

Phase behavior of asphaltenes + polystyrene + toluene mixtures at 293 K

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The phase behavior of hydrocarbon mixtures where one of the constituents is prone to self-aggregation is a subject of significant industrial interest. Here, a phased-array acoustic technique is used to investigate the phase behavior of asphaltenes, a self-aggregating species of interest to the petroleum industry, in mixtures with polystyrene and toluene at 293 K and atmospheric pressure. The phased array records the speed of sound and attenuation spectra simultaneously at 113 positions along the height of the cell with a resolution of 0.3 mm. Over a range of compositions, the ternary asphaltenes + polystyrene + toluene exhibits liquid-liquid phase behavior where both liquids are opaque to visible light, are of uniform composition and are stable. As polystyrene is likely to be non-adsorbing on asphaltenes, depletion flocculation is hypothesized to be the mechanism causing phase separation [1,2].

Figure 1 shows an example of the profiles of the speed of sound in the cell obtained for a mixture of 14.4%vol asphaltenes and 3.9 %vol polystyrene in toluene before and after phase separation. The evolution of the profile to a steady state is reached after 90 minutes. Figure 2 shows a comparison between the attenuation spectra recorded just after mixing and that recorded after phase separation in two positions along the height of the cell: z_1 and z_2 . After phase separation, they are located in the lower and the upper phases respectively. The lower phase has a higher attenuation and speed of sound than the upper phase. The higher density of asphaltenes (1.17) vis-a-vis polystyrene (1.047) suggests that the upper phase is asphaltene poor and the lower phase is asphaltene rich. The speed of sound and attenuation in both separated phases are found to be between the experimental speed of sound and attenuation measured in the solutions of 15.8 vol% and 24.1 vol% of asphaltenes in toluene.

Experimental results are compared with the depletion flocculation theory of Fler et al [2]. Their theory predicts liquid-liquid phase separation at the compositions investigated but the calculated speeds of sound obtained from Fler's model do not agree with experimental speed of sound data per phase. In particular, the experimental differences between the speed of sound in the upper and the lower phases are significantly smaller than those calculated using Fler's model. It is suggested that the compositions of the three mixtures investigated are close to the colloidal gas-liquid critical point.

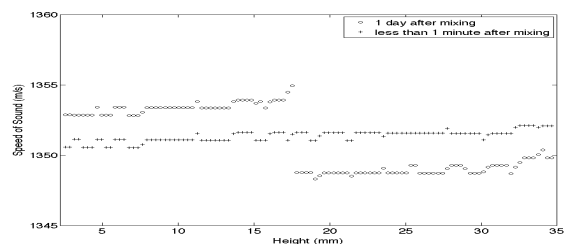


Fig. 1. Speed of sound profiles along the height of the acoustic cell for a mixture of 14.4%vol asphaltenes and 3.9 %vol polystyrene in toluene.

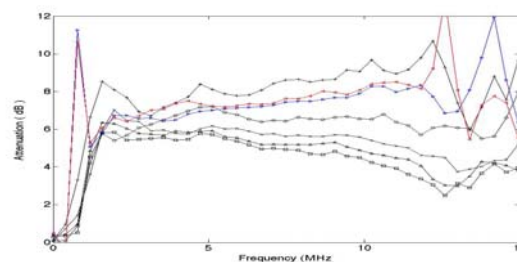


Fig. 2.a. Attenuation spectra at height $z_1=11.24$ mm for: (a) A mixture of 14.4%vol asphaltenes and 3.9 %vol polystyrene in toluene: (>) Attenuation before phase separation, (<) Attenuation after phase separation. (b) Binary mixtures of asphaltenes in toluene: (sq) pure toluene, (Δ) 3.3 vol%, (x) 7.6 vol%, (\diamond) 15.8 vol%, (+) 24.1 vol%.

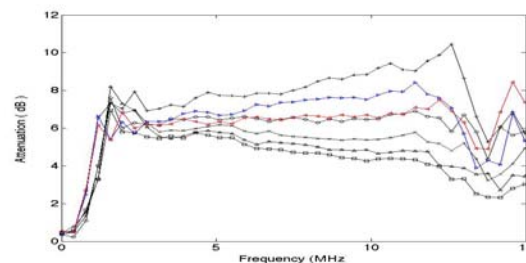


Fig. 2.b. Attenuation spectra at height $z_2=23.24$ mm for: (a) A mixture of 14.4%vol asphaltenes and 3.9 %vol polystyrene in toluene: (>) Attenuation before phase separation, (<) Attenuation after phase separation. (b) Binary mixtures of asphaltenes in toluene: (sq) pure toluene, (Δ) 3.3 vol%, (x) 7.6 vol%, (\diamond) 15.8 vol%, (+) 24.1 vol%.

References

- [1] Myakonkaya, O. & Eastoe, J. (2009). Advances in Colloid and Interface Science 149, 39-46.
- [2] Fler, G. J. & Tuinier, R. (2008), Advances in Colloid and Interface Science 143, 1-47.