advanced oil extraction methods that is conducted by adding chemical compounds into injection water to improve oil recovery through sweeping performance enhancement and/or lowering oil residue saturation in the tank. There are two most common chemical injection methods namely surfactant and alkali injections [2]. Chemical injection is intended to lower interfacial tension between oil and rocks. By lowering the interfacial tension, oil can flow and recovery factor can be improved. Surfactant and polymer injections are implemented to improve oil recovery. The goal of surfactant injection is to improve displacement efficiency by lowering interfacial tension, meanwhile polymer utilization is intended to improve sweep efficiency by rectifying rock permeability and increase driving fluid's viscosity. The utilization of surfactant and polymer is aimed to lower interfacial tension (IFT), improving rock permeability and increase driving fluid's viscosity [3]. Eco-enzyme or garbage enzyme is a liquid produced from organic waste fermentation. There are a number of eco-enzyme function namely floor cleaner, vegetables and fruits sanitizer, bug repellent, and fertilizer. The utilization of eco-enzyme as disinfectant is available due to its alcohol and acetate acid contents. The fermentation process is enabled by the activities of enzymes produced by bacteria or fungi. The production of eco-enzyme can provide a vast impact on the environment and on economic perspectives. The benefit for the environment can be seen by the process, which at the first day will produce O_3 gas or known as the ozone. The ozone is extremely useful as lower stratosphere layer that decrease greenhouse gasses and heavy metal compounds trapped in the atmosphere. Besides that, the process will also produce NO_3 and CO_3 gasses required by soil as nutrition for plants. The objective of this study is to acknowledge the characteristics of eco-enzyme products that include aroma, color, and volume [4].

In this research, fruit skin wastes used to produce eco-enzyme is pineapple peel. Eco-enzyme made from pineapple peel contains multi-hydrolytic enzymes such as amylase, protease, and lipase with ability to degrade waste water. Extracellular hydrolytic enzymes are quite stable and utilizable at vast temperature range outside its protective cellular wall [5].

II. METHODS

Advanced oil recovery effort or known as enhanced oil recovery (EOR) is a process to produce oil through external energy utilization. EOR method is categorized into a number of types. This research utilizes chemical injection. Chemical injection is an effort by adding chemical compounds into injection water to improve oil recovery through sweeping efficiency enhancement and/or increasing saturation level of oil trapped in the reservoir. There are three commonly used chemical compounds in chemical injection, and in this study, the utilized compound is surfactant (surface active agents) [6]. Material to produce eco-enzyme in this research is mixture of

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pineapple peel, water, and brown sugar. The compound was applied on phase behavior test at Enhanced Oil Recovery Laboratory of Universitas Trisakti. The utilized NaCl in this study is the Oxoid LP0005 (Sodium Chloride Bacteriological Grade). The synthetic brine water in this research comes with salinity variations of 20,000 and 40,000 ppm. The pineapple peel eco-enzyme surfactant concentration levels tested in this study are 20%, 30%, and 40%. The type of oil utilized in this study is R- crude oil

The work procedure in this study was conducted by dividing eco-enzyme surfactant into a number of concentration levels; 20%, 30%, and 40%. To produce surfactant solution, salt water with different salinity levels were mixed with surfactant. Brine production is implemented by mixing eco-enzyme on a magnetic stirrer for 15 minutes. Phase behavior test was conducted to witness the type of phase and the level of total emulsion volumes occurred between surfactant and oil. IFT test is fundamental in chemical EOR study. This test is aimed to measure interfacial tension value formed between brine (pure brine or brine with chemical EOR addition) with crude oil in the reservoir. The lower the IFT value produced between chemical EOR-brine with crude oil, more effective the surfactant will be. Low IFT value will leads to easier oil penetration inside reservoir's rocks. Thermal stability IFT test is aimed to evaluate chemical EOR solution performance. The performance is indicated by IFT value stability formed at reservoir temperature against time. This will enable confirmation of thermal degradation ability to lower performance of chemical EOR during flooding process. The following figure shows the flow chart of this research eco-enzyme performance study.

Fig. 1. Study Flow Chart.

III. Results and Discussion

This eco-enzyme performance study was conducted for 1 month, located in Enhanced Oil Recovery Laboratory of Universitas Trisakti, Jakarta. In this study, pineapple peel was utilized as main material, mixed with water and brown sugar. Through 3 months of fermentation process, eco-enzyme produced was utilized to create surfactant. Brine solution with variations of salinity levels were utilized to obtain the lowest interfacial tension level to ensure the optimum salinity performance [7]. After conducted series of tests with different levels of salinity, solution with optimum salinity was obtained; namely 20,000 ppm and 40,000 ppm. The brine salinity variations were mixed with eco-enzyme with concentration levels of 20%,30%, and 40%.

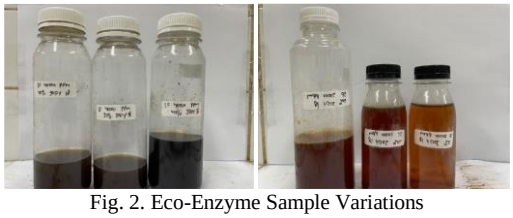

Fig. 2. Eco-Enzyme Sample Variations

TABLE I. IFT Value of Research Sample at 60oC Temperature.

