Technical Data Book: Chapter 10—Surface and Interfacial Tension

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SCOPE

Technical Report TDB-10 provides methods for estimating both the surface tension and interfacial tension of pure components, petroleum fractions and mixtures that are common in refinery applications. Computer algorithms and figures are presented for estimation of these properties. An estimate of the accuracy and range of application for each method is presented.

Any references to other chapters within this document refer to the corresponding Technical Data Book chapter, which is published as API Technical Report TDB-x, where x is the chapter number.

10-0 Introduction

Surface Tension

The molecules at a liquid-gas interface are acted upon by unbalanced forces of attraction whose net inward force tends to minimize the surface area of the liquid. The work required to expand the surface area by 1 square centimeter is called the surface free energy. The opposing force in the surface of the liquid acts parallel to the plane of the surface and is called the surface tension.

Knowledge of surface tension behavior is becoming increasingly important where foaming, wetting, emulsification and droplet formation are encountered. Specifically, surface tension data are used in designing phase separation equipment like separators, distillation and extraction towers and their internals.

Pure Hydrocarbons and Nonhydrocarbons

The general behavior of surface tension for various hydrocarbons and nonhydrocarbons is illustrated in Figures 10-0.3, 10-0.4, 10-0.5 and 10-0.6. Surface tension values for n-alkanes ranging from ethane to nC20 are shown in Figure 10-0.3. The value for the surface tension is primarily determined by the reduced temperature. Surface tension depends to a lesser degree on the identity of the n-alkane.

Figure 10-0.4 shows surface tension values of various C6 hydrocarbons, including benzene, cyclohexane, n-hexane, 2,2 dimethyl butane, and 1-hexene. Aromatics tend to have the highest surface tension, followed by naphthenic rings, with alkanes and alkenes possessing lower surface tensions. The surface tension for branched paraffins is lower than straight chain paraffins. The structure has a greater effect on surface tension than the degree of saturation (single versus double bonds).

Figure 10-0.5 shows surface tension values of multiring and paraffin C10 hydrocarbons, including naphthalene, decalin, n-butylbenzene, n-decane, and 2,2,5,5-tetramethylhexane. As demonstrated in the previous figure, aromatic rings tend to have the highest surface tension, followed by naphthenic rings, with paraffins possessing lower surface tensions. As seen previously, the surface tension for branched paraffins is lower than straight chain paraffins.

Surface tension values of hydrocarbons, substituted hydrocarbons, and water are shown in Figure 10-0.6. Water, which is hydrogen bonding, has an appreciably higher surface tension