MICROBIAL ENHANCED OIL RECOVERY

ABSTRACT

Microbial enhanced oil recovery is a tertiary oil recovery mechanism that uses microorganisms and their metabolites to recover residual oil from reservoir through mechanisms such as, production of biosurfactants, biomass, acids, or gas that alters reservoir fluid properties. MEOR is an effective, economically friendly technology with several advantages over other recovery technology such as been inexpensive for field operation, wide variety of application, good ecological characteristics, highly efficient in oil recovery, use of less energy as compared to other tertiary recovery technology and offers the opportunity to optimize production in marginal fields. MEOR has huge resemblance to chemical EOR (CEOR) because same chemical used in CEOR are same with those produced by microbes for EOR.

In the past, it was argued that biodegraded of oil by microorganisms was only possible in the presence of oxygen but recent investigations have revealed the possibility of biodegradation of oil in the absence of oxygen by facultative or anaerobic microbes.

This study covers both critical literature review and laboratory study. Literature review revealed that vast amount of successful laboratory studies that supports microbial use in oil recovery have been conducted as against field applications due to extensive unavailability of laboratory trails results in public domain and MEOR been perceived as an indistinct process, etc. A laboratory study that focused on the rate of biodegradation of decane using batch bioreactors under anaerobic condition for an incubation period of 29-days was conducted with soil sample randomly collected within Aberdeen city and inoculated in batch bioreactors in the presence of Nitrogen. Nitrate reducing bacteria consumed 63% of nitrate resulting to 28 % biodegradation of decane with a peak formation of 3.58 g/L of total suspended solid on day 22 of study and a low growth rate of 0.0325 per day in comparison with a previous study that obtain which used galactose used as carbon source with nitrate as carbon source.

MEOR is therefore a high-risk and high-reward process that is very dependent on the selection, injection of microbes and nutrient respectively or activation of indigenous microbes by injected nutrient is managed during field application(s) to overcome the constraints of MEOR for production of the required metabolite(s).

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CHAPTER 1

INTRODUCTION

1.1 Problem Background

Energy plays significant roles in various sectors of countries across the globe such as transportation, agriculture, education, and production sectors, etc. [1]. The increase in world population estimated to reach 9.1 billion by 2050, an estimated annual economic growth rate of 3.3 % and a 0.74 % annual increase in global energy consumption poses serious concerns on energy security, affordability and reliability due to the determinant roles of energy in the stability of a country and the global economy [2]. World Energy Assessment 2000, buttressed this when it said, *"the accomplishments of civilization have largely been achieved through the increasingly efficient and extensive harnessing of various forms of energy so as to extend human competencies and inventiveness" [3].* Therefore, it is right to acknowledge that the world runs on energy.

Energy sources extend from renewables to non-renewables sources such as wind, hydro, geothermal and solar to crude oil, natural gas, coal which are collectively called fossil fuels [4, 5]. Presently, the total global energy use is 524 quadrillion British Thermal Unit (BTU) with fossil fuels supplying 82 % out of which oil accounts for 33 % of theglobal energy generated from fossil fuels [6]. Although, there are huge concerns of the impact of oil on the environment, its use is still profound even in the 21st century due to its high calorific energy value [7]. More so, most economies of the world currently rely on products from crude oil and any situation of insufficient supply of oil will endanger the development of these countries not forgetting the simultaneous effect of an increase in living cost [8].

However, with the finite nature of oil reservoir, depleting mature oilfields and difficulties in discovery of alternative new oilfields, there are fears if the present amount of oil recovered will be sufficient to meet increasing global demand especially as two-third of original oil in place remain trapped in pores after primary and secondary recovery [5, 9-11]. However, the prospective alternatives to mitigate these fears lies in the possibility of exploring of new energy sources or the utilization of enhanced oil recovery (EOR) a more

efficient and effective recovery mechanism that target recovery of residual oil from the reservoir.

Although, oil recovery has improved with the deployment of enhanced oil recovery (EOR) techniques like thermal recovery, chemical and gas injection, there is still need for massive development of EOR and other new technologies mainly because only about 0.3 million m^3 of oil is recovered from mature oilfields using the present EOR technologies [12].

A promising alternative is microbial enhanced oil recovery (MEOR), a novel approach that involves the use of microbes and their metabolites to enhance the recovery of residual oil from the reservoir [13]. MEOR process involves the injection of microbes and relevant nutrients into the reservoir, thereby facilitating microbial growth and reaction under favourable conditions resulting to mobilization of residual oil by metabolites [14]. The use of microbe is of great advantage economically when compared with the other techniques of enhanced oil recovery because microorganisms require insignificant amount of energy input for oil recovery [15, 16]. This is can enhance oil recovery because microbial culture media have the capability to synthesize various biochemical using crude oil if provided with the appropriate nutrient and favorable biochemical condition in the reservoir. In addition, several types of microbes have been found to exist in-situ in the reservoir.

1.2 Problem Statement

Oil recovery from reservoir is achieved through three recovery mechanisms; primary, secondary and tertiary recovery. In primary recovery, oil is produced using the natural pressure drive present in the reservoir and when the pressure in the reservoir declines due to production and can no longer force oil into production wells, secondary recovery mechanism is employed to recover oil by the injection of fluids such as water or gas. The amount of oil re covered in the primary and secondary stage is within the range of $20\ \% - 50\ \%$ of original oil in place although this is dependent on the properties of oil and the reservoir [17]. However, after primary and secondary recovery mechanism, two-third of original oil in place (OOIP) remain trapped in reservoir pore spaces as residual oil, although with the application of EOR, this percentage is drastically reduced [10].

Although, the present EOR technologies has improved oil production, there is need to develop a more efficient and effective EOR technique like MEOR to enhance oil recovery from the reservoir due to the amounf or residual oil left in the reservoir with present EOR. MEOR comprises of a series of biochemical reactions and production of several metabolites such as biopolymers; bio-surfactants etc., which facilitate oil recovery from the reservoir.

MEOR stands out from other EOR techniques such as thermal EOR because it uses small amount of energy, non-thermal method like chemical injection because bacteria produce extensive products from renewable sources in the reservoir while the later uses synthetic chemical products of petroleum based compounds for EOR [14]. There is no doubt in the ability of microorganisms been relevant in enhanced oil recovery but the concern is how to transform MEOR from laboratory-based technology to a field technology with extensive application. Hence, more research is required for MEOR, which in so doing will facilitate full field application.

1.3 Research Objectives

The objectives of this study are:

1. Review of relevant literature on microbial enhanced oil recovery (MEOR).
2. Investigate the rate of biodegradation of decane under anaerobic condition using a batch bioreactor.

1.4 Novelty and Significance

Fields in the North Sea have seen decline in oil production rate that averages around 6 % with projections indicating lower production in 2014 and continuous decline in the future due to mature UK fields [18]. This study will be relevant and propel further studies towards the application of MEOR technology to boost production in the North Sea especially as the UK oil and gas sector is aiming for higher recovery factor, which now averages about 46 % [19].