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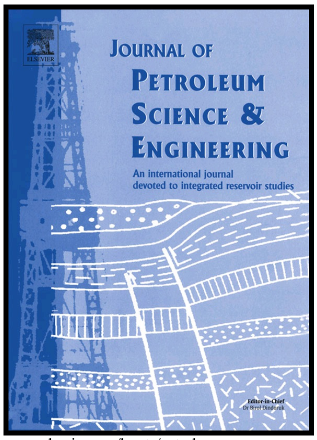

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CO_2 Microbubbles - a Potential Fluid for Enhanced Oil Recovery: Bulk and Porous Media Studies

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Abstract

Carbon dioxide foam flooding is a conventional process to increase the quantity of extracting oil. The short-term stability and relatively low viscosity of CO_2 foam motivate the researchers to find a more stable fluid. Colloidal gas Aphrons (CGAs) are microbubbles confined by the surfactant multilayer and the viscous water layer. One of the most important characteristics of CGA is their gas-blocking ability. They increase the stability of the surfactant/polymer solution as well as reduce the mobility of CO_2 gas. Accordingly, CGA has been recently used in the petroleum industry (drilling operation, production management etc.). The CO_2 enhanced oil recovery and sequestration can be one of the major interests of CO_2 gas microbubbles. The pressure-volume-temperature (PVT) relationship of CO_2 microbubbles is of particular interest, due to the presence of gas in the form of microbubbles in the bulk of the fluid.

This paper discusses the phase behavior, rheological characterization, and microbubble size analysis of CO_2 microbubbles at different conditions. A PVT cell was used to analyze the stability of CO_2 microbubbles after encountering elevated pressure and temperature. The rheological properties and microbubble size analysis of this fluid were performed both before and after the PVT study to demonstrate the effect of compression/decompression and temperature on CO_2 microbubbles properties. Furthermore, macro and micro scale porous media experiment were performed to analyze the behavior of microbubbles during heavy oil recovery.

Microbubble size analysis revealed that most of the initial microbubbles located within a diameter range of 100-120 µm. After PVT tests, fewer amounts of large microbubbles (due to the coalescence of small bubbles) existed compared to that of preserved samples under low pressure condition. This result demonstrates good capability of CO_2 microbubbles to maintain their stability under the high pressure and temperature conditions. Compression/decompression of microbubbles revealed that microbubbles can survive up to at least a pressure of 2000 psi, demonstrating its potential for subterranean applications. However, above 50 °C (122 F), the stability of microbubbles was decreased after compression/decompression up to 2000 psi. Higher temperatures decrease viscosity and elastic/viscous moduli of microbubbles and this study showed that temperature above 50°C can be critical for rheological properties and the P-V relation of CO_2 microbubbles. Furthermore, PVT studies showed that the lower compression/decompression rate drastically affects the stability of CO_2 microbubbles and the higher temperature enhances this effect. Finally, the flow resistance characteristic of