IOP Conference Series: Earth and Environmental Science

Preface

IOP Conf. Series: Earth and Environmental Science **1451** (2025) 011001 doi:10.1088/1755-1315/1451/1/011001

PREFACE

The 1st International Conference of Petroleum, Mining, Geology, Geoscience, Energy, and Environmental Technology (ICPMGET) 2024: *Empowering of Earth Resources for Sustainable Energy*

The 1st International Conference of Petroleum, Mining, Geology, Geoscience, Energy, and Environmental Technology (ICPMGET) 2024 is being organized by the Faculty of Earth Technology and Energy, Universitas Trisakti, Indonesia, and was held in a hybrid format on July 24-25, 2024, in Jakarta, Indonesia. The theme of the conference, *"Empowering of Earth Resources for Sustainable Energy,"* plays a part in shaping the future of energy. As the world confronts the dual challenges of meeting rising energy demands while ensuring environmental sustainability, it is important to explore new methods, technologies, and strategies to harness earth resources more efficiently and responsibly. This conference aims to create opportunities for academics, professionals, researchers, and students to collaborate, share, and discuss the innovations in resource management and environmental protection strategies that will drive the transition to a sustainable energy future.

The proceedings of ICPMGET 2024 capture the breadth and depth of the discussions that took place during the conference and peer-reviewed papers that cover a diverse range of topics:

- Earth natural resources and exploration
- Mineralogy and petrology
- Paleontology
- Vulcanology
- Water and Hydrology
- Geological science and engineering
- Geophysics and geochemistry
- Reservoir exploration
- Mining and metallurgical engineering
- Environmental and hazard mitigation
- Policy and energy sustainability.

The diversity of research showcased highlights the interdisciplinary nature of the challenges and solutions facing the energy and resource sectors. The conference was attended by more than 150 participants from Indonesia, South Korea, Japan, Vietnam, Australia, and Thailand and 78 contributed presenters. The output of the conference is well documented in the extended abstract of 66 reviewed papers. The conference proceeding can be beneficial for the authors, institutions, and worldwide scientific communities.

We extend our deepest gratitude to the honorable speakers for their willingness to share the knowledge:

1. Prof. Shun Chiyonobu (Petroleum Geology, Akita University, Japan)
   Presentation topic: The Hydrocarbon Potential based on The Geological Analyses.
2. Prof. Kun Sang Lee (Petroleum Engineering, Hanyang University, South Korea)
   Presentation topic: Economic Analysis of CO2 Capture, Transportation, and Storage during Water Alternating Gas (WAG) Process.
3. Prof. Ir. Asep Kurnia Permadi, M.Sc., Ph.D (Petroleum Engineering, Institut Teknologi Bandung, Indonesia)
   Presentation Topic: The Potential of Integrated CO2 Enhanced Oil Recovery (EOR) and CCS/CCUS in Indonesia
4. Associate Prof. Dr. Hoai Nga Nguyen (Mining and Geology, Hanoi University and Mining Geology, Vietnam)
   Presentation Topic: Vision Zero and Sustainable and Responsible Mining in Southeast Asia
5. Associate Prof. Dr. Ir. Muhammad Burhannudinnur, M.Sc (Geological Engineering, Universitas Trisakti, Indonesia)
   Presentation Topic: Transition Energy – Leveraging the Opportunities of the Indonesian Oil and Gas Industry and Education.

We appreciate to all the authors, presenters, and participants contributions to sharing ideas and innovations. We also thank our sponsors and partners: BATM Trisakti, PT. Kideco jaya Agung, PT. Elnusa Tbk, PT. Cipta Kridatama, PT. Andamas Global Energi, Ikatan Alumni (IKA) Trisakti, Bank Negara Indonesia (BNI), and Bapak Silmy Karim (Chairman of IKA Trisakti). Special thanks go to the organizing committee, whose dedication and hard work ensured the smooth execution of the conference.

As the global demand for energy and resources rises, the need for continued innovation and sustainable practices has never been more urgent. We hope that the proceedings of ICPMGET 2024 will serve as an essential resource for researchers, professionals, and policymakers, inspiring continued collaboration and progress in the years ahead.

Sincerely,

Dr. Kartika Fajarwati Hartono
(Chairperson of ICPMGET 2024)

IOP Conf. Series: Earth and Environmental Science **1451** (2025) 011001 doi:10.1088/1755-1315/1451/1/011001

Steering Committe:

- Associate Prof. Dr. Ir. Muhammad Burhannudinnur, M.Sc (Geological Engineering, Universitas Trisakti)
- Prof. Dr. Ir. Astri Rinanti Nugroho, S.Si., M.T. (Environmetal Engineering, Universitas Trisakti)
- Associate Prof. Dr. Ir. Suryo Prakoso, S.T., M.T (Petroleum Engineering/Petrophysics, Universitas Trisakti)
- Ir. Dewi Syavitri., M.Sc., Ph.D (Geological Engineering/Paleontology, Universitas Trisakti)
- Dr. Ir. Pantjanita Novi Hartami, S.T., M.T. (Mining Engineering/Geotechnical, Universitas Trisakti)

Organizing Committee:

- **Chairperson**
  Dr. Kartika Fajarwati Hartono, S.T., M.T. (Petroleum Engineering/Reservoir Exploration, Universitas Trisakti)
- **Vice Chair**
  Dr. Ir. Edy Jamal Tuheteru, S.T., M.T. (Mining Engineering, Universitas Trisakti)
- **Secretary**
  Dr. Eng. Shabrina Sri Riswati, S.T. (Geothermal/Petroleum Engineering, Universitas Trisakti)
- **Tressurer**
  Ir. Ririn Yulianti, S.T., M.T (Mining Engineering, Universitas Trisakti)
- **Website and Article Management**
  Dr. Cahaya Rosyidan, S.Si., M.Sc (Material Science, Universitas Trisakti)
- **Public Relation Coordinator**
  Havidh Pramadika, S.T., M.T (Petroleum Engineering, Universitas Trisakti)
  Himmes Fitra Yuda, S.T., M.T (Geological Engineering/Hydrology, Universitas Trisakti)
  Prayang Sunny Yulia, S.T., M.T (Petroleum Engineering, Universitas Trisakti)
  Riskaviana Kurniawati, S.Pd., M.Si (Metallurgical Engineering, Universitas Trisakti)
- **Hybrid Event Coordinator**
  Ir. Wildan Tri Koesmawardani, S.T., M.T (Geological Engineering/Geophysics, Universitas Trisakti)
  Ir. Yuga Maulana, S.T., MT (Mining Engineering, Universitas Trisakti)
  Mixsindo Korra Herdyanti, S.T., M.T (Mining Engineering, Universitas Trisakti)

IOP Conf. Series: Earth and Environmental Science **1451** (2025) 011001 doi:10.1088/1755-1315/1451/1/011001

Ir. Sigit Rahmawan, S.T., M.T (Petroleum Production, Universitas Trisakti)

- **Paralel Session Coordinator**
  Ir. Sigit Rahmawan, S.T., M.T (Petroleum Production, Universitas Trisakti)
- **Panel Session Coordinator**
  Dr. Sc. Ir. Rendy, S.T., M.Eng (Geological Engineering/Paleontology, Universitas Trisakti)
  Ir. Danu Putra, S.T., M.T (Mining Engineering, Universitas Trisakti)
  Ir. Ramadhan Adhitama, S.T., M.Sc (Geological Engineering/Geophysics, Universitas Trisakti)
- **Logistic Coordinator**
  Dra. Mustamina Maulani, M.T (Industrial Engineering and Mathematics, Universitas Trisakti).

