UNIVERSITI TEKNOLOGI MARA

CHARACTERIZATION OF SILICATE SCALE FORMATION : THE EFFECT OF PH ON SILICATE SCALE FORMATION MECHANISM

MUHAMMAD FARID BIN MOHD YAZID

B.Eng. (Hons) Oil & Gas

January 2019

ABSTRACT

One of the challenging situations or problems that engineers nowadays have been encountering in oil and gas industry is the formation of silicate scale. ASP flooding is one of the methods used to improve the oil recovery efficiency, however this technique could produce the silicate scale which apparently are difficult to be removed once they formed. Frequent shut down for cleaning and maintenance not only costing more money, but also will causing loss in profit as the production and process need to be stopped during maintenance. Initially, the ASP sludge was injected into the reservoir at high pH value and this condition will silica dissolution in the sandstone reservoir. As it propagating within the reservoir from the injection well to the production well, it will mix up with the connate water that is essentially at neutral pH. The mixing of these waters resulted in reduced pH condition inside the reservoir which will reduce the solubility of silica. Supersaturation condition is achieved and will induce the formation of silicate scale formation. Silicate scale is pH dependent scale type and it is postulated that different type and morphology will be produced with the variation of pH. In this work, duplicate samples were prepared to reproduce the ASP leachate by mixing the magnesium brine to represent the connate water (low pH) with silica brines that represent ASP sludge (high pH). The first duplicate sample was pH adjusted to pH 8.5 and left reacted at room temperature for 22 hours. Another duplicate sample was left reacted at its mixed pH of approximately ~11, room temperature for the same duration. The third duplicate sample was reacted at the same condition as the second duplicate before being pH adjusted to pH 8.5 at 22 hours and left reacted for another 22 hours. All precipitate produced from these three reaction condition were filtered and analyzed using Fourier’s Transformation Infra-Red (FTIR) and X-ray Diffraction (XRD) to characterize the samples. The pure commercial samples which were magnesium silicate, magnesium hydroxide and silicon dioxide were also analyzed as a comparison to the produced precipitate. Sample in lower initial pH condition demonstrated a XRD pattern with higher intensity, sharp peak and also longer diffraction signals distance indicates that the scale is crystalline. FTIR spectra confirmed the presence of Si-O covalent bond and Si-O-Si stretching and Si-O-Mg functional group in all three conditions. Results clearly show that pH will affect the type and morphology of precipitate significantly and the precipitates were able to be characterized by using the spectroscopic analysis.

ACKNOWLEDGEMENT

Alhamdulillah. Praise to god for giving me this precious opportunity to commence on this pleasurable and challenging journey during progress of completing my thesis. I also would like to show my special gratitude to my parents, Mohd Yazid Bin Kasim and for the continuous love and support to me throughout completing this thesis. Apart from supports in terms of money and time, they were always beside me to encourage and boost my morale.

My next special gratitude goes to my supervisor, Madam Rozana Azrina Binti Sazali for always giving support, guidance, supervision, encouragement and advices in assisting me to make this final year project a successful one.

Apart from that, I also would like to express my appreciation to researchers, academicians, lab technician, my colleagues and friends for their help in completing my project.

TABLE OF CONTENT

CHAPTER ONE: INTRODUCTION

CHAPTER TWO: LITERATURE REVIEW

CHAPTER ONE

INTRODUCTION

1.1 Definitions and mechanism of silicate scale formation

Scale can be defined as the secondary deposit of inorganic compounds that is caused by the presence of fluids in a system at least partially manmade (Vetter, 1987) by which silicate scale formation is not a foreign thing in oil and gas industry. Silicate scaling usually occurs in the production well during alkaline surfactant polymer (ASP) flooding. Generally, during alkaline flooding, the water usually has pH 11 or higher when it sweeps the fluid within the reservoir. This water with high pH usually dissolves quartz in the formation, producing dissolve monomeric silica ($Si(OH)_3O^- Na^+$) ion, along with the water flood (Arensdorf et al., 2010).

Apart from that, scaling problems are usually caused from the usage of geothermal fluid. Apparently, water chemistry is reliant on the water rock interaction, and controlled by mineral equilibrium. The processes will cause scaling to occur, and the forming mineral with the water chemistry makes it hard to predict scaling during utilization of geothermal (Hirasaki et al.,2008). The most common deposits that can be found in geothermal utilization are due to silica, calcium carbonate, amorphous silica, iron silicates, calcite and magnesium silicates. Calcium carbonate and amorphous silica is the mostly predicted well product of scaling by chemical analysis of the water. Furthermore, scaling also can be produced from formation of solids in drillholes, corrosion of metals in the drillholes casing and from other installations processes.

As ASP water has high pH, it does contain dissolved silica but does not contain calcium or magnesium. This is because both of these cations precipitate in the formation as hydroxides and carbonates. At first, the ASP water will enter the well, then mixes with neutral pH water that contains calcium and magnesium. From this,