Effect of Dispersed Phase Fraction on Drop Size in Immiscible Liquid-Liquid Dispersions: Coalescence or Turbulence Damping?

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Abstract

The average drop sizes of immiscible liquid-liquid dispersions in the turbulent regime are often correlated using a model based on the Hinze-Kolmogorov equilibrium theory (Weber number correlation). This model assumes that there is no coalescence in the system. Therefore, it is usually applied when the dispersed phase fraction is very low (less than 1%vol). Many authors have used a modified form of this model to correlate data from systems with higher dispersed phase fractions. This usually leads to the expression $d_{32}/D = A(1+C\phi)We^{-3/5}$, where C is an empirical constant and its value depends on the degree of coalescence in the system. Values for C reported in the literature range from 2.5 to 9 and even higher.

Equilibrium average drop size (d_{32}) values will be presented for two liquid-liquid systems, one freely coalescing (silicone oil in distilled water) and one completely non-coalescing (silicone oil in surfactant solution). The drop sizes have been obtained in a 1ft diameter stirred tank under fully turbulent conditions and with dispersed phase fractions of up to 50%vol. The results show that, in the case of the coalescing system, drop size increases with increasing dispersed phase fraction and the value of the constant C is within the range reported in the literature. The value of C also seems to vary with impeller geometry in a way that is consistent with varying degrees of coalescence.

In the case of the surfactant-stabilised system, the average drop size also increases with increasing dispersed phase fraction, despite the lack of coalescence in the system (which has been established under both static and dynamic conditions). The value of C, however, is significantly lower than those obtained with the coalescing system. Several authors have argued that the presence of the drops in the dispersion decreases the intensity of the turbulent flow field, which would result in an increase on average drop size, even in the absence of coalescence. The values of C in these cases have been would be expected to be within 0.96 and 3, which is consistent with the value obtained with the surfactant stabilised system. Potential turbulence damping mechanisms are discussed.

keywords: Dispersed Phase Fraction, Drop Size, Immiscible, Liquid-Liquid, Dispersion, Coalescence, Turbulence Damping, Stirred Tank, Silicone Oil, Surfactant

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