Abstract

Polymeric scale inhibitors are widely used in the oil and gas field because of their better thermal stability and improved environmental compatibility. However, the squeeze performance of such inhibitors is typically poorer than that of the phosphonates type scale inhibitors in conventional squeeze treatment. In this research, a new method of delivering chemicals to formation has been developed. Polymeric scale inhibitor nanoparticles were developed for scale control. Boehmite (γ-AlO(OH)) nanoparticles (NPs) with particle size from 3 to 10 nm were used to cross-link sulphonated polycarboxylic acid (SPCA). Cross-linked polymeric scale inhibitors were synthesized and developed to increase their retention in formations by converting free flowing water-soluble scale inhibitors into a viscous gel. The viscosity of NPs-polymer gel systems can be manipulated by changing reaction conditions such as NP and polymer concentrations, pH, temperature and ionic strength. Polymer adsorbs to the NP surface via an ion exchange mechanism with hydroxyl group on boehmite. The adsorption and desorption behavior of scale inhibitors onto both nanoparticles and core materials are investigated at different pH and temperature values.

Introduction

Scale formation in the oil and gas production system significantly reduces the productivity and increases operation cost (Kelland 2006; Kan & Tomson 2012). Squeeze treatment of scale inhibitor is the most efficient and widely used method to prevent scale formation. Threshold scale inhibitors include phosphonates, polyvinyl sulfonate (PVS), and sulfonated polycarboxylic acid (SPCA) or phosphino-tagged polycarboxylic acid (PPCA). Many of these inhibitors are commonly applied by an inhibitor squeeze treatment (Rosenstein 1936; Kan, et al. 2005). Phosphonates are prohibited in North Sea due to the environmental concern and they are perceived to be unstable at high temperature environment. Polymeric scale inhibitors typically have better thermal stability than phosphonates (Wang, et al. 2012; Fan, et al. 2011; Wang, et al. 2009; Graham, et al. 1998). However, the squeeze performance of such inhibitors is typically poorer than that of the phosphonates in conventional squeeze treatment. For example, Kan et al. have shown that the retention of NTMP and DTPMP in laboratory column squeeze simulation are approximately 80%, while that of PPCA is only 39% (Kan 2004). How to improve the efficiency of squeeze treatments is one of the main issues for scale inhibitors. Efficiency of squeeze treatments depends on the treatment lifetime of specific inhibitors. The squeeze lifetime of phosphonates can be prolonged by performing precipitation squeeze. In such a treatment, acidified phosphate pill solutions are injected into a carbonate formation (Jordan 1995; Tomson 2006) to form highly insoluble in-situ phosphate precipitate (Kan, et al. 1994; Friedfeld, et al. 1998; Frostman, et al. 1998; Xiao, et al. 2001). It has been proposed that the long term inhibitor flowback with produced brine is controlled by their low solubility (Kan, et al. 1994; Kan, et al. 2004; Tomson 2006).

Other approaches such as adding metal ions and making inhibitor nanoparticles are also investigated to improve efficiency. It has been reported that both the inhibition efficiency and the squeeze lifetime of BHPMP and PPCA can be improved by introducing Zn2+ ions to the inhibitor pill solution (Kan, et al. 2009). In addition, inhibitor nanoparticle suspensions containing phosphonate inhibitors such as Ca-DTPMP and Zn-DTPMP were developed (Shen, et al. 2008; Zhang, et al. 2010; Zhang, et