Fabrication of Rosemary Essential Oil Nanoemulsions via Phase Inversion Temperature

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Abstract

This research aimed to develop a rosemary essential oil nanoemulsion using the phase inversion temperature method.

Various factors influencing emulsion formation and characteristics, including oil phase composition, surfactant type, and mixing temperature, were investigated.

The phase inversion temperature of the system was determined to be approximately 70°C. Among the surfactants evaluated, Tween 80 exhibited exceptional performance in producing nanoemulsions. Nanoemulsions containing up to 10% oil phase could be successfully formulated using 10% Tween 80. Stability testing indicated that the rosemary nanoemulsion remained stable for over 30 days. These findings hold potential for expanding the utilization of rosemary essential oil

Introduction

One of the primary drawbacks of rosemary essential oil is its susceptibility to rapid volatilization and biodegradation when exposed to environmental conditions. This inherent instability significantly limits its practical applications. To overcome these challenges, the formulation of nanoemulsions, comprising nanoscale droplets dispersed within an aqueous phase, emerges as a promising strategy for effectively utilizing rosemary essential oil.

Numerous studies have demonstrated that the diminutive size of droplets in nanoemulsions confers several advantages for commercial applications, including exceptional stability against gravitational separation, enhanced optical clarity, and amplified bioactivity. These properties collectively contribute to the improved performance and extended shelf life of rosemary essential oil-based products.

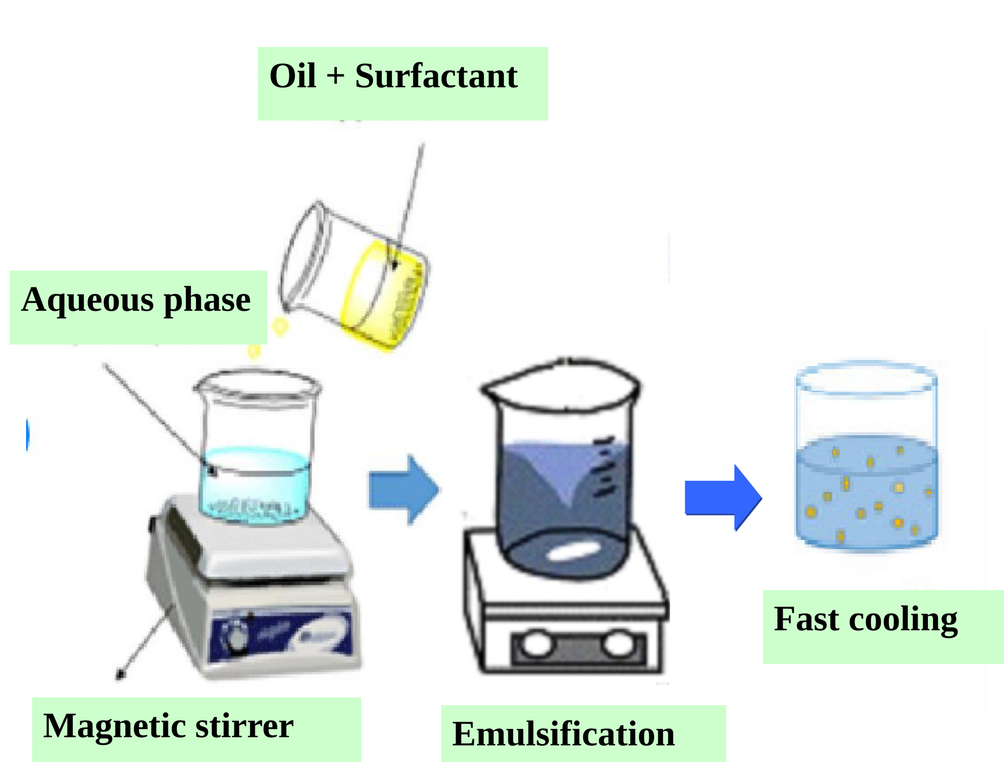


Figure 1. Experimental process

Methods and Materials

Material

-Rosemary essential oil
-Surfactants (Tween 20, 40, 60, 80)
-Distilled water

Fabrication of rosemary essential oil

The essential oil, deodorized coconut oil, and surfactant were mixed, while water was heated to 50°C beforehand. Then, the oil phase was added to the aqueous phase under continuous magnetic stirring (700 rpm). The system was mixed together for 1 hour and 30 minutes and heated to the PIT temperature (approximately 70°C). Afterward, the system was rapidly cooled to 8°C using iced water to form nanoemulsions (Figure 1).

Survey parameters: oil phase composition, surfactant type, and nanoemulsion stability.

Results & Discussion

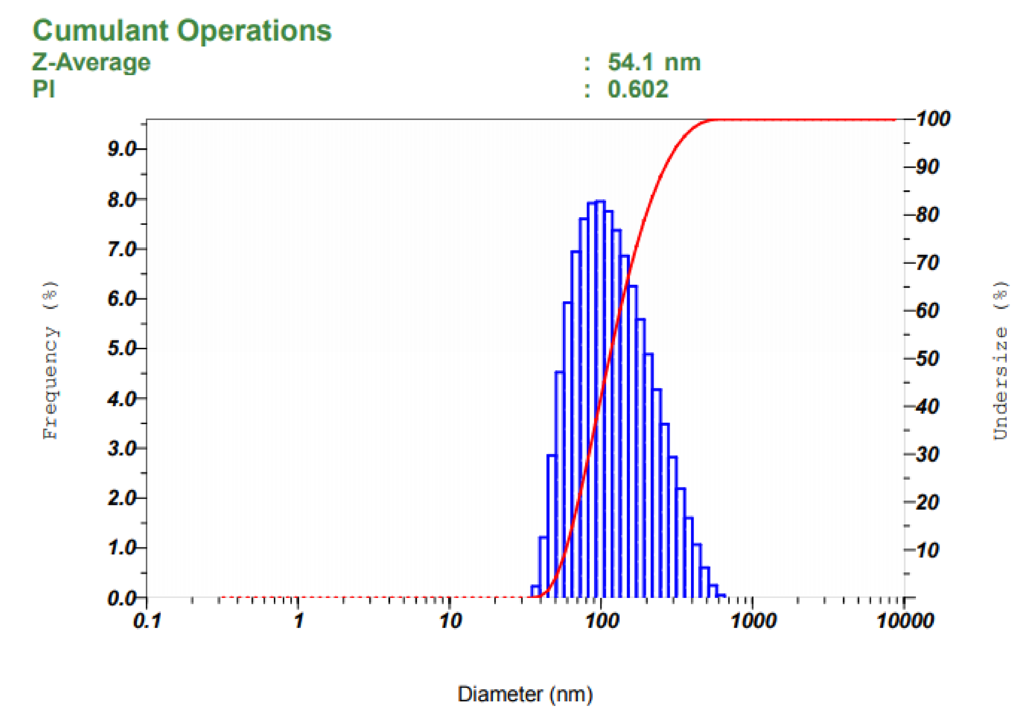
The oil phase system containing up to 8% essential oil produced emulsions with transparency comparable to those with only 2% essential oil. Absorbance measurements showed no significant difference in the range of 2% to 8% essential oil content. Consequently, an oil phase system with up to 8% essential oil was chosen for further experimental investigation.

A comparison of HLB values for different Tweens revealed that Tween 80 and 60 possess lower HLB numbers (14.9 and 15.0, respectively) compared to Tween 20 and 40 (16.7 and 15.6, respectively). Interestingly, nanoemulsions formulated with Tween 60 and 80 exhibited the smallest droplet size.

