

## Article

# Waterflooding of Surfactant and Polymer Solutions in a Porous Media Micromodel

Hsiang-Lan Yeh and Jaime J. Juárez \* 

Department of Mechanical Engineering, Iowa State University, 2529 Union Drive, Ames, IA 50011, USA; hsiang@iastate.edu

\* Correspondence: jjuarez@iastate.edu; Tel.: +1-515-294-3298

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**Abstract:** In this study, we examine microscale waterflooding in a randomly close-packed porous medium. Three different porosities were prepared in a microfluidic platform and saturated with silicone oil. Optical video fluorescence microscopy was used to track the water front as it flowed through the porous packed bed. The degree of water saturation was compared to water containing two different types of chemical modifiers, sodium dodecyl sulfate (SDS) and polyvinylpyrrolidone (PVP), with water in the absence of a surfactant used as a control. Image analysis of our video data yielded saturation curves and calculated fractal dimension, which we used to identify how morphology changed the way in which an invading water phase moved through the porous media. An inverse analysis based on the implicit pressure explicit saturation (IMPES) simulation technique used mobility ratio as an adjustable parameter to fit our experimental saturation curves. The results from our inverse analysis combined with our image analysis show that this platform can be used to evaluate the effectiveness of surfactants or polymers as additives for enhancing the transport of water through an oil-saturated porous medium.

**Keywords:** porous media; optical video microscopy; microfluidics; waterflooding; surfactants; polymers

## 1. Introduction

Understanding multiphase flows in porous media is critical for enhancing the recovery of oil from porous bedrock [1]. When a reservoir is tapped through a wellbore in the bedrock for the first time, a pressure differential between the reservoir and the wellbore can be used as a primary form of recovery. Once the pressure differential reaches hydrostatic equilibrium, secondary forms of recovery such as waterflooding (i.e., water injection) can be used to extract the remaining oil [2]. Approximately 40% of the total available oil is extracted using these two methods [3].

Chemical methods, including the addition of surfactants, polymers, or alkali to the water, are used to enhance the recovery of oil beyond the 40% limit encountered with hydrostatic pressure and water [4,5]. Surfactants in water reduce the interfacial tension between the water and the oil, which also reduce the capillary forces and enhance the oil displacement efficiency [6,7]. Polymers act as viscosifying agents, where the inherent viscoelasticity of the polymer flood generates localized non-Newtonian shear stress that pulls oil threads [8,9]. A modification of the relative difference in phase viscosities, known as mobility, is known to enhance oil displacement [10,11]. A combination of chemical methods has been proposed as an effective method for enhancing oil recovery [12].

Understanding how these mechanisms act in isolation to each other and how they can be combined is critical for improving oil displacement efficiency. However, transport through oil-bearing porous media occurs at a rate of one linear foot per day [13], and the direct observation of large-scale oil displacement phenomena can take weeks [14], making the study of multiphase processes slow and

# Solution Manual For Waterflooding

**RJ Alexander**



## **Solution Manual For Waterflooding:**

Surfactants and Cosolvents for NAPL Remediation A Technology Practices Manual Donald F. Lowe, Carroll L. Oubre, C. H. Ward, 1999-03-26 A 19 3 million Department of Defense grant to Rice University funds the Advanced Applied Technology Demonstration Facility AATDF One of the project goals is the development of reduction strategies for nonaqueous phase liquids NAPLs in the subsurface Surfactants and Cosolvents for NAPL Remediation records the results of AATDF research The manual is a guide to the practical application of surfactants cosolvent for in situ remediation It is targeted to decision makers and anyone concerned with the design or implementation of these technologies The book discusses the situational viability of surfactants cosolvents the possible results design and operation It includes case studies step by step guidance and project cost work sheets The successful results of the AATDF research as documented Surfactants and Cosolvents for NAPL Remediation are an invaluable contribution to the future of subsurface remediation Without source NAPL reduction the alternative is decades of plume management through pump and treat Field Manual of Techniques in Invertebrate Pathology Lawrence A. Lacey, Harry K. Kaya, 2013-06-29 The 38 chapters of this Field Manual provide the tools required for planning experiments with entomopathogens and their implementation in the field Basic tools include chapters on the theory and practice of microbial control agents statistical design of experiments equipment and application strategies The major pathogen groups are covered in individual chapters virus bacteria protozoa fungi nematodes Subsequent chapters deal with the impact of naturally occurring and introduced exotic pathogens and inundative application of microbial control agents The largest section of the Manual is composed of 21 chapters on the application and evaluation of entomopathogens in a wide range of agricultural forest domestic and aquatic habitats Mites and slugs broaden the scope of the book Supplementary techniques and media for follow up laboratory studies are described Three final chapters cover the evaluation of Bt transgenic plants resistance to insect pathogens and strategies to manage it and guidelines for evaluating the effects of MCAs on nontarget organisms Readership Researchers graduate students practitioners of integrated pest management regulators those doing environmental impact studies The book is a stand alone reference but is also complementary to the laboratory oriented Manual of Techniques in Insect Pathology and similar comprehensive texts Development Geology Reference Manual Diana Morton-Thompson, Arnold M. Woods, 1993 Fossil Energy Update, 1977 The Design Engineering Aspects of Waterflooding Stephen C. Rose, John F. Buckwalter, 1989 The Design Engineering Aspects of Waterflooding provides a practical guide to the design of surface facilities and wells for a waterflood A Qualitative Evaluation of Stochastic Waterflood Performance Prediction Models Tracy A. Freeling, 1993 **Reservoir Simulation Manual** Scientific Software Corporation, 1975 Laboratory Evaluation of Water Additives for Petroleum Displacement H. N. Dunning, Robert T. Johansen, 1957 **Catalog of Copyright Entries. Third Series** Library of Congress. Copyright Office, 1974 *Monthly Catalog of United States Government Publications*, 1975 **Petroleum Engineering Handbook**

Howard B. Bradley, Fred W. Gipson, 1987      **Space Shuttle--skylab 1973** United States. Congress. House. Committee on Science and Astronautics, 1973      Machine Learning Applications in Subsurface Energy Resource Management Srikanta Mishra, 2022-12-27 The utilization of machine learning ML techniques to understand hidden patterns and build data driven predictive models from complex multivariate datasets is rapidly increasing in many applied science and engineering disciplines including geo energy Motivated by these developments Machine Learning Applications in Subsurface Energy Resource Management presents a current snapshot of the state of the art and future outlook for ML applications to manage subsurface energy resources e g oil and gas geologic carbon sequestration and geothermal energy Covers ML applications across multiple application domains reservoir characterization drilling production reservoir modeling and predictive maintenance Offers a variety of perspectives from authors representing operating companies universities and research organizations Provides an array of case studies illustrating the latest applications of several ML techniques Includes a literature review and future outlook for each application domain This book is targeted at practicing petroleum engineers or geoscientists interested in developing a broad understanding of ML applications across several subsurface domains It is also aimed as a supplementary reading for graduate level courses and will also appeal to professionals and researchers working with hydrogeology and nuclear waste disposal      **Report of Investigations** ,1957      **EPA-600/2** ,1979      **Radius of Pressure Influence of Injection Wells** University of Missouri--Rolla, Donald L. Warner, 1979      *Research Reporting Series* ,1979      **Modern Water Resources Engineering** Lawrence K. Wang, Chih Ted Yang, 2014-01-11 The Handbook of Environmental Engineering series is an incredible collection of methodologies that study the effects of pollution and waste in their three basic forms gas solid and liquid This exciting new addition to the series Volume 15 Modern Water Resources Engineering has been designed to serve as a water resources engineering reference book as well as a supplemental textbook We hope and expect it will prove of equal high value to advanced undergraduate and graduate students to designers of water resources systems and to scientists and researchers A critical volume in the Handbook of Environmental Engineering series chapters employ methods of practical design and calculation illustrated by numerical examples include pertinent cost data whenever possible and explore in great detail the fundamental principles of the field Volume 15 Modern Water Resources Engineering provides information on some of the most innovative and ground breaking advances in the field today from a panel of esteemed experts      **Energy Research Abstracts** ,1985      **Petroleum Abstracts** ,1993

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