Editorial Board:

- Associate Prof. Ariani Dwi Astuti, ST., MT., Ph.D (Environmetal Engineering, Universitas Trisakti)
- Dr. Kartika Fajarwati Hartono, S.T., M.T (Petroleum Engineering/Reservoir Exploration, Universitas Trisakti)
- Dr. Ir. Edy Jamal Tuheteru, S.T., M.T., IPM (Mining Engineering, Universitas Trisakti)
- Dr. Sc. Ir. Rendy, S.T., M.Eng. (Geological Engineering/Paleontology, Universitas Trisakti)
- Dr. Eng. Shabrina Sri Riswati, S.T., M.T (Geothermal/Petroleum Engineering, Universitas Trisakti)

Scientific Committee:

- Prof. Shun Chiyonobu (Petroleum Geology, Akita University, Japan)
- Prof. Ir. Asep Kurnia Permadi, M.Sc., Ph.D (Petroleum Engineering, Institut Teknologi Bandung, Indonesia)
- Associate Prof. Dr. Ir. Muhammad Burhannudinnur, M.Sc. (Geological Engineering, Universitas Trisakti)
- Prof. Dr. Ir. Astri Rinanti Nugroho, S.Si., M.T. (Environmetal Engineering, Universitas Trisakti)
- Associate Prof. Dr. Ir. Suryo Prakoso, S.T., M.T (Petroleum Engineering, Universitas Trisakti)
- Associate Prof. Ariani Dwi Astuti, ST., MT., Ph.D. (Environmetal Engineering, Universitas Trisakti)

IOP Conf. Series: Earth and Environmental Science **1451** (2025) 011001 doi:10.1088/1755-1315/1451/1/011001

- Associate Prof. Dr. Hoai Nga Nguyen (Mining and Geology, Hanoi University and Mining Geology, Vietnam)
- Ir. Dewi Syavitri, M.Sc., Ph.D (Geological Engineering/Paleontology, Universitas Trisakti)
- Associate Prof. Dr. Ir. Singgih Saptono, M.T. (Mining Engineering, Universitas Pembangunan Nasional Veteran Yogyakarta)
- Dr. Ir. Pantjanita Novi Hartami, S.T., M.T. (Mining Engineering, Universitas Trisakti)
- Dr. Ir. Junita Trivianty Musu, S.T., M.Sc. (Geological Engineering/Petrophysics , LEMIGAS Research and Development Center of Oil & Gas Technology, Indonesia)
- Dr. Boni Swadesi, S.T., M.T (Petroleum Engineering/Reservoir Exploration, Universitas Pembangunan Nasional Veteran Yogyakarta)
- Dr. Ir. Junita Trivianty Musu, S.T., M.Sc. (Geological Engineering/Petrophysics , LEMIGAS Research and Development Center of Oil & Gas Technology, Indonesia)
- Associate Prof. Dr. Ir. Moeh. Ali Jambak, M.T (Geological Engineering, Universitas Trisakti)
- Associate Prof. Dr. Ir. Benyamin, M.T. (Geophysics Engineering, Universitas Trisakti)
- Associate Prof. Dr. Dwi Atty Mardiana, S.T., M.T (Energy Policies and Economics, Universitas Trisakti)
- Associate Prof. Dr. Ir. Masagus Ahmad Azizi, S.T., M.T (Mining Engineering/Geotechnical Engineering, Universitas Trisakti)
- Associate Prof. Dr. Ir. Irfan Marwanza, S.T., M.T. (Mining Exploration/Geological Engineering, Universitas Trisakti)
- Dr. Reno Pratiwi, S.T., M.T (Chemical Engineering/Renewable Energy, Trisakti University)

Table of contents

Volume 1451

2025

Previous issue

The 1st International Conference of Petroleum, Mining, Geology, Geoscience, Energy, & Environmental Technology (ICPMGET 2024) 24/07/2024 - 25/07/2024 West Jakarta, Indonesia

Accepted papers received: 23 January 2025
Published online: 19 February 2025

Open all abstracts

Reservoir and Earth Natural Resources Exploration

Environmental, Hazard Mitigation, Policy and Energy Sustainability

IOP Conference Series: Earth and Environmental Science

PAPER • OPEN ACCESS

Variation of palm oil MES surfactant concentrations using CMG software

To cite this article: Firdha Meidya Buana *et al* 2025 *IOP Conf. Ser.: Earth Environ. Sci.* **1451** 012038

Variation of palm oil MES surfactant concentrations using CMG software

Firdha Meidya Buana[1], Listiana Satiawati[1], Prayang Sunny Yulia[1*]

[1] Petroleum Engineering Department, Faculty of Earth and Energy Technology, Universitas Trisakti, Jakarta, Indonesia

*E-mail: prayang@trisakti.ac.id

Abstract. This study utilizes computer simulations to explore the potential use of Methyl Ester Sulfonate (MES) surfactants derived from palm oil to enhance oil recovery stability. The main function of MES in reducing interfacial tension (IFT) and boosting recovery factor (RF) includes several key actions. MES molecules align at the oil-water interface, reducing interfacial energy and IFT. It also forms micelles that encapsulate oil, further lowering IFT. By disrupting water's cohesive forces, MES helps disperse oil droplets, improving fluid dynamics and stabilizing emulsions. These effects enhance oil recovery, making MES effective in enhanced oil recovery applications. Using simulation software, this approach offers a simpler and more flexible way to evaluate different concentration levels, as it can be performed anytime and anywhere without incurring extra expenses typically associated with laboratory setups. It enables researchers to quickly identify the optimal concentration that yields the best recovery factor. Various concentration levels were tested to determine the optimal concentration that yields the best recovery factor. The tested concentrations ranged from 0.50% to 2.03%, with a specific gravity of 41 API for all variations and salinity brine at 8900 ppm. At a concentration of 0.50%, the lowest recovery factor (RF) obtained is 35.62%, while the highest RF is achieved at a concentration of 2.00%, with a value of 55.35%.

1. Introduction

The surfactants that are generally used, which are based on petroleum sulfonate, are quite expensive, are non-renewable, and are not resistant to formation water with high levels of salinity and temperature [1]. This creates an excellent opportunity to develop a local type of palm oil-based surfactant that is more affordable, abundant and environmentally friendly. Methyl ester sulfonate (MES), which is produced from palm oil, has renewable properties, is easily degraded, lower production costs, good dispersion characteristics, and effective washing properties, especially in water with a high level of hardness [2]. With a lower concentration, MES is able to provide cleaning power equivalent to petroleum sulfonate [3].

Several critical problems demand attention to enhance oil recovery processes. One primary challenge is developing an accurate model for surfactant injection within a laboratory setting using reservoir simulation techniques. This involves creating a realistic representation that can reliably predict the behaviour of surfactants in the subsurface environment. Another pertinent issue is understanding the effect of surfactant concentration on the recovery factor. Determining the optimal concentration is crucial for maximizing oil recovery while minimizing costs and potential environmental impacts [4]. Finally, assessing the suitability of Computer Modelling Group (CMG) software for reservoir simulation modelling is essential [5]. CMG's capabilities and limitations must be thoroughly evaluated to ensure it can effectively simulate the complex interactions between surfactants and reservoir fluids [6], [7].

The palm oil-based surfactant Methyl Ester Sulfonate (MES) is a major breakthrough in the chemical industry, especially for use as emulsion stabilizers and cleaning agents. Sulfonation of methyl esters obtained from palm oil yields MES, an environmentally benign anionic surfactant. Because palm oil is a renewable resource and readily available, it presents MES as a more environmentally friendly surfactant than petroleum-based surfactants. Furthermore, MES has a low toxicity and is largely biodegradable, which makes it a great option for a variety of industrial uses, such as oil processing, detergents, and cosmetics.

