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Pseudo-Compositional Model for the Calculation of Liquid Viscosity in Oil Production Systems

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Abstract
Modern numerical simulators can couple models to represent the behavior of reservoir, wells and surface facilities. This has created a need for a method to calculate viscosity over a wide range of compositions, pressures, and temperatures. Current compositional viscosity models cannot predict viscosities over these wide ranges. Bergman and Sutton (2006, 2007a, 2007b) published three new correlations that matched viscosity changes with temperature and pressure. Their correlations were based on typical black-oil model parameters; among them solution gas-oil ratio, mole weight and API gravity of the stock tank oil. These parameters change with liquid composition. This paper provides a method for estimating these parameters from liquid composition for calculating viscosity using the Bergman-Sutton correlations. Comparisons with other compositional viscosity models were made to show the new model's improved behavior.

Introduction
The correlations presented by Bergman and Sutton (2006, 2007a, 2007b) require pressure, temperature, saturation pressure, solution gas-oil ratio, mole weight and API gravity of the stock tank oil. In addition, an adjustment parameter on the calculated Watson K factor can be input to tune the correlations to match known data points. If the liquid composition is known, the gas in solution can be estimated as being formed by the light components of the mixture. The key to estimating gas in solution for use in viscosity calculations is the light component – heavy component split or "cut point" necessary for the solution gas-oil ratio estimate.

Correlation Development
A data set consisting of differential liberation analyses (DL) for 143 samples was gathered for this study. Table 1 contains the summary of the data used. These studies contained most of the parameters required by the Bergman-Sutton (BS) correlations. Nevertheless, many older data sets did not report a value for the molecular weight of the DL stock tank oil. Different methods were used to estimate this value from other data such as single stage flash values or from the compositional data.

Property	Minimum	Maximum
Oil gravity, °API	15.4	41.2
Gas-oil ratio, scf/STB	53	3275
Dead oil viscosity, cp	1.52	83.5
Temperature, °F	82	280
Bubble point pressure, psia	430	9530
Pressure differential, psi	0	22,841
Bubble point viscosity, cp	0.199	45.2
Under saturated viscosity, cp	0.206	32.9

Table 1. Data Summary

Our approach relies on the assumption that the gas phase is formed mostly by the lightest components in the mixture and that components with a carbon number below a "cut point" are in the gas phase while the rest are in the liquid phase. A carbon