New in situ measurements of the viscosity of gas clathrate hydrate slurries formed from model water-in-oil emulsions

Ahmad A. A. Majid[1,2], David T. Wu[1,3], Carolyn A. Koh[1]

[1] Center for Hydrate Research, Department of Chemical and Biological Engineering, Colorado School of Mines, Golden, Colorado 80401, United States

[2] Faculty of Chemical & Natural Resources Engineering, Universiti Malaysia Pahang, Lebuhraya Tun Razak, 26300 Gambang, Malaysia

[3]Department of Chemistry, Colorado School of Mines, Golden, Colorado 80401, United States

ABSTRACT

In situ rheological measurements for clathrate hydrate slurries were performed using a high pressure rheometer to determine the effect of hydrate particles on the viscosity and transportability of these slurries. These measurements were conducted using a well-characterized model water-in-oil emulsion (Delgado-Linares et al. Model Water in-Oil Emulsions for Gas Hydrate Studies in Oil Continuous Systems. Energy Fuels 2013, 27, 4564-4573). The emulsion consists of a model liquid hydrocarbon, water, and a surfactant mixture of sorbitane monooleate 80 (Span 80) and sodium di-2-ethylhexylsulfosuccinate (Aerosol OT, AOT). This emulsion was used as an analog to water-in-crude oil (w/o) emulsions and provides reproducible results. The flow properties of the model w/o emulsion prior to hydrate formation were investigated in terms of several parameters including water percentage, temperature and pressure. A general equation that describes the viscosity of the emulsion as a function of the aforementioned parameters was developed. This general equation was able to predict the viscosity of a saturated emulsion at various temperatures and water percentages to within ±13% error. The general equation was then used to analyze the effect of hydrate formation on the transportability of gas hydrate slurries. As for hydrate slurries investigation, measurements were performed using methane gas as the hydrate former and a straight vane impeller as a stirring system. Tests were conducted at constant temperature and pressure (1 °C and 1500 psig of methane) and water percentages ranging from 5 to 30 vol %. Results of this work were analyzed and presented in terms of relative values, i.e., viscosities of the slurries relative to the viscosities of the continuous phase at similar temperature and pressure. In this work, a correlation to predict the relative viscosity of a hydrate slurry at various hydrate volume fractions was developed. Analysis of the developed correlation showed that the model was able to predict the relative viscosity of a hydrate slurry to within ±17% error.

KEYWORDS

Constant temperature; In-situ measurement; Liquid hydrocarbons; Relative viscosity; Rheological measurements; Surfactant mixture; Temperature and pressures; Water in oil emulsions

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