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Broadening the Application Range of Water Shutoff / Conformance Control Microgels: an Investigation of their Chemical Robustness

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Abstract

The performances of water shutoff and conformance control microgels were extensively investigated in previous works. Microgels are polymeric particles which are preformed, stable, fully water soluble and size controlled with a narrow size distribution. They are also non toxic, satisfying the OSPAR environmental tests. Microgels allow a controlled Permeability Reduction to water through their adsorption as monolayers. When injected in a multilayered reservoir, unlike conventional polymer-based systems, they invade significantly less the low permeability layers, thanks to the low viscosity of their solutions as well as to steric effects. Their penetration in the highest permeability layers is thus largely improved. Microgel technology was successfully applied in 2005 for the treatment of an underground gas storage reservoir: results were very positive in terms of water shutoff and sand control.

However, a broad range of potential applications cases for microgels involve harsh conditions such as high salinity reservoir brines. This paper is principally aimed at studying how high salinity impacts microgel treatment efficiency.

Solubility of microgels was first evaluated in an extended domain of brine salinities (up to 200 g/L NaCl with a high content of calcium). Viscosity measurements and filterability tests through calibrated membrane filters were performed, and led to specifications for optimum microgel dissolution.

Injections in granular pack models were then carried out with microgels diluted in brines of various salinities and at various microgels concentrations. These tests allowed to assess the injectivity and to determine the permeability reductions. After injection, the packs were flushed with different brine salinities. Such a procedure reproduces setting a well back in production after a microgel treatment. Results showed that the hydrodynamic thicknesses of adsorbed layers did not vary significantly when microgels were injected in brines of moderate to high salinities. At very high salinity (200 g/L NaCl with calcium), a shear-controlled over-adsorption of the microgels was observed. Results also showed that adsorbed layers were very stable when exposed, after microgels adsorption, to brines of low to very high salinity.

These positive results are due to the crosslinked structure of the microgels. They highlight once again their excellent chemical stability compared to linear polymer based systems. They bring new encouraging insights for the success of the microgels applications to come.

Introduction

Water control is becoming increasingly important in oil production operations. Most oil companies have to deal with critically high water cuts as many wells reach maturity. The oil production decreases and water disposal creates intricate environmental issues as the environmental regulations for water discharge are becoming more and more severe. The purpose of water shutoff treatments in production wells is to reduce water production without damaging the oil productivity.

Among the available methods for conformance control or for reducing water production (Seright et al, 2003), injecting a gelling system composed of a polymer and a crosslinker has been widely used (Seright et al, 1994; Fullleylove et al, 1996; Zaitoun et al, 1999; Sydansk et al, 2000). However, since gelling properties have been found to depend on many factors, the gelling time, the final gel strength, the depth of the gel penetration but also the efficiency of the treatment are quite difficult to predict. More recent gel-based technologies include preformed bulk gels (Seright, 2004), partially preformed gels (Sydansk et al, 2004; Sydansk et al, 2005), Colloidal Dispersion Gels (CDG) (Chang et al, 2004; Chang et al, 2006; Muruaga et al, 2008) and Preformed Particle Gels (PPG) (Coste et al, 2000; Bai et al, 2008) which are more dedicated to treatments of fracture or very-high permeability streaks.