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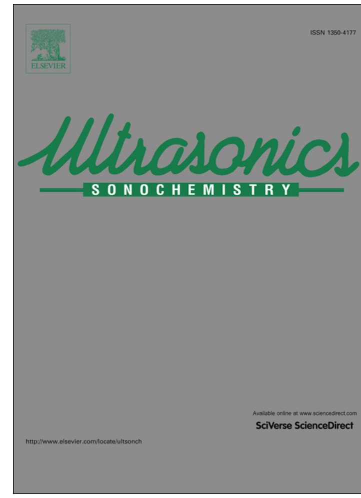

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Ultrasonication assisted Formation and Stability of water-in-oil Nanoemulsions: Optimization and Ternary Diagram analysis

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Abstract

An energy efficient and scalable method designed to form stable and transparent water-in-oil (W/O) nanoemulsion can be attained by optimization of process parameters and study of ternary diagram. Application of high energy in addition to the low energy at the optimized conditions have been targeted to make the process energy efficient, since later part is applied to droplets formed at less energy. In the present work, formation of combined energy mixed surfactant nanoemulsion was achieved by combined approach of isothermal low energy followed by ultrasonication that could be used as a fuel in compression ignition engine free from NO_x and particulate matter emissions. A mixture of two functional groups (ether and ester) non-ionic surfactants was used at optimized ratio of 0.71/0.29 (Span 80/Tx-100; w/w). Optimization of ultrasonicated parameters resulted in 25% amplitude, 0.5 pulse mode factor and 8.5 minutes of sonication time. A ternary diagram study was performed to recognize the compositions accountable for the formation of transparent, translucent and opaque emulsions in the bounded range of water fraction 0.02 to 0.11 and surfactant fraction 0.10 to 0.20. Surfactant-to-water (β) ratio found applicable for the production of nano-sized droplets in the range of $2\leq\beta\leq3$. A minimum droplet size of 25±1 nm was attained in the present study. An increase in surfactant fraction decreased average droplet size, whereas, increase in water fraction increased average droplet size. Reduction in droplet size was prominently found in the range of energy density from 15.23 $J.ml^{-1}$ to 40 $J.ml^{-1}$ thereafter, it decelerated up to 160 $J.ml^{-1}$. Prediction of average droplet size modeled with energy density fitted well and could be used for scaling up and tuning the droplet size. Resultant nanoemulsion samples displayed kinetic stability whereas long term stability (45 days) assessed using Ostwald ripening model showed stability in the order of β=2.0>β=2.5>β=3.0>β=4.0.

Keywords: *Ultrasonication; Cavitation; Nanoemulsion; Ternary diagram; Energy density; Stability.*

1. Introduction