Formation and stability of highly concentrated essential oil in water emulsions

Nahyan Liz [1], Nezia de Rosso [1], Henrique Fujiwara [1], Maria Clara Diniz [1], Cezar Negrão [1]

[1] Research Center for Rheology and Non-Newtonian Fluids (CERNN), Federal University of Technology – Paraná (UTFPR), Brazil

liz.nahyan@gmail.com

The increasing need for sustainable alternatives across the pharmaceutical, healthcare, and food preservation sectors has driven extensive research into essential oils (EOs)[1]. While these natural compounds present remarkable functional properties, their widespread industrial application is frequently limited by inherent challenges such as high volatility, poor water solubility, and chemical degradation. Encapsulation methods, particularly ionic gelation, serve as a crucial strategy to circumvent these limitations[2]. The effectiveness of this process relies heavily on formulating a robust oil-in-water (O/W) emulsion that incorporates the encapsulating matrix within its continuous phase. To address the scarcity of comprehensive studies regarding this primary emulsification stage, the present study evaluates how different surfactant-derived bio-emulsifiers influence the stability of O/W systems engineered with a high EO payload. Formulations were prepared using EOs with diverse chemical profiles (specifically orange, peppermint, lavender, and vetiver) enabling an in-depth assessment of the dynamics between the oil composition and the emulsifying agents. Emulsion integrity was meticulously assessed using macroscopic phase separation, microscopic characterization (droplet size and polydispersity index), and rheological testing. It was observed that both orange and lavender oils formed o/w emulsions using emulsifiers that exhibited high Hydrophilic-Lipophilic Balance (HLB), the more hydrophilic behaviour. On the other hand, peppermint and vetiver oils presented a more curious profile of emulsion formation. As for the stability as a function of the time, lavender and orange emulsions exhibited small increase in droplet size, not impacting significantly, however, in their rheological behaviour. Furthermore, it was found that viscosity is a key factor for the long-term stability of the samples.

Keywords:
Essential oil, emulsion, bio-emulsifiers, rheology, microscopy

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