Preparation and Characterization of Chemical Agents for Injectivity Improvement in Low Permeability Reservoirs

Min Zhao[1], Xiutai Zhao[2] and Daoyong Yang[1]

Abstract

Although volumes of original-oil-in-place (OOIP) are large in reservoirs with low and ultralow permeability, the inherent low permeability creates huge challenges in producing hydrocarbons from and injecting external fluids into such formations. In this study, techniques have been developed to prepare and characterize chemical agents for improving injectivity in low permeability reservoirs. Firstly, chemical agents are selected, formulated, and optimized on the basis of interfacial tension (IFT), scale inhibition ratio, and clay particle size distribution and specific surface area. The spinning drop method is utilized to measure the IFT between crude oil and the formulated solution, while contact angle between brine and rock surface is measured to examine effect of the chemical agents on the rock wettability. Also, scale inhibition ratio and anti-swelling ratio are respectively measured by performing static state scale inhibition experiments and centrifugation experiments. Then, displacement experiments are conducted to evaluate injectivity improvement after one pore volume (PV) of such formulated chemical agents has been injected into a core plug. It is found that the optimized solution consists of 0.15 wt% fluorocarbon surfactant FC-117, 1.2×10^{-3} wt% scale inhibitor PBTCA (2-phosphonobutane-1,2,4-tricarboxylic acid), 4.00 wt% isopropanol, and 1.50 wt% clay stabilizer DMDAAC (diallyl dimethyl ammonium chloride). The IFT between crude oil and the optimized solution can be reduced to 5.36×10^{-3} mN/m within a short time, while the scale inhibition ratio and anti-swelling ratio are measured to be 94.83% and 86.96%, respectively. It is found from comprehensive evaluation experiments that such a formulated and optimized solution can not only alter the rock surface from oil-wet to water-wet, but also reduce the scale formation of the reservoir brine. In addition, it is shown from displacement experiments that the pressure is decreased by 34.67% after the injection of such formulated solution. When the formulated solution contains 0-300000 mg/L NaCl and 0-5000 mg/L $CaCl_2$ at 50-90°C, the IFT between crude oil and the formulated solution can be reduced to lower than 10^{-2} mN/m.

[1]Petroleum Systems Engineering, Faculty of Engineering and Applied Science, University of Regina, Regina, Saskatchewan, Canada S43 0A2
[2]College of Petroleum Engineering, China University of Petroleum (East China), Qingdao, China, 266580

Min Zhao is a Ph.D. candidate in petroleum systems engineering in the Faculty of Engineering and Applied Science at the University of Regina. Her major interests include chemical flooding, numerical modeling and simulation, and production optimization. Zhao holds a B.Sc. degree and an M.A.Sc. degree in petroleum engineering from the China University of Petroleum (East China).