CHAPTER 8

Estimation of Incremental Oil Recovery in Heterogeneous Formation for the Surfactant-Polymer Formulation and Salinity Variation via Simulation Approach

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8.1 INTRODUCTION

Energy demand is constantly increasing across the world due to the economic development and increase in world population. Energy is the foundation that sustains and propels a country's socio-economic growth. Malaysia is well-known as one of the countries that had been relied on fossil fuels as primary sources of energy for decades. Oil and gas which are categorized under fossil fuels are generally dominant world energy sources compared to the other sources of energy such as hydro, solar, or wind. For instance, oil is the most extensively used energy source globally, representing 33% of total demand. The total energy consumed is expected to rise to 38% between 2015 and 2035, due to population expansion and global economic development

(Druetta et al., 2019). Obviously, the global economy has not ready yet in abandoning its reliance on oil. This statement was in line with previous scholars who claimed that cleaner energy sources such as wind, solar, and fuel cells are still not yet ready to move to the next level and replace oil as the world's primary source of demand (Chapman, 2014; Maggio & Cacciola, 2012).

Oil recovery contained primary, secondary, and tertiary phases. For the primary, oil recovery is limited to oil that rises naturally to the surface or with the assistance of artificial lift devices. For the secondary phase, oil recovery employs water and gas injection. The most interesting one is tertiary oil recovery-enhanced oil recovery (EOR), whereby the incremental oil recovery (IOR) is obtained due to its efficiency in displacing the un-mobilized and un-swept oil in the reservoir after performing the oil recovery either by the primary or secondary phases. Briefly, EOR can be classified into three categories which are thermal, solvent, and chemical methods. Thermal methods basically reduce the oil viscosity by adding heat to the reservoir while the solvent methods apply an injection of solvents (for example, hydrocarbon miscible, CO_2 miscible and immiscible, nitrogen) which subsequently mix together with oil in the reservoir to increase the mobility of oil. A chemical enhanced oil recovery (CEOR) method exploits chemicals such as polymer, surfactant, alkali, or a combination of them (SP: surfactant-polymer, ASP: alkaline-surfactant-polymer) to increase oil recovery. Oil-water interfacial tension (IFT) can be lowered and the wettability of the reservoir rock can be changed by an application of surfactants (Wang et al., 2019). Polymers are added to increase the viscosity and control the mobility of injected water (Wang et al., 2019). In-situ surfactant will form when the alkali reacts with crude oil. Those above-mentioned chemicals could be combined and acted as complements to each other so that, the desired properties and functions could be obtained.

Due to the shortage of oil resources and the passage of the first and second life periods of present reservoirs (matured reservoirs), the application of EOR methods becomes substantial increasingly important. Along with technological advancements and the introduction of supercomputers in recent years, the utilization of simulation approaches in EOR methods has expanded and become a major interest (Jafari et al., 2020). As a branch of fluid mechanics, computational fluid dynamics (CFD) is well suited to be applied in researching as well as simulating EOR methods. In comparison to experimental methods, this simulation strategy saves time and money, is capable of efficiently simulating complicated and difficult conditions, and provides useful information which resembles what is happening in the actual conditions. In several sectors of chemical and petroleum engineering, CFD is commonly used because it can provide engineers with a better comprehension of fluid flow systems. Thus, CFD is highly preferred as a tool for analyzing systems as well as monitoring fluid flow in hydrocarbon resource (Jafari et al., 2020) which specifically use the generated quantitative prediction of fluid flow phenomena based on the equations of mass, momentum, and energy conservation that govern the fluid flow (Jacinta et al., 2021).

In previous reported works (Saxena et al., 2019), they synthesized and characterized a new anionic surfactant from Madhuca longifolia (Mahua) which contained a mixture of the sulphonated ester. Besides, a core flooding experiments using a sandstone core (porosity ~ 0.32, permeability = 350 mD) and CFD simulations for the IOR determination were also performed, but limited to the concentration of surfactant which produced an ultralow interfacial tension (IFT) i.e., surfactant flooding (IFT oil-9000 ppm surfactant = 0.01 mN/m) and SP flooding (IFT oil-9000 ppm surfactant + 200 ppm partially