

UNICAMP



HEAVY OILS VISCOSITY: AN INVESTIGATION USING A SERIES OF DIFFERENT ADDITIVES



PETROBRAS

Lilian Padula ^{a,*}, Edvaldo Sabadini ^a, Watson Loh ^a, Nelson de Oliveira Rocha ^b, Carlos Henrique Monteiro de Carvalho ^b.

^a Institute of Chemistry – Universidade Estadual de Campinas (UNICAMP) - Campinas, SP, Brazil.

^b Cenpes- Petrobras- Rio de Janeiro, RJ, Brazil

*lpadula@iqm.unicamp.br

Introduction

Asphaltenes extractions of two different Brazilian heavy oils (OF1 and OF2) have shown great viscosity decrease confirming that the aggregation of this fraction plays a key role on heavy oils viscosity. Because these oils have asphaltene content higher than 10% wt. the oils are in a semi dilute regime where entanglement between asphaltenes molecules occurs, accordingly to Argillier,¹ which promotes an elevated viscosity. The aim of this work is to study additives effects on rheological properties of two Brazilian heavy oils and study how they affect the asphaltenes organization in the semi dilute regime.

Results and Discussion

Additives with different Hildebrand parameters were tested and presented a maximum of viscosity reduction in values around $\delta=18-23 \text{ MPa}^{1/2}$ (see Figure 01 (a)), region typically associated with the asphaltene fraction.

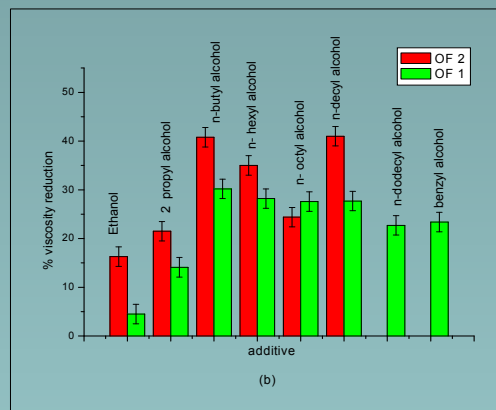
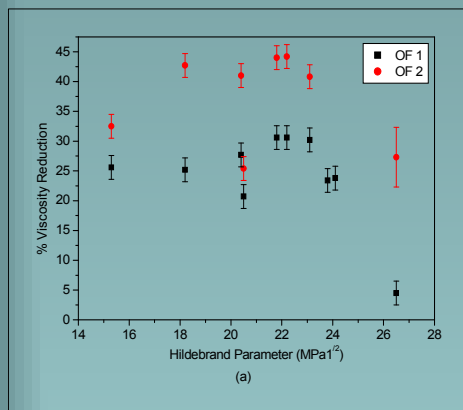


Fig. 1. (a) Oil viscosity reduction for oils from two different fields (1 and 2) as a function of additive (1% w/w) Hildebrand solubility parameter. (b) Viscosity reduction using a series of alcohols (1%w/w).

Alcohols up to 10 carbons presented a viscosity reduction capability (Fig 1(b)) as good as toluene, indicating that two mechanisms (in terms of the type of molecular interactions) are interfering on asphaltene-asphaltene interactions. Some additives were studied using Wide Angle X-Ray Scattering to see structural changes that might occur.

Additives such as dodecyl benzene sulfonic acid (DBSA) and ethoxylated nonylphenol (NPethoxy) were also tested. Opposite behaviors were observed, as DBSA increases and NPethoxy decreases the viscosity. The large increase in the viscosity promoted by Polyphosphoric acid (PPA) indicates a reticulation reaction between asphaltenes (see Figure 2(a)).

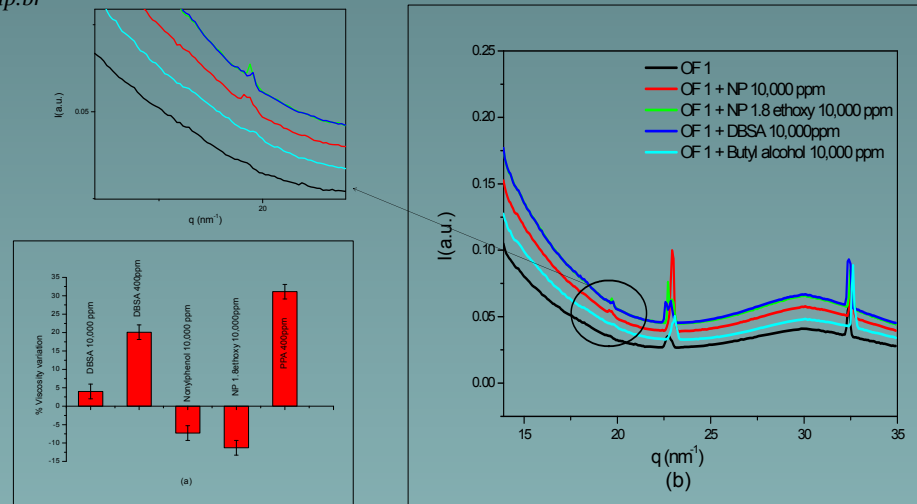


Fig.2: (a) Viscosity reduction with additives and (b) the WAXS curves of the oil in presence of additives.

q (nm ⁻¹)	d (Å)
19.8	3.2
23.0	2.7
32.5	1.9

Table 1: Scattering vectors (q) and correspondent structural distances (d).

Only in presence of aromatic additives the WAXS showed a third peak (Fig 2(b)) corresponding to a distance of 3.2 Å, possibly due to the insertion of these molecules between the asphaltenes aromatic sheets, resulting in the observed reduction in the viscosity.

Conclusions

- Acid-base interactions presented an important role on heavy oil viscosity;
- Two mechanisms of Asphaltene-Asphaltene interaction are observed: one aromatic (π - π interactions) and other through Hydrogen bonding;
- WAXS presented distance changes between the aromatic sheets confirming that aromatic additives affect π - π interactions, but it seems not to be related to viscosity reduction because butyl alcohol does not show the peak appearance.

Reference

1. Hénaut, I.; Barré, L.; Argillier, J-F.; Brucy, F.; Bouchard, R.; presented at SPE Conference Houston, Texas, February, 2001.