Heavy oils viscosity: An investigation using a series of different additives

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Recent studies from our laboratory verified that asphaltenes extraction from heavy oils caused a remarkable decrease of the heavy oil viscosity, suggesting that the aggregation of this fraction plays a key role in heavy oil high viscosity.

The aim of this work is to study the viscosity reduction using additives of different chemical nature. Figure 1 shows the viscosity decrease for oils from two different fields (OF) analyzed as a function of the additives Hildebrand solubility parameters.

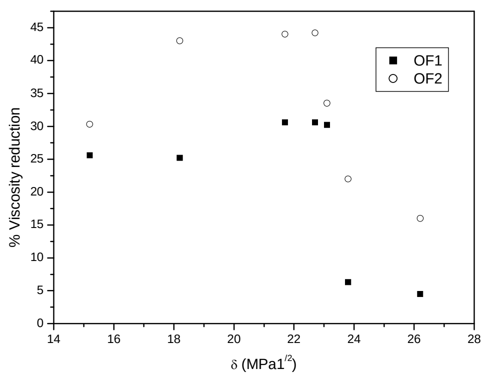

Fig. 1. Oil viscosity reduction for oils from two different oil fields (1 and 2) as a function of additive Hildebrand solubility parameter. The additive concentration was 1 wt%.

The region of maximum viscosity reduction is around values of δ=18-23 $MPa^{1/2}$ which is typically associated with the asphaltene fraction.

A thorough additive screening was performed and among them the alcohol class caused significant viscosity reduction. Alcohols from 4 up to 10 carbons show better performance reducing viscosity than the other ones. At 25°C the Hildebrand parameter of these alcohols lies between 23-21 $MPa^{1/2}$. Once more, this effect can be related to their solubility parameter, with a maximum effect for alcohols of medium chain length, corresponding to δ values between 21-23$MPa^{1/2}$.

Additives such as dodecylbenzene sulfonic acid (DBSA) and a series of ethoxylated nonylphenols (NP, n= number of EO units) were also tested for their amphiphilic properties. Although DBSA displays a significant capability for asphaltene dispersion (determined as the amount of asphaltene dispersed in alkanes) [1], its effect was of a 5% increase in the oil viscosity. For surfactants of the nonylphenol ethoxylated family, which are known to affect asphaltene precipitation onset, a slight decrease (less than 10%) in the oil viscosity was observed (Fig.2). The viscosity reduction capability increases with the increase in the ethoxy chain length up to ca. 10 EO units, decreasing for larger ethoxylated chains

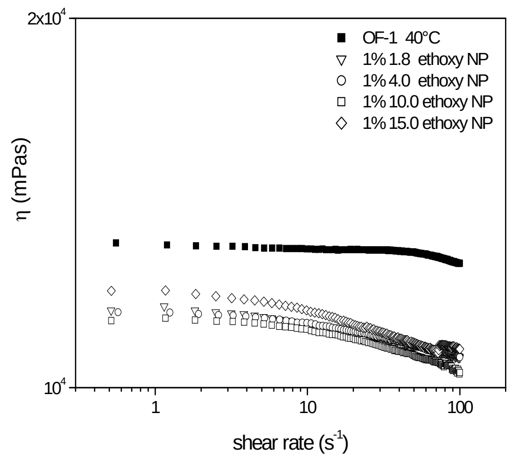

Fig. 2. Flow curves from oil field 1 and surfactants with variable ethoxylation degree.

Polyphosphoric acid (PPA) promotes a four times increase in viscosity indicating a crosslink reaction between asphaltene groups and the polyacid.

Conclusions

Significant reductions of heavy oil viscosity were obtained with small amounts of solvents displaying solubility parameters in the range of 18-23 $MPa^{1/2}$. This is also the range commonly ascribed to the asphaltene fraction, what confirms that their capability to dissolve (or disaggregate) asphaltene molecules may be proposed as their mechanism of action.

Both DBSA and PPA cause significant viscosity increases indicating an important role of acid-base interactions on heavy oils viscosity.

References

1. da Silva, A.C.; Haraguchi, L.; Notrispe, F. R.; Loh, W.; Mohamed, R. S.; *J.Pet. Sci. Eng.* 2001, 32, 201.