By efficiently lowering surface tension and enhancing emulsion stability, the application of MES improves product performance while also lessening its negative effects on the environment. CMG simulation is utilized for the MES palm oil-based surfactant to analyse and optimize various operational parameters, such as environmental conditions and concentrations. This aims to determine the effectiveness of MES in enhancing oil stability and improving the efficiency of the oil recovery process.

The recovery factor for surfactants denotes the proportion of the original oil in place (OOIP) that can be extracted from a reservoir using surfactant-enhanced oil recovery methods [8]. This factor assesses how efficiently and effectively the surfactant mobilizes and displaces oil within the reservoir, thereby boosting the overall hydrocarbon recovery [9]. It serves as a crucial metric for evaluating the success of surfactant injection techniques in increasing oil production [10].

2. Methods

The CMG simulation software is employed alongside parameters derived from EOR laboratory data, with simulations carried out at Universitas Trisakti simulation and computer laboratory.

The first major step was the literature review, which was essential for establishing a solid theoretical foundation. During this phase, previous studies, publications, and relevant data were gathered and analysed to understand the background and context of the study. This step informed the research objectives and helped identify gaps in the existing knowledge.

Following the literature review, laboratory data collection was conducted. In this phase, experimental work was carried out to gather empirical data that would be critical for the later stages of the project. These experiments involved measuring parameters such as interfacial tension, which could directly influence the accuracy of the subsequent simulation.

The next step was the inputting of laboratory data into CMG STAR. Here, the collected data were inputted into CMG STAR, a simulation tool that played a vital role in predicting the behaviour of the system under different conditions based on the input data.

The subsequent step, history matching, involved comparing the simulation results to actual field or laboratory data. The aim was to ensure that the model's output reflected real-world conditions accurately. If discrepancies arose, the model underwent adjustments or recalibration. This iterative process of tuning the model parameters ensured that the simulation was reliable and valid for further analysis.

Once the history matching was successful, the process moved to results and data analysis, where the validated simulation results were thoroughly examined. This stage was critical for interpreting the outcomes of the research and drawing conclusions about the system's behaviour or the effectiveness of the process being studied.

Finally, the project concluded by marking the successful completion of the research after all data had been collected, simulated, and analysed. Figure 1 shows the whole process that illustrated on the flow chart as follows:

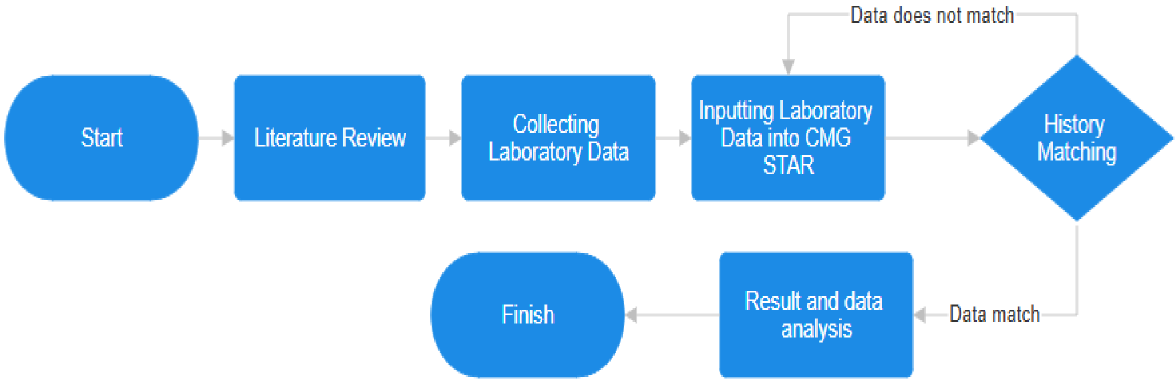


Figure 1. Flow chart

3. Materials

The core sample used is Berea Sandstone, with a diameter of 2.48 cm and a length of 2.96 cm. The injection rate is 0.3 cm^3/min. From the data obtained in the EOR laboratory at Universitas Trisakti, the parameters to be input into the CMG application as seen on Table 1:

Table 1. Parameters Input

No	Parameter	Value
1	Oil Gravity	41 API
2	Injection Rate	0.3 cm^3/cc
3	Core Diameter	2.48 cm
4	Permeability	170 mD
5	Rock Compressibility	psi-1
6	Porosity	19%
7	Bubble Point Pressure	1364.733 psi
8	Reservoir Temperature	60°C
9	Reservoir Pressure	14.7 psi
10	Water Density	1.0011 gr/cm^3

IOP Conf. Series: Earth and Environmental Science **1451** (2025) 012038 doi:10.1088/1755-1315/1451/1/012038

4. CMG STAR

The advanced reservoir modeling program CMG STARS (Steam, Thermal, and Advanced Processes Reservoir Simulator) was developed by Computer Modelling Group Ltd. This program can simulate complex chemical, thermal, and sophisticated recovery processes in reservoirs. Because of its accuracy in replicating the fluid behavior of reservoirs under several enhanced oil recovery (EOR) procedures, such as chemical flooding, thermal recovery, and steam injection, it is widely used in the petroleum sector.

5. Result and Discussion

In this research, the rock core initially had a cylindrical shape, but for simulation purposes, the researchers decided to use a Cartesian type grid, as seen on Figure 2. In applying the Cartesian grid, the core rock which was originally round is assumed to be a cube with a known diameter of around 2.5 cm, which is equivalent to a radius of around 1.25 cm. Thus, the surface area of the core rock obtained is 4.908738521 cm^2. In the context of a Cartesian grid, the side of the cube obtained is about 2.70 cm, which is obtained by calculating the known area. In determining the Cartesian grid, the researcher decided to use 10 grids in the I direction, 1 grid in the J direction, and 1 grid in the K direction.

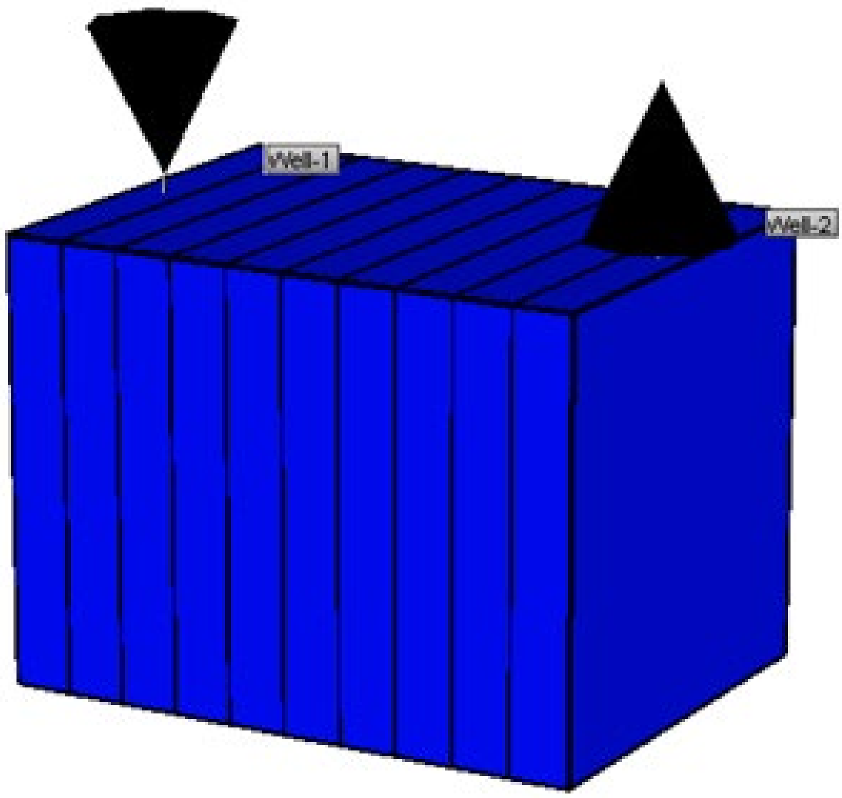


Figure 2. 3D grid model

The test results of Palm Oil MES from the EOR Laboratory had been inputted into the CMG simulation, that can be seen at the Table 2 as follows:

Table 2. Reservoir condition

No	Parameter	Mark
1	Permeability i	170 ms
2	Permeability j	170 ms
3	Permeability k	170 ms
4	Grid Top	230.94 cm
5	Grid Thickness	2,197 cm
6	Porosity	15.151%

Furthermore, the parameters related to the numerical method has been identified in the system process simulation, by entering a first time interval of 1 minute after a change occurs in the well.