Temperature (°C)	Solution	Salinity	Concentration (%)	Week	IFT
60	Eco-Enzyme	40,000 ppm	30	0	4.26
				1	4.82
				2	5.80
				3	6.14
				4	6.14
				5	6.52

The objective of thermal stability IFT test is to evaluate chemical EOR solution performance. The indication is a stable IFT value formed on reservoir temperature against time. This would measure whether the solution's performance can be affected by thermal degradation during flooding process in chemical EOR. The interfacial tension value is highly affecting oil production level, because lower interfacial tension will lead to higher micellar concentration that would lead to higher oil binding, which would improve oil recovery level. After obtaining interfacial tension value as shown in Table 1, there is a weekly increase of IFT value on solution with 30% eco-enzyme surfactant and 40,000 ppm NaCl brine. The increase is also shown in the following figure that illustrate IFT value ratio of the solution for every 60◦C each week.

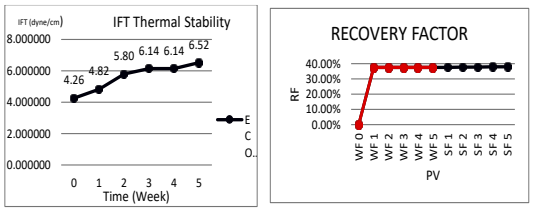

Fig. 3. IFT Value Ratio of The Solution for Every 60◦C Each Week and Recovery Factor.

The first injection process utilizes brine solution as injection fluid. Injection fluid selection was based on the low interfacial tension (IFT) value as shown in Figure 3. The lowest IFT value is indicated on eco-enzyme solution with 40,000 ppm salinity and 30% concentration. This is why, the surfactant was utilized as injection fluid in this study. The recovery factor obtained in this study was at 57.2 %. In the previous figure, it can be witnessed that on the tested surfactant solution injected water flood method and surfactant flood, stability was obtained on brine with 40,000 ppm salinity with recovery factor of 57.2. This result shows that pineapple peel eco-enzyme surfactant can be utilized in oil recovery enhancement.

IV. Conclusion

Pineapple peel eco-enzyme characteristic is able to lower IFT from 12.71 dyne/cm to 6.52 dyne/cm on solution with 40,000 ppm salinity. The best result was obtained from solution of 30% concentration of pineapple peel eco-enzyme and 40.000 ppm salinity with recovery factor of 57.2%. The study shows low level of oil recovery enhancement; 3% from water flood into surfactant flood. Based on this result, it can be concluded that pineapple peel eco-enzyme utilization requires co-surfactant to be able to improve oil recovery.

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REFERENCES

[1] B. P. Putra and B. F. T. Kiono, "Mengenal Enhanced Oil Recovery (EOR) Sebagai Solusi Meningkatkan Produksi Minyak Indonesia," *Jurnal Energi Baru dan Terbarukan*, vol. 2, no. 2, pp. 84–100, 2021, doi: 10.14710/jebt.2021.11152.

[2] H. B. Sulistyarso, Y. D. Hermawan, and J. Pamungkas, *Prospek Surfaktan Berbahan Dasar Ketapang Sebagai Alternatif Untuk Injeksi Kimia pada Metode Enhanced Oil Recovery (EOR)*. Yogyakarta: Lembaga Penelitian dan Pengabdian Masyarakat Universitas Pembangunan Nasional "Veteran" Yogyakarta, 2022.

[3] M. Damanik, S. Kasmungin, and R. Sudibjo, "Study Peningkatan Oil Recovery Pada Injeksi Surfaktan-Polimer Pada Batuan Karbonat," *Jurnal Penelitian Dan Karya Ilmiah Lembaga Penelitian Universitas Trisakti*, vol. 3, no. 1, pp. 27–33, 2018, doi: 10.25105/pdk.v3i1.2480.

[4] D. Larasati, A. P. Astuti, and E. T. Maharani, "Uji Organoleptik Eco-Enzyme dari Limbah Kulit Buah (studi kasus di Kota Semarang)," in *Edusaintek*, 2022, vol. 5, no. 1, pp. 24–30.

[5] M. M. Gaspersz and H. Fitrihidajati, "Pemanfaatan Ekoenzim Berbahan Limbah Kulit Jeruk dan Kulit Nanas sebagai Agen Remediasi LAS Detergen Utilization of Eco-enzyme from Citrus Peels and Pineapple Peels Waste as Detergent LAS Remediation Agent," *Lentera Bio*, vol. 11, pp. 503–513, 2022, [Online]. Available: https://journal.unesa.ac.id/index.php/lenterabio/index503.

[6] M. R. Ansyori, "Mengenal Enhanced Oil Recovery (EOR) Sebagai Solusi Meningkatkan Produksi Minyak," *Swara Patra: Majalah Ilmiah PPSDM Migas*, vol. 8, no. 2, pp. 1–7, 2018.

[7] M. Rivai, T. T. Irawadi, A. Suryani, and D. Setyaningsih, "Perbaikan proses produksi surfaktan metil ester sulfonat dan formulasinya untuk aplikasi Enhanced Oil Recovery (EOR)," 1997.