Morphological Change in Drop Structure during Phase Inversion Emulsification Process

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Phase inversion is a process by which emulsification can be carried out. The advantage of this technique over the conventional emulsification process is the possibility of producing very fine particles with minimum energy consumed. Two types of phase inversion exist which can be induced by variation in volume fraction of water phase (f_w) and hydrophilic-lipophilic balance (HLB) of the surfactant system. The former is called catastrophic inversion, whereas that latter is called transitional inversion. In this research work the morphological variation of complex drops during phase inversion of Polyisobutylene/water/non-ionic surfactant system is investigated. The variations in drop structures during both transition time and at steady-state were studied. A new, but simple, technique was developed to measure the internal phase ratio of multiple drops. The morphology change occurred because of inclusion of oil droplets into the dispersed water drops which contained water-soluble surfactant, or vice-versa. For catastrophic inversion the variation in morphology can lead to a delayed-phase inversion if a substantial variation in the effective volume fraction of the dispersed phase occurs. The time sequence of morphology change of complex drops was clarified. As time proceeds, the relative size of internal droplets to that of surrounding drops is appreciably reduced, while the water drops become richer in the continuous phase. The progressive increase in the internal phase ratio of the dispersed phase will continuously increase the effective volume fraction of the dispersed phase and hence enlarge the multiple drops. Eventually a balance might be reached between drop inclusion and escape, to give a steady state, at which the drop morphology and size reach a constant value. If the rate of inclusion exceeds that of escape, so that a steady state is not reached, a phase inversion will occur. The extent of variation in drop morphology with time was found to depend on the size of drops, which is highly influenced by the volume fraction of the dispersed phase, and the surfactant concentration in the system, which enables the water drops to entrain a larger volume of the continuous phase. The large multiple drops are able to entrain a larger volume of internal phase and, thus, contribute more contribute to increasing the effective volume fraction of dispersed phase and to inducing a catastrophic phase inversion. The size of internal droplets continuously decreased with time until it reached a steady-state value whereas, the size of multiple drops showed a minimum. After the minimum, the size of multiple water drops either reached a steady state value or continued enlarging until phase inversion occurred. By reducing the surfactant concentration, the ability of the dispersed phase to entrain the continuous phase decreased so that no minimum was achieved for the size of multiple drops with time, similar to conventional systems with simple drops. The possible mechanisms for complex drop formation are discussed and drop deformation is suggested as the main cause for inclusion at a low dispersed phase ratio. Evidence was found to indicate that phase inversion occurs at the vicinity of closest packing arrangement. For transitional inversion, little, or no, delay was observed and the transition period was reduced as the optimum HLB was approached. Drops as small as 200 *nm* were obtained during transitional phase inversion. The transitional inversion boundaries did not vary with surfactant concentration. Multiple emulsion drops formed in the vicinity of transitional inversion points.