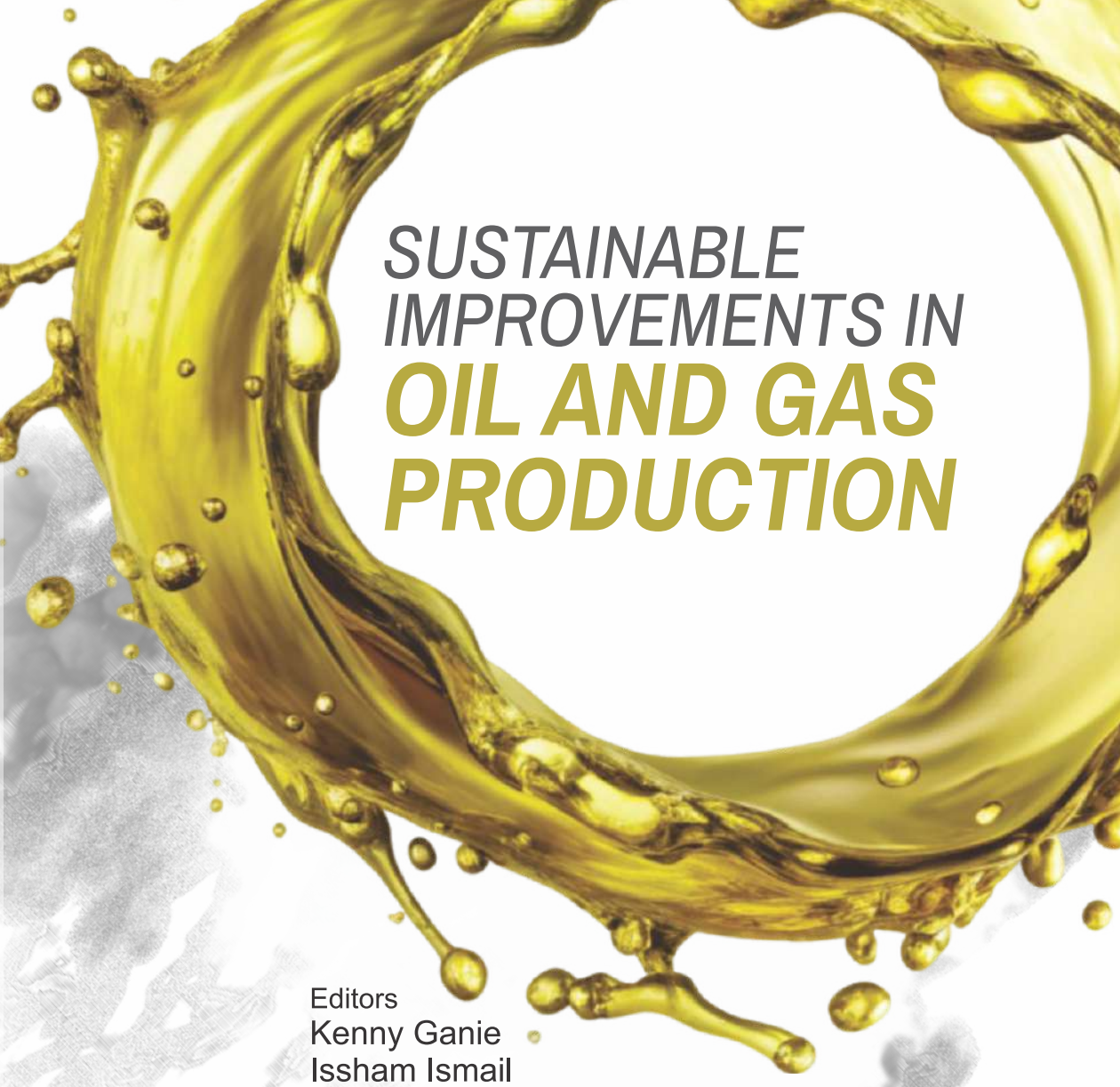

SUSTAINABLE IMPROVEMENTS IN OIL AND GAS PRODUCTION

Editors
Kenny Ganie
Issham Ismail

UTM
UNIVERSITI TEKNOLOGI MALAYSIA

SUSTAINABLE IMPROVEMENTS IN **OIL AND GAS PRODUCTION**

This book explores the importance of hydrocarbons in various aspects of human existence, including their recovery. It highlights the need for renewable energy sources and discusses the hydrocarbon formation process, drilling procedures, and reservoir production obstacles. It also discusses condensate banking, a problem in retrograde condensate reservoirs, and the development of a wettability alterationagent from surface-modified nanoparticles to enhance hydrocarbon recovery. Additionally, the study investigates the feasibility of using partly hydrophobic nanoparticles to enhance foam stability in oil recovery. The authors suggest that adding nanoparticles with changed wettability can improve the performance of traditional surfactant-stabilised foam. The study also examines the interplay between nanoparticles and wettability alteration, focusing on changes in interfacial energy, modulation of contact angles, and surface functionalisation. Similarly, the book also discusses the application of nanoparticles in enhanced oil recovery (EOR) techniques, which involve the injection of various chemicals. Nanoparticles have shown significant benefits in EOR applications due to their small size, significant surface energy, and adaptability to incorporate multiple functionalities. However, applying nanoparticles in EOR has drawbacks, such as agglomeration and precipitation in porous media, leading to core plugging and reduced permeability and oil recovery. In conclusion, this book provides a comprehensive understanding of the sustainable improvements in oil and gas production. By addressing these challenges and developing effective recovery techniques, the oil and gas recovery can be significantly improved.

UTM
UNIVERSITI TEKNOLOGI MALAYSIA
Penerbit
UTM Press

UTM PRESS

ISBN 978-983-52-2106-4
9 789835 221064
RM50.00

SUSTAINABLE IMPROVEMENTS IN ***OIL AND GAS PRODUCTION***

SUSTAINABLE IMPROVEMENTS IN ***OIL AND GAS PRODUCTION***

Editors
Kenny Ganie
Issham Ismail

Penerbit UTM Press
UNIVERSITI TEKNOLOGI MALAYSIA
www.penerbit.utm.my
2025

First Edition 2025

Editor/ *Editors*: **KENNY GANIE & ISSHAM ISMAIL**
Editor Penyelaras/*Acquisition Editor*: **MAZLAN BIN SAID**
Pereka Kulit /*Cover Designer*: **FAHAMIN BIN ABDUL GHANI**

Diatur huruf oleh /*Typeset by*:
KENNY GANIE & ISSHAM ISMAIL
Faculty of Chemical & Energy Engineering
UNIVERSITI TEKNOLOGI MALAYSIA
81310 UTM Johor Bahru,
Johor Darul Ta'zim, MALAYSIA

Diterbitkan di Malaysia oleh/
Published in Malaysia by:
PENERBIT UTM PRESS
UNIVERSITI TEKNOLOGI MALAYSIA
81310 UTM Johor Bahru,
Johor Darul Ta'zim, MALAYSIA
(Ahli Majlis Penerbitan Ilmiah Malaysia (MAPIM) dan
Persatuan Penerbit Buku Malaysia (MABOPA)
no. keahlian 9101)

Dicetak di Malaysia oleh/
Printed in Malaysia by:
JASAMAX ENTERPRISE
No.16, Jalan Kebudayaan 2,
Taman Universiti,
81310 Skudai,
Johor Darul Ta'zim,
MALAYSIA

Cataloguing-in-Publication Data
Perpustakaan Negara Malaysia
A catalogue record for this book is available from the
National Library of Malaysia
ISBN 978-983-52-2106-4

CONTENTS

CONTRIBUTORS

Abdul Rahim Risal *Faculty of Chemical and Energy Engineering, Universiti Teknologi Malaysia, Johor Bahru*

Ahmad Kamal Idris *Faculty of Chemical and Energy Engineering, Universiti Teknologi Malaysia, Johor Bahru*

Azad Anugerah Ali Rasol *Faculty of Chemical and Energy Engineering, Universiti Teknologi Malaysia, Johor Bahru*

Chong Aik Shye *Faculty of Chemical and Energy Engineering, Universiti Teknologi Malaysia, Johor Bahru*

Dzeti Farhah Mohshim *Universiti Teknologi PETRONAS, Tronoh*

Issham Ismail *Faculty of Chemical and Energy Engineering, Universiti Teknologi Malaysia, Johor Bahru*

Jeffrey O. Oseh *Faculty of Chemical and Energy Engineering, Universiti Teknologi Malaysia, Johor Bahru*

Kenny Ganie *Faculty of Chemical and Energy Engineering, Universiti Teknologi Malaysia, Johor Bahru*

Luqman Norrani *MISE Energy Sdn. Bhd., Kuala Lumpur*

Muhammad Muhammad *Faculty of Chemical and Energy Engineering, Universiti Teknologi Malaysia, Johor Bahru*

Muhammad Noorul Anam Mohd Norddin *Faculty of Chemical and Energy Engineering, Universiti Teknologi Malaysia, Johor Bahru*

Muhd. Hafeezuddin *Faculty of Chemical and Energy Engineering, Universiti Teknologi Malaysia, Johor Bahru*

Nadiah N. Yaakob *Faculty of Chemical and Energy Engineering, Universiti Teknologi Malaysia, Johor Bahru*

Nur Aisyah Ismail *Faculty of Chemical and Energy Engineering, Universiti Teknologi Malaysia, Johor Bahru*

Nur Bashirah Azli *Faculty of Chemical and Energy Engineering, Universiti Teknologi Malaysia, Johor Bahru*

Osmah Amer Abduljaleel *Faculty of Chemical and Energy Engineering, Universiti Teknologi Malaysia, Johor Bahru*

Sharul Nizam Hasan *Faculty of Chemical and Energy Engineering, Universiti Teknologi Malaysia, Johor Bahru*

PREFACE

The first chapter examines multiple facets of hydrocarbons and their significance to humanity. This underscores the necessity for alternate sources of renewable energy in view of the diminishing hydrocarbon resources and the concomitant challenges posed by their utilisation, such as air pollution and global warming. The next paragraphs provide an explanation of the hydrocarbon formation process, the drilling procedure, the utilisation of drilling fluids, and the obstacles encountered during reservoir production. It also examines the significance of traps and reservoirs within the petroleum industry, as well as the various classifications of hydrocarbons present in these reservoirs. In general, this chapter presents a thorough exposition of hydrocarbons and their importance in diverse facets of human existence.

Chapter 2 highlights the issue of condensate banking (also known as condensate blockage) in a retrograde condensate reservoir. The resulting condensate banking will clog the connected pore spaces, which can lead to a reduction in the reservoir's permeability. Generally, the condensate banking can happen when a reservoir pressure drops below the dew point of its phase envelope with constant temperature, and subsequently some heavy components in the gas stream will start to condense and result in a liquid condensate. Reservoir and production engineers can employ a variety of tactics and strategies to address the issue, but wettability alteration using chemical injection is believed to be the best option for a long-term solution. The collaborative research work used three types of chemicals, WA A, WA B, and WA C, supplied by MISE Energy Sdn. Bhd. The three chemicals can alter the petrophysical properties of the core slices by changing them from liquid wet to gas wet and this may increase the gas deliverability in condensate reservoirs that

are facing clogging issues caused by the condensate banking. The Krüss DSA25E apparatus and sandpack testing were used in laboratory works to evaluate their performances and eventually to determine the best chemical that could alter the wettability of sandstone to water wet in an effective manner.

Chapter 3 focusses on the development of a wettability alteration agent from surface modified nanoparticles to enhance hydrocarbon recovery. By using 1H, 1H, 2H, 2H-perfluorodecyl-triethoxysilane (FAS17), a novel surface-modified silica nanoparticle was synthesised and characterised further to evaluate the wettability alteration capability. To begin, tetraethoxysilane (TEOS) was used as the silica precursor and a water-soluble amine was used as the catalyst in the in-situ functionalisation technique. To create fluorinated silica nanoparticles, FAS17 was added to an ethanolic solution. The application of in-situ functionalisation was validated by characterisation techniques like Fourier transform infrared spectroscopy (FTIR), dynamic light scattering (DLS) measurement, zeta potential analysis, X-ray photoelectron spectroscopy (XPS), and thermogravimetric analysis (TGA). This novel surface-modified silica nanoparticle can change the wettability of the solid surface and exhibit self-cleaning properties, as shown by a series of wettability screening tests. Hence, with the development of this wettability alteration agent, the hydrocarbon recovery could be improved by changing the wettability of the reservoir.

The present study investigates the feasibility of utilising partly hydrophobic nanoparticles to enhance foam stability in the context of oil recovery. The authors in Chapter 4 further suggest that the addition of nanoparticles with changed wettability can enhance the performance of traditional surfactant-stabilised foam. The study aims to examine the efficacy of nanoparticles' attachment in foam film and evaluate the hydrophobic or wettability properties of these nanoparticles. The investigation took into account other characteristics, including pH, salinity, concentration of surfactants, and concentration of nanoparticles. The primary objective of the researchers is to enhance the stability of foam by the reduction of gas mobility and the

improvement of the controlling viscosity ratio. The study employs traditional surfactant-stabilised foam as a reference point while including wettability-modified nanoparticles in order to enhance the stability of the foam.

The intricate interplay between nanoparticles and the alteration of wettability is further highlighted in Chapter 5. Its aim is to provide a comprehensive understanding of the underlying mechanisms and diverse applications. The chapter begins by elucidating the fundamental principles of wettability and emphasising its pivotal role in interfacial phenomena, particularly in improving oil and gas production. It then explores the multifaceted ways in which nanoparticles can modify surface wettability, including changes in interfacial energy, modulation of contact angles, and surface functionalisation. The theoretical frameworks and experimental methodologies employed in studying these modifications are also discussed. In this chapter, the investigation of wettability alteration and interfacial tension of carbonate reservoirs using silica nanoparticles with surfactant in the presence of low saline water is presented. The results show that the adsorption of nanoparticles and surfactants of appropriate size can change the wettability of the wall surface and facilitate fluid flow in the nanopore. It was observed that smaller particle sizes resulted in higher wettability alteration and oil recovery. The chapter also discusses the surface modification of silica nanoparticles to achieve colloidal stability in concentrated brine and change the wettability of carbonate reservoirs from oil-wet to water-wet. It was found that negatively charged silica nanoparticles in low saline water altered the wettability of the calcite surface to intermediate wet, while cationic surfactants altered it to water-wet.

The need for natural resources is increasing as industrialisation expands, and oil companies aim to increase mature oilfields' recovery factor through enhanced oil recovery (EOR) techniques. Chemical enhanced oil recovery (CEOR) involves the injection of various chemicals, such as alkaline substances, surfactants, polymers, and combinations thereof. Nanoparticles have demonstrated remarkable benefits in EOR applications due to their small size, significant surface

energy, and adaptability to incorporate multiple functionalities. However, applying nanoparticles in EOR has some drawbacks, such as agglomeration and precipitation in porous media, leading to core plugging and reducing permeability and oil recovery. Nanoparticle-surfactant mixtures have proven superior EOR performance as the surfactant can stabilise the nanoparticles. This study in Chapter 6 investigates how the salt content can affect the interfacial tension (IFT), wettability, and oil recovery by comparing oil recovery by displacing sandpacks with water, sodium dodecyl sulphate (SDS), zinc oxide nanoparticles (ZnO NPs) with SDS, and the mixture of SDS, ZnO NPs, and sodium chloride (NaCl).

Finally, the authors and editors express their gratitude to the Universiti Teknologi Malaysia Press for publishing the book chapters. To the readers, should you have any comments and constructive ideas to improve the contents of this book, please do not hesitate to forward them to us.

Thank you.

Kenny Ganie
Issham Ismail
Universiti Teknologi Malaysia
2025