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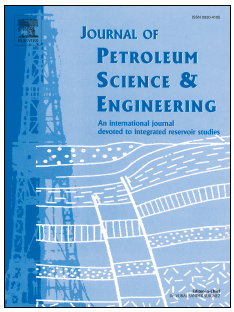

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Kwang Hoon Baek, Francisco J. Argüelles-Vivas, Ryosuke Okuno, Kai Sheng, Himanshu Sharma, Upali P. Weerasooriya

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Emulsification of Athabasca bitumen by organic alkali: emulsion phase behavior and viscosity for bitumen/brine/triethylenetetramine

Kwang Hoon Baek, Francisco J. Argüelles-Vivas, Ryosuke Okuno*, Kai Sheng, Himanshu Sharma, Upali P. Weerasooriya

* Corresponding author. E-mail address: okuno@utexas.edu (R. Okuno).
Hildebrand Department of Petroleum and Geosystems Engineering, University of Texas at Austin, 200 E. Dean Keeton Street, Stop C0300, Austin, TX 78712, USA.
Phone: +1.512.471.3250
Email: okuno@utexas.edu

Abstract

Recovery of bitumen commonly uses steam assisted-gravity drainage, in which water throughput is intrinsically high. A large amount of condensed water near thermal fronts tends to substantially decrease the effective permeability to bitumen in the conventional gravity drainage process. This research investigates a potential way to use the condensed-water phase as an effective carrier for bitumen by making oil-in-water (o/w) emulsion. The expected mechanism depends on emulsification of bitumen into the water phase by natural surfactants that are generated through reactions of acidic oil components with organic alkali.

The main objective of this paper is to study the ability of an organic alkali to create o/w emulsions that are much more mobile than the original bitumen. Triethylenetetramine (TETA) was selected as organic alkali for this paper with no other additives. The main contribution of this paper is a new set of experimental data (phase behavior and viscosities) for emulsions for mixtures of Athabasca bitumen, TETA, and NaCl brine at a wide range of alkali concentrations, salinities, and water-to-oil ratios (WORs) at temperatures up to 373 K.

Results show that the o/w emulsions created by TETA can be an effective bitumen carrier with a low viscosity and high bitumen content in the emulsion. It is possible to create o/w emulsions by adding a small amount of TETA to Athabasca bitumen and NaCl brine. Single-phase o/w emulsions, which are desirable as a bitumen carrier, were observed for TETA concentrations below 5.0 wt% at salinities 0 ppm and 1000 ppm at 373 K. The bitumen content in o/w emulsion was the highest for 2.0 wt% TETA samples, and it increased with increasing temperature. In comparison to the original bitumen, o/w emulsions were 4 to 5 orders of magnitude less viscous at 298 K, 2 to 3 orders of magnitude less viscous at 323 K, and 1 to 2 orders of magnitude less viscous at 353 K.

Keywords: bitumen; organic alkali; natural surfactant; emulsion phase behavior; emulsion viscosity

1. Introduction

Steam injection is the most widely used method of bitumen recovery, which uses the sensitivity of bitumen viscosity to temperature. Steam injection processes, such as cyclic steam stimulation (CSS) and steam assisted gravity drainage (SAGD), are energy-intensive, using water as a heat carrier. Water throughput is intrinsically high in these steam-based oil recovery methods. For example, a cumulative steam-to-oil ratio (SOR) is between 2 and 5 in successful SAGD for relatively homogeneous reservoirs (Butler, 2001). Cumulative SOR tends to increase for more heterogeneous reservoirs (Venkatramani and Okuno 2017). Therefore, it is important to consider how the water component and/or the aqueous phase can be used to improve the efficiency of steam-based oil recovery methods. For the conventional steam injection processes, however, the condensed water

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