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Surface tension of HCl-based stimulation fluids at high temperatures

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Abstract

Surface tension of hydrochloric acid (HCl) solutions plays a key role in matrix stimulation of gas wells. A low surface tension is required to reduce the capillary forces that trap the aqueous phase in the formation. Accumulation of the aqueous phase near the well-bore area, known as water blockage, leads to a significant reduction in gas production. This work provides, for the first time, surface tension of acid-stimulating fluids at temperatures up to 120 °C, HCl concentrations up to 28 wt.%, and pressures up to 220 bar. A pendant drop apparatus specially designed for corrosive fluids was used to measure the surface tension between acid solutions and nitrogen.

The effects of commonly used acid additives on the surface tension of HCl solutions were also studied in detail. These additives included corrosion inhibitors, acetic acid, formic acid, methanol, mutual solvent, a nonionic fluorocarbon surfactant, iron control chemicals, and hydrogen sulfide scavengers.

In addition to surface tension values of HCl up to 28 wt.% HCl at temperatures up to 120 °C, experimental results indicated that several acid additives are capable of significantly lowering the surface tension of HCl solutions. The trends discussed in this study can be used to better design acid formulae used to stimulate deep gas wells.

Keywords: Surface tension; Water blockage; Pendant drop method; Stimulation fluids; Well acidizing; Hydrochloric acid

1. Introduction

The surface tension of aqueous solutions plays a key role in the flow of acids and fracturing fluids in porous media. It is also important in studies related to understanding structures of various molecules at the interface (Rychlicka-Rybska, 1996), mass transfer processes (Álvarez et al., 1997), enhanced oil recovery using gas injection (Millette et al., 2002), and the flow of contaminants in soils (Smith and Gillham, 1994; Lord et al., 1997). In the area of matrix acidizing of gas wells, low surface tension is required to reduce the capillary forces that hinder deep acid penetration and trap the spent acid in the pores of the formation rock. Accumulation of the aqueous phase near the well-bore area, known as water blockage, leads to significant reduction in gas production (Conway et al., 1995; Bennion et al., 1996).

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