ABSTRACT

Bitumen and heavy oils produced in Alberta frequently contain asphaltenes. These asphaltenes may play a significant role in the primary upgrading or visbreaking of the bitumen and heavy oils. This paper describes an experimental study of the effect of asphaltene content on the viscosity of bitumen. Rheological studies were carried out using virgin bitumen as well as using mixtures of de-asphalted bitumen and asphaltenes. The viscosity of the mixture was found to be a strong function of asphaltene content. However, it was not possible to ascertain the exact nature of this functionality. In order to obtain further insight into this, processed samples were also included in the study. Since, the aggregate nature of the asphaltene is subject to change when subjected to the high severity conditions of upgrading reactors, the use of processed sample was expected to provide some additional information on the asphaltene content-viscosity relationship. It was found that asphaltenes with higher molecular weight resulted in higher viscosity of the mixture than those with lower molecular weights.

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INTRODUCTION

In many petroleum reservoirs around the world, reservoir fluid composition has been found to vary with location and depth. In almost all the cases, reservoir fluid density increases with the depth of the reservoir. Tar sand bitumen deposits found in the Province of Alberta are no exceptions. Patel found the viscosity of Athabasca, Peace River, Wabasca and Cold Lake bitumen vary with the depth of the formation. In most cases, samples obtained from higher depths showed greater viscosity. Schutze studied the compositional variations within a hydrocarbon column due to gravity and found the gravitational forces to be responsible for the variation in composition in thick reservoirs. He found the extent of this variation to be higher with larger aromatic fractions in the hydrocarbon fluid.

Hirschberg, in his analysis of the role of asphaltenes in the compositional variation of a reservoir fluid column concluded that the heavy polar compounds play a key role in this regard. He found asphaltene segregation to have a dominant effect in the process. One of the principal effect of compositional changes is the variation in viscosity. For a reservoir oil sample from a North African field, Hirschberg found the viscosity to increase by a factor of 4 (from 9 to 36 mPa.s) when the asphalt content increased from 10 to 16%. Indeed, the effect of asphaltene concentration on the viscosity of oil has been known for a long time. Mack, in 1932, presented viscosity data on asphaltene and oil mixtures obtained from a Mexican asphalt that clearly showed an increase in viscosity with increasing asphaltene concentration. Waxman et al. as well as Kitzan and Parsons have found the viscosity of Peace River bitumen samples to vary with asphaltene concentration. Dealy studied the effect of asphaltene concentration on the viscosity of Athabasca bitumen by adding 5 wt% of additional asphaltene to a bitumen sample that originally contained 16 wt% of asphaltene. The viscosity of the bitumen was found to increase from about 300 Pa.s to 1000 Pa.s as a result of asphaltene addition. When higher shear was applied, the viscosity of the mixture was found to decrease somewhat, but was still above that of the original bitumen.

Altgelt and Harle also studied the effect of asphaltenes on asphalt viscosity. They found the asphaltenes to form aggregates in solution, the degree of which was found to depend on the structure, molecular weight and concentration of the asphaltenes as well as the power of the solvent. They concluded that the viscosity of asphaltene containing fluids is primarily due to the aggregation of the asphaltenes.

Chakma and Berruti studied the effect of ultrasound on the viscosity of Athabasca bitumen and found that the viscosity reduction of up to 15% can be achieved by the application of ultrasound. They concluded that ultrasound causes the asphaltene aggregates to break up to some extent.