In the final stage, as seen on Table 3, researchers input the parameters required for making the well. There are two types of wells used, namely injection wells and production wells. In the injection well, researchers input a surface water rate of 0.3 cc/min.

Table 3. Well and recurrent

Fluid Type	Fluid Composition
Water	98%
Surfactant	2%
Total	100%

In the surfactant flooding process, water is still used because its presence allows oil, which has experienced a decrease in surface tension due to the surfactant, to be pushed to the surface. The next step, researchers made a production well in base case conditions by entering a bottom hole pressure value of 101,325 kPa.

After perforating the well, researchers determine the time for waterflooding and surfactant flooding. Waterflooding starts in the time range 0 to 14 minutes, while surfactant flooding starts in the time range 14 to 30 minutes. At this stage, the model creation has been completed, and the cumulative oil results in surfactant trials from palm oil can be seen.

In the initial stage, the OOIP (original oil in place) obtained from laboratory testing will be adjusted (history matching) with the data generated by the CMG application. Table 4 shows the OOIP number from laboratory tests was 1.40 cm^3 and compared with CMG data.

Table 4. Comparison of error results

Items	LAB	CMG	ERROR
OOIP	1.40	1.39	0.01%

Surfactants from palm oil can be used and seen by varying the concentration value in obtaining the recovery factor as seen on Table 5, therefore the optimal recovery can be known which is recommended for use.

Table 5. Recovery factor value

Concentration	RF CMG (%)
0.50%	35.62177
0.75%	38.90137
1.00%	42.06398
1.25%	44.74862
1.50%	48.49816
1.75%	52.1187
2.00%	55.34526

The table explains that each variation in surfactant concentration has an impact on the recovery factor, but the optimal concentration is 2%. With this concentration, there is an increase in oil production or a recovery factor of 55.34526%, as seen on Figure 3.

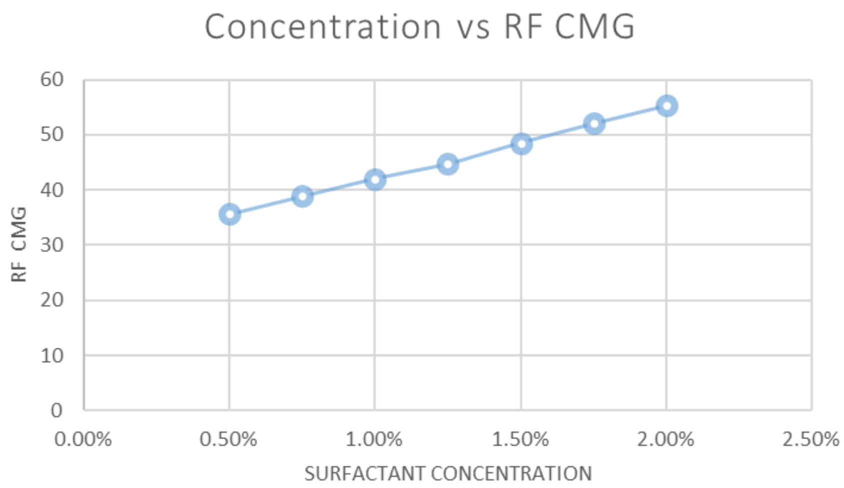


Figure 3. Surfactant concentration vs RF CMG

As the surfactant concentration rises, it enhances its capability to lower the tension between oil and water interfaces, thereby improving the mobilization and displacement of oil in the reservoir. This often results in a higher recovery factor, allowing more oil to be extracted effectively. However, it's crucial to pinpoint the ideal concentration because excessively high levels could lead to economic inefficiencies and potentially harm the reservoir's characteristics.

6. Conclusions

The influence of surfactant concentration on the recovery factor indicates that among the tested levels (0.5%, 1.0%, 1.5%, and 2.0%), the concentration of 2% achieves the highest recovery factor. This implies that as the concentration of surfactant increases, it improves its capability to reduce the interfacial tension between oil and water in the reservoir, thereby facilitating better mobilization and displacement of oil. As a result, higher concentrations are expected to enhance the efficiency of oil recovery. However, it's important to acknowledge that while higher concentrations of surfactant generally correlate with increased recovery factors, there are cases where further increases in concentration may not necessarily lead to higher recovery rates. This highlights the critical importance of carefully optimizing surfactant concentrations in reservoir engineering to maximize both the efficiency of oil recovery and economic viability.

7. Acknowledgement

This acknowledgement is dedicated to the Faculty of Earth Technology and Energy, Petroleum Engineering Department of Trisakti University, for their support in this research.

References

[1] Y. Zhu, G. Jian, W. Liu, L. Cheng, Q. Hou, and J. Li, "Recent Progress and Effects Analysis of Surfactant-Polymer Flooding Field Tests in China," in *All Days*, SPE, Jul. 2013. doi: 10.2118/165213-MS.

[2] R. L. Permadani, M. Ibadurrohman, and Slamet, "Utilization of waste cooking oil as raw material for synthesis of Methyl Ester Sulfonates (MES) surfactant," *IOP Conf Ser Earth Environ Sci*, vol. 105, p. 012036, Jan. 2018, doi: 10.1088/1755-1315/105/1/012036.

[3] S. Mahendran, P. Siwayanan, N. A. Shafie, S. K. Subbiah, and B. Azeem, "Exploring the Potential Application of Palm Methyl Ester Sulfonate as an Interfacial Tension Reducing Surfactant for Chemical Enhanced Oil Recovery," *Key Eng Mater*, vol. 797, pp. 402–410, Mar. 2019, doi: 10.4028/www.scientific.net/KEM.797.402.

[4] M. S. Dahbag and M. E. Hossain, "Simulation of Ionic Liquid Flooding for Chemical Enhance Oil Recovery Using CMG STARS Software," in *All Days*, SPE, Apr. 2016. doi: 10.2118/182836-MS.

[5] S. K. Rai, A. Bera, and A. Mandal, "Modeling of surfactant and surfactant–polymer flooding for enhanced oil recovery using STARS (CMG) software," *J Pet Explor Prod Technol*, vol. 5, no. 1, pp. 1–11, Mar. 2015, doi: 10.1007/s13202-014-0112-3.

[6] V. Fernanda, M. Ginting, and P. S. Yulia, "ANALISIS PENGARUH INJEKSI CO2 TERHADAP RECOVERY FACTOR MENGGUNAKAN SIMULASI CMG DI LAPANGAN X," *PETRO:Jurnal Ilmiah Teknik Perminyakan*, vol. 8, no. 1, pp. 28–34, Apr. 2019, doi: 10.25105/petro.v8i1.4292.

[7] R. R. Sukmana, A. Trisetia Anggara, M. M. Azis, R. B. Cahyono, and D. F. Putra, “A Simulation of Enhanced Oil Recovery of Surfactant Flooding Using Sodium Lignosulfonate by CMG-STARS,” in *2019 2nd International Conference on Applied Information Technology and Innovation (ICAITI)*, IEEE, Sep. 2019, pp. 227–230. doi: 10.1109/ICAITI48442.2019.8982155.

[8] P. S. Yulia, S. Kasmungin, and M. T. Fathaddin, “ANALISIS SALINITAS DAN KONSENTRASI SURFAKTAN AOS DAN TWEEN 20 TERHADAP RECOVERY FACTOR PADA PROSES IMBIBISI DAN CORE-FLOODING,” *PETRO:Jurnal Ilmiah Teknik Perminyakan*, vol. 9, no. 4, 2020, doi: 10.25105/petro.v9i4.8227.

[9] P. S. Yulia, S. Kasmungin, and M. T. Fathaddin, “Kajian Laboratorium Mengenai Pengaruh Salinitas, Jenis Surfaktan Dan Konsentrasi Surfaktan Terhadap Recovery Factor Dalam Sistem Injeksi Surfaktan Untuk Batuan Karbonat,” *Prosiding Seminar Nasional Cendekiawan*, vol. 3, 2017.

[10] J. J. Sheng, “A Comprehensive Review of Alkaline-Surfactant-Polymer (ASP) Flooding,” in *All Days*, SPE, Apr. 2013. doi: 10.2118/165358-MS.

UNIVERSITAS TRISAKTI

Prayang Sunni <prayang@trisakti.ac.id>

Paper(s) for ICPMGET-2024 entering Production
1 message

Morressier Team <discover@morressier.com> Thu, Jan 23, 2025 at 8:42 PM
To: prayang@trisakti.ac.id

IOP Publishing

Dear Prayang Sunny Yulia,

We are pleased to inform you that the following Papers have passed the Publisher's checks and are being finalized for publication:

- Variation of palm oil MES surfactant concentrations using CMG software

The Papers are now entering the Production process to prepare them for publication on the IOPscience platform. An overview of the publication procedure is available here.

You can access a list of your Submissions using the link below. If you have any problems accessing the link, please contact support@morressier.com.

Your Paper for ICPMGET-2024

1 message

Morressier Team <discover@morressier.com> Tue, Dec 3, 2024 at 11:36 AM
To: prayang@trisakti.ac.id

IOP Publishing

Hi there,

Thank you for your Paper Submission to 'ICPMGET-2024'.

The Editor has requested that you resubmit your Paper 'Variation of Palm Oil MES Surfactant Concentrations Using Reservoir Simulation ' with some changes. Go to My Submissions to see any comments from the Reviewers or Editor and submit an updated version of your Paper. The Deadline for resubmitting is December 04, 2024.

Please note that your revised Paper must be a camera-ready manuscript without any highlighted changes. A summary of the changes you have made to your Paper can be included in your Response to Reviewers, which you may upload as a separate document.

Go to My Submissions

IOP Publishing

IOP Conference Series: Earth and Environmental Science

COUNTRY

United Kingdom

Universities and research institutions in United Kingdom

Media Ranking in United Kingdom

SUBJECT AREA AND CATEGORY

Earth and Planetary Sciences
- Earth and Planetary Sciences (miscellaneous)

Environmental Science
- Environmental Science (miscellaneous)

Physics and Astronomy
- Physics and Astronomy (miscellaneous)

PUBLISHER

IOP Publishing Ltd.

H-INDEX

48

PUBLICATION TYPE

Conferences and Proceedings

ISSN

17551307, 17551315

COVERAGE

2010-2023

INFORMATION

Homepage

How to publish in this journal

ees@ioppublishing.org

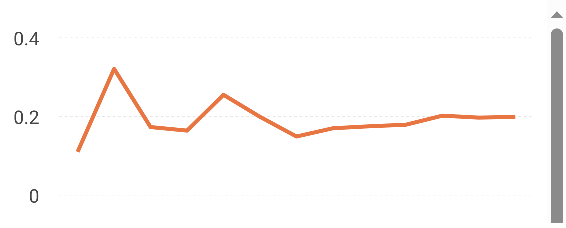
SCOPE

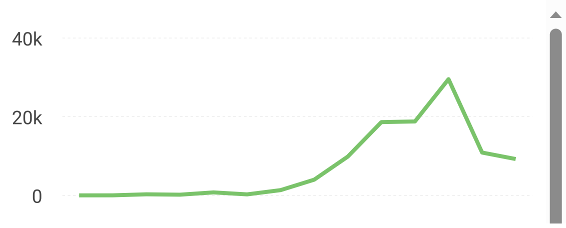
The open access IOP Conference Series: Earth and Environmental Science (EES) provides a fast, versatile and cost-effective proceedings publication service.

Join the conversation about this journal

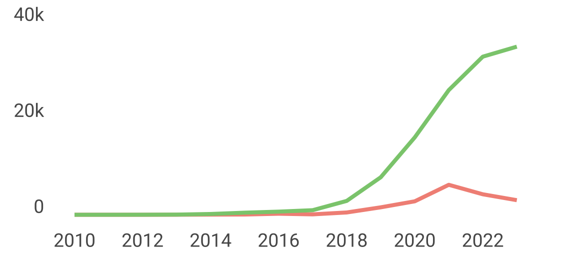
SJR

Total Documents

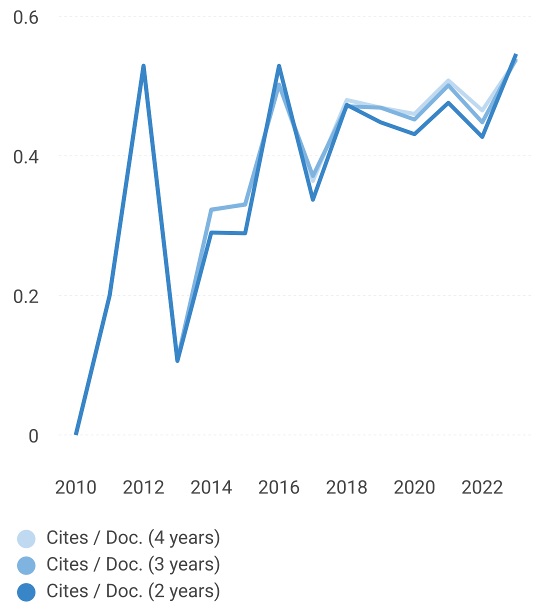




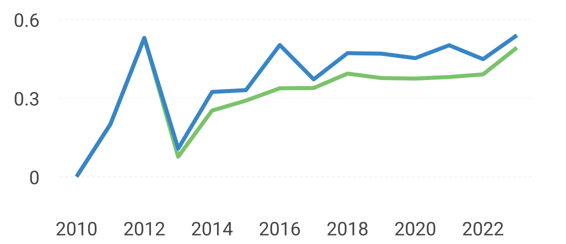
Total Cites Self-Cites



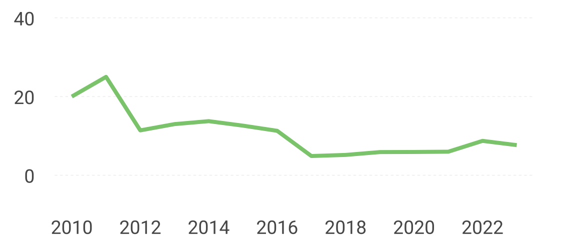
Citations per document



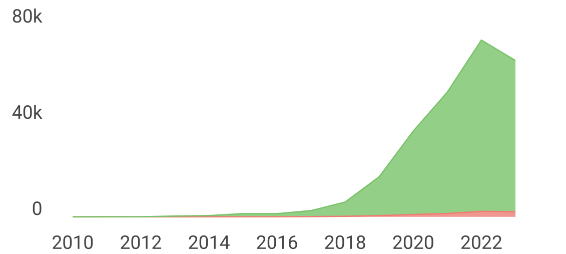
External Cites per Doc Cites per Doc



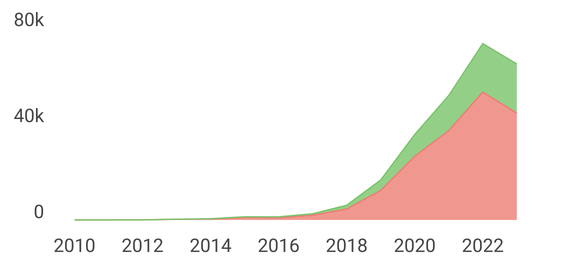
% International Collaboration



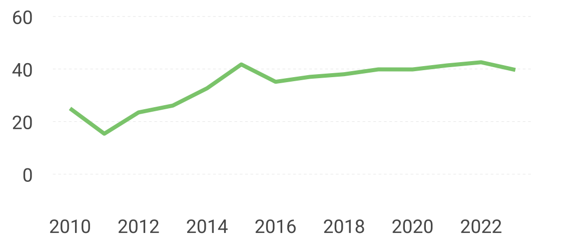
Citable documents Non-citable documents



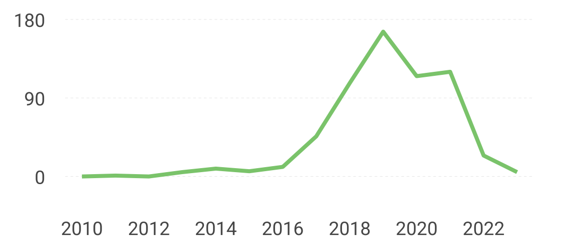
Cited documents Uncited documents



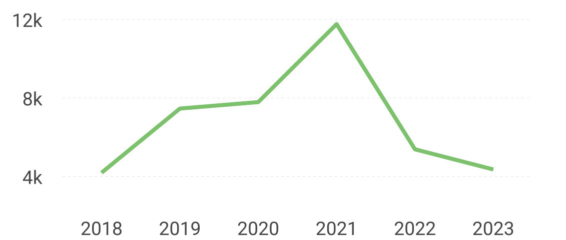
% Female Authors



Documents cited by public policy (Overton)



Documents related to SDGs (UN)



← Show this widget in your own website

Just copy the code below and paste within your html code:

<a href="https://www.scimag

SCImago Graphica

Explore, visually communicate and make sense of data with our **new data visualization tool**.

Metrics based on Scopus® data as of March 2024

R **RIBKA ROSARI NABABAN** 4 months ago

What is the quartal of this journal?

reply

SCImago Team

Melanie Ortiz 4 months ago

Dear Ribka,
Thank you for contacting us. Please see comments below.
Best regards, SCImago Team

D **Dilnozakhon Tursunova** 6 months ago

This is the only site for submitting articles. The information is not enough, the article was sent through the site, but there is no official reply. They demand payment before there are any changes on the site.
I think this site is not original https://icem.uns.ac.id/

reply

SCImago Team

Melanie Ortiz 6 months ago

Dear Dilnozakhon, thanks for your participation! Best Regards, SCImago Team

N **Nilufar Rajabova** 7 months ago

IOP Conference Series: Earth and Environmental Science
If you provide an official link to submit an article to the conference.

reply

IOP Conference Series:
Earth and
Environmental Science

PAPER • OPEN ACCESS

Variation of palm oil MES surfactant concentrations using CMG software

To cite this article: Firdha Meidya Buana *et al* 2025 *IOP Conf. Ser.: Earth Environ. Sci.* **1451** 012038

Variation of palm oil MES surfactant concentrations using CMG software

Firdha Meidya Buana[1], Listiana Satiawati[1], Prayang Sunny Yulia[1*]

[1] Petroleum Engineering Department, Faculty of Earth and Energy Technology, Universitas Trisakti, Jakarta, Indonesia

[*]E-mail: prayang@trisakti.ac.id

Abstract. This study utilizes computer simulations to explore the potential use of Methyl Ester Sulfonate (MES) surfactants derived from palm oil to enhance oil recovery stability. The main function of MES in reducing interfacial tension (IFT) and boosting recovery factor (RF) includes several key actions. MES molecules align at the oil-water interface, reducing interfacial energy and IFT. It also forms micelles that encapsulate oil, further lowering IFT. By disrupting water's cohesive forces, MES helps disperse oil droplets, improving fluid dynamics and stabilizing emulsions. These effects enhance oil recovery, making MES effective in enhanced oil recovery applications. Using simulation software, this approach offers a simpler and more flexible way to evaluate different concentration levels, as it can be performed anytime and anywhere without incurring extra expenses typically associated with laboratory setups. It enables researchers to quickly identify the optimal concentration that yields the best recovery factor. Various concentration levels were tested to determine the optimal concentration that yields the best recovery factor. The tested concentrations ranged from 0.50% to 2.03%, with a specific gravity of 41 API for all variations and salinity brine at 8900 ppm. At a concentration of 0.50%, the lowest recovery factor (RF) obtained is 35.62%, while the highest RF is achieved at a concentration of 2.00%, with a value of 55.35%.

1. Introduction

The surfactants that are generally used, which are based on petroleum sulfonate, are quite expensive, are non-renewable, and are not resistant to formation water with high levels of salinity and temperature [1]. This creates an excellent opportunity to develop a local type of palm oil-based surfactant that is more affordable, abundant and environmentally friendly. Methyl ester sulfonate (MES), which is produced from palm oil, has renewable properties, is easily degraded, lower production costs, good dispersion characteristics, and effective washing properties, especially in water with a high level of hardness [2]. With a lower concentration, MES is able to provide cleaning power equivalent to petroleum sulfonate [3].

Several critical problems demand attention to enhance oil recovery processes. One primary challenge is developing an accurate model for surfactant injection within a laboratory setting using reservoir simulation techniques. This involves creating a realistic representation that can reliably predict the behaviour of surfactants in the subsurface environment. Another pertinent issue is understanding the effect of surfactant concentration on the recovery factor. Determining the optimal concentration is crucial for maximizing oil recovery while minimizing costs and potential environmental impacts [4]. Finally, assessing the suitability of Computer Modelling Group (CMG) software for reservoir simulation modelling is essential [5]. CMG's capabilities and limitations must be thoroughly evaluated to ensure it can effectively simulate the complex interactions between surfactants and reservoir fluids [6], [7].

The palm oil-based surfactant Methyl Ester Sulfonate (MES) is a major breakthrough in the chemical industry, especially for use as emulsion stabilizers and cleaning agents. Sulfonation of methyl esters obtained from palm oil yields MES, an environmentally benign anionic surfactant. Because palm oil is a renewable resource and readily available, it presents MES as a more environmentally friendly surfactant than petroleum-based surfactants. Furthermore, MES has a low toxicity and is largely biodegradable, which makes it a great option for a variety of industrial uses, such as oil processing, detergents, and cosmetics.

By efficiently lowering surface tension and enhancing emulsion stability, the application of MES improves product performance while also lessening its negative effects on the environment. CMG simulation is utilized for the MES palm oil-based surfactant to analyse and optimize various operational parameters, such as environmental conditions and concentrations. This aims to determine the effectiveness of MES in enhancing oil stability and improving the efficiency of the oil recovery process.

The recovery factor for surfactants denotes the proportion of the original oil in place (OOIP) that can be extracted from a reservoir using surfactant-enhanced oil recovery methods [8]. This factor assesses how efficiently and effectively the surfactant mobilizes and displaces oil within the reservoir, thereby boosting the overall hydrocarbon recovery [9]. It serves as a crucial metric for evaluating the success of surfactant injection techniques in increasing oil production [10].

2. Methods

The CMG simulation software is employed alongside parameters derived from EOR laboratory data, with simulations carried out at Universitas Trisakti simulation and computer laboratory.

The first major step was the literature review, which was essential for establishing a solid theoretical foundation. During this phase, previous studies, publications, and relevant data were gathered and analysed to understand the background and context of the study. This step informed the research objectives and helped identify gaps in the existing knowledge.

Following the literature review, laboratory data collection was conducted. In this phase, experimental work was carried out to gather empirical data that would be critical for the later stages of the project. These experiments involved measuring parameters such as interfacial tension, which could directly influence the accuracy of the subsequent simulation.

The next step was the inputting of laboratory data into CMG STAR. Here, the collected data were inputted into CMG STAR, a simulation tool that played a vital role in predicting the behaviour of the system under different conditions based on the input data.

The subsequent step, history matching, involved comparing the simulation results to actual field or laboratory data. The aim was to ensure that the model's output reflected real-world conditions accurately. If discrepancies arose, the model underwent adjustments or recalibration. This iterative process of tuning the model parameters ensured that the simulation was reliable and valid for further analysis.

Once the history matching was successful, the process moved to results and data analysis, where the validated simulation results were thoroughly examined. This stage was critical for interpreting the outcomes of the research and drawing conclusions about the system's behaviour or the effectiveness of the process being studied.

Finally, the project concluded by marking the successful completion of the research after all data had been collected, simulated, and analysed. Figure 1 shows the whole process that illustrated on the flow chart as follows:

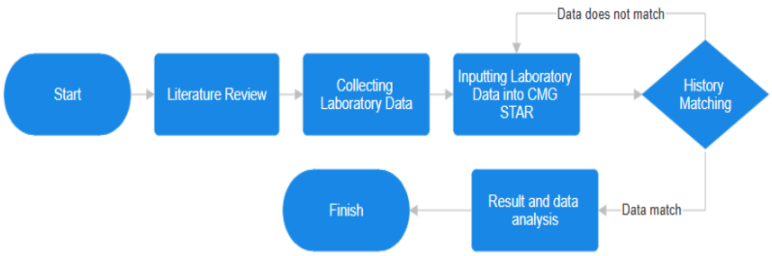


Figure 1. Flow chart

3. Materials

The core sample used is Berea Sandstone, with a diameter of 2.48 cm and a length of 2.96 cm. The injection rate is 0.3 cm^3/min. From the data obtained in the EOR laboratory at Universitas Trisakti, the parameters to be input into the CMG application as seen on Table 1:

Table 1. Parameters Input

No	Parameter	Value
1	Oil Gravity	41 API
2	Injection Rate	0.3 cm^3/cc
3	Core Diameter	2.48 cm
4	Permeability	170 mD
5	Rock Compressibility	psi-1
6	Porosity	19%
7	Bubble Point Pressure	1364.733 psi
8	Reservoir Temperature	60°C
9	Reservoir Pressure	14.7 psi
10	Water Density	1.0011 gr/cm^3

IOP Conf. Series: Earth and Environmental Science **1451** (2025) 012038 doi:10.1088/1755-1315/1451/1/012038

4. CMG STAR

The advanced reservoir modeling program CMG STARS (Steam, Thermal, and Advanced Processes Reservoir Simulator) was developed by Computer Modelling Group Ltd. This program can simulate complex chemical, thermal, and sophisticated recovery processes in reservoirs. Because of its accuracy in replicating the fluid behavior of reservoirs under several enhanced oil recovery (EOR) procedures, such as chemical flooding, thermal recovery, and steam injection, it is widely used in the petroleum sector.

5. Result and Discussion

In this research, the rock core initially had a cylindrical shape, but for simulation purposes, the researchers decided to use a Cartesian type grid, as seen on Figure 2. In applying the Cartesian grid, the core rock which was originally round is assumed to be a cube with a known diameter of around 2.5 cm, which is equivalent to a radius of around 1.25 cm. Thus, the surface area of the core rock obtained is 4.908738521 cm^2. In the context of a Cartesian grid, the side of the cube obtained is about 2.70 cm, which is obtained by calculating the known area. In determining the Cartesian grid, the researcher decided to use 10 grids in the I direction, 1 grid in the J direction, and 1 grid in the K direction.

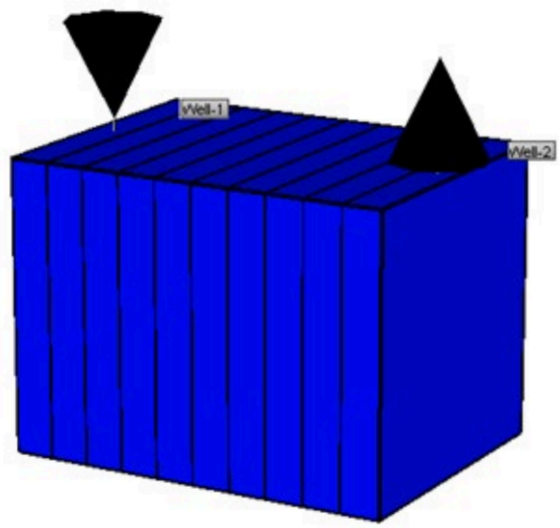


Figure 2. 3D grid model

IOP Conf. Series: Earth and Environmental Science **1451** (2025) 012038 doi:10.1088/1755-1315/1451/1/012038

The test results of Palm Oil MES from the EOR Laboratory had been inputted into the CMG simulation, that can be seen at the Table 2 as follows:

Table 2. Reservoir condition

No	Parameter	Mark
1	Permeability i	170 ms
2	Permeability j	170 ms
3	Permeability k	170 ms
4	Grid Top	230.94 cm
5	Grid Thickness	2,197 cm
6	Porosity	15.151%

Furthermore, the parameters related to the numerical method has been identified in the system process simulation, by entering a first time interval of 1 minute after a change occurs in the well.

In the final stage, as seen on Table 3, researchers input the parameters required for making the well. There are two types of wells used, namely injection wells and production wells. In the injection well, researchers input a surface water rate of 0.3 cc/min.

Table 3. Well and recurrent

Fluid Type	Fluid Composition
Water	98%
Surfactant	2%
Total	100%

In the surfactant flooding process, water is still used because its presence allows oil, which has experienced a decrease in surface tension due to the surfactant, to be pushed to the surface. The next step, researchers made a production well in base case conditions by entering a bottom hole pressure value of 101,325 kPa.

After perforating the well, researchers determine the time for waterflooding and surfactant flooding. Waterflooding starts in the time range 0 to 14 minutes, while surfactant flooding starts in the time range 14 to 30 minutes. At this stage, the model creation has been completed, and the cumulative oil results in surfactant trials from palm oil can be seen.

In the initial stage, the OOIP (original oil in place) obtained from laboratory testing will be adjusted (history matching) with the data generated by the CMG application. Table 4 shows the OOIP number from laboratory tests was 1.40 cm^3 and compared with CMG data.

Table 4. Comparison of error results

Items	LAB	CMG	ERROR
OOIP	1.40	1.39	0.01%

Surfactants from palm oil can be used and seen by varying the concentration value in obtaining the recovery factor as seen on Table 5, therefore the optimal recovery can be known which is recommended for use.

Table 5. Recovery factor value

Concentration	RF CMG (%)
0.50%	35.62177
0.75%	38.90137
1.00%	42.06398
1.25%	44.74862
1.50%	48.49816
1.75%	52.1187
2.00%	55.34526

The table explains that each variation in surfactant concentration has an impact on the recovery factor, but the optimal concentration is 2%. With this concentration, there is an increase in oil production or a recovery factor of 55.34526%, as seen on Figure 3.

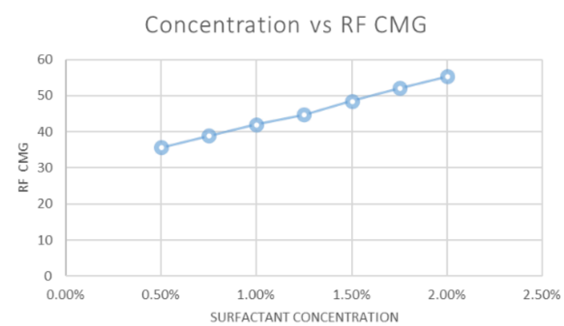


Figure 3. Surfactant concentration vs RF CMG

As the surfactant concentration rises, it enhances its capability to lower the tension between oil and water interfaces, thereby improving the mobilization and displacement of oil in the reservoir. This often results in a higher recovery factor, allowing more oil to be extracted effectively. However, it's crucial to pinpoint the ideal concentration because excessively high levels could lead to economic inefficiencies and potentially harm the reservoir's characteristics.

6. Conclusions

The influence of surfactant concentration on the recovery factor indicates that among the tested levels (0.5%, 1.0%, 1.5%, and 2.0%), the concentration of 2% achieves the highest recovery factor. This implies that as the concentration of surfactant increases, it improves its capability to reduce the interfacial tension between oil and water in the reservoir, thereby facilitating better mobilization and displacement of oil. As a result, higher concentrations are expected to enhance the efficiency of oil recovery. However, it's important to acknowledge that while higher concentrations of surfactant generally correlate with increased recovery factors, there are cases where further increases in concentration may not necessarily lead to higher recovery rates. This highlights the critical importance of carefully optimizing surfactant concentrations in reservoir engineering to maximize both the efficiency of oil recovery and economic viability.

7. Acknowledgement

This acknowledgement is dedicated to the Faculty of Earth Technology and Energy, Petroleum Engineering Department of Trisakti University, for their support in this research.

References

[1] Y. Zhu, G. Jian, W. Liu, L. Cheng, Q. Hou, and J. Li, "Recent Progress and Effects Analysis of Surfactant-Polymer Flooding Field Tests in China," in *All Days*, SPE, Jul. 2013. doi: 10.2118/165213-MS.

[2] R. L. Permadani, M. Ibadurrohman, and Slamet, "Utilization of waste cooking oil as raw material for synthesis of Methyl Ester Sulfonates (MES) surfactant," *IOP Conf Ser Earth Environ Sci*, vol. 105, p. 012036, Jan. 2018, doi: 10.1088/1755-1315/105/1/012036.

[3] S. Mahendran, P. Siwayanan, N. A. Shafie, S. K. Subbiah, and B. Azeem, "Exploring the Potential Application of Palm Methyl Ester Sulfonate as an Interfacial Tension Reducing Surfactant for Chemical Enhanced Oil Recovery," *Key Eng Mater*, vol. 797, pp. 402–410, Mar. 2019, doi: 10.4028/www.scientific.net/KEM.797.402.

[4] M. S. Dahbag and M. E. Hossain, "Simulation of Ionic Liquid Flooding for Chemical Enhance Oil Recovery Using CMG STARS Software," in *All Days*, SPE, Apr. 2016. doi: 10.2118/182836-MS.

[5] S. K. Rai, A. Bera, and A. Mandal, "Modeling of surfactant and surfactant–polymer flooding for enhanced oil recovery using STARS (CMG) software," *J Pet Explor Prod Technol*, vol. 5, no. 1, pp. 1–11, Mar. 2015, doi: 10.1007/s13202-014-0112-3.

[6] V. Fernanda, M. Ginting, and P. S. Yulia, "ANALISIS PENGARUH INJEKSI CO2 TERHADAP RECOVERY FACTOR MENGGUNAKAN SIMULASI CMG DI LAPANGAN X," *PETRO:Jurnal Ilmiah Teknik Perminyakan*, vol. 8, no. 1, pp. 28–34, Apr. 2019, doi: 10.25105/petro.v8i1.4292.

[7] R. R. Sukmana, A. Trisetia Anggara, M. M. Azis, R. B. Cahyono, and D. F. Putra, "A Simulation of Enhanced Oil Recovery of Surfactant Flooding Using Sodium Lignosulfonate by CMG-STARS," in *2019 2nd International Conference on Applied Information Technology and Innovation (ICAITI)*, IEEE, Sep. 2019, pp. 227–230. doi: 10.1109/ICAITI48442.2019.8982155.

[8] P. S. Yulia, S. Kasmungin, and M. T. Fathaddin, "ANALISIS SALINITAS DAN KONSENTRASI SURFAKTAN AOS DAN TWEEN 20 TERHADAP RECOVERY FACTOR PADA PROSES IMBIBISI DAN CORE-FLOODING," *PETRO:Jurnal Ilmiah Teknik Perminyakan*, vol. 9, no. 4, 2020, doi: 10.25105/petro.v9i4.8227.

[9] P. S. Yulia, S. Kasmungin, and M. T. Fathaddin, "Kajian Laboratorium Mengenai Pengaruh Salinitas, Jenis Surfaktan Dan Konsentrasi Surfaktan Terhadap Recovery Factor Dalam Sistem Injeksi Surfaktan Untuk Batuan Karbonat," *Prosiding Seminar Nasional Cendekiawan*, vol. 3, 2017.

[10] J. J. Sheng, "A Comprehensive Review of Alkaline-Surfactant-Polymer (ASP) Flooding," in *All Days*, SPE, Apr. 2013. doi: 10.2118/165358-MS.

Paper

ORIGINALITY REPORT

13%	12%	13%	7%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	Submitted to University of Kufa Student Paper	5%
2	research.chalmers.se Internet Source	2%
3	Qian Dong, Zhaogong Zhang, Dayuan Zheng, Zhiliang Zhang. "A New Method of Gene Information Vectorization and its Application in Similarity Search", Journal of Physics: Conference Series, 2020 Publication	1%
4	eprints.covenantuniversity.edu.ng Internet Source	1%
5	www.ceocongress.org Internet Source	1%
6	Yurong Jin, Shuxia Li, Daoyong Yang, Xingxing Jiang. "Determination of dissociation front and operational optimization for hydrate development by combining depressurization and hot brine stimulation", Journal of Natural Gas Science and Engineering, 2018 Publication	1%
7	Noraishah Othman, Akram Mujaddid Bin Abdul Halim, Muhammad Firdaus Hakimi bin Mohd Zulkarnain, Nazrul Hizam Yusoff. "Optimization of oil recovery using heated low salinity water (HLSW) in the horizontal sand pack column during water flooding:	1%

radiotracer intervention", IOP Conference Series: Materials Science and Engineering, 2024
Publication

8	Submitted to University of California, Los Angeles Student Paper	1 %

Exclude quotes	On	Exclude matches	< 15 words
Exclude bibliography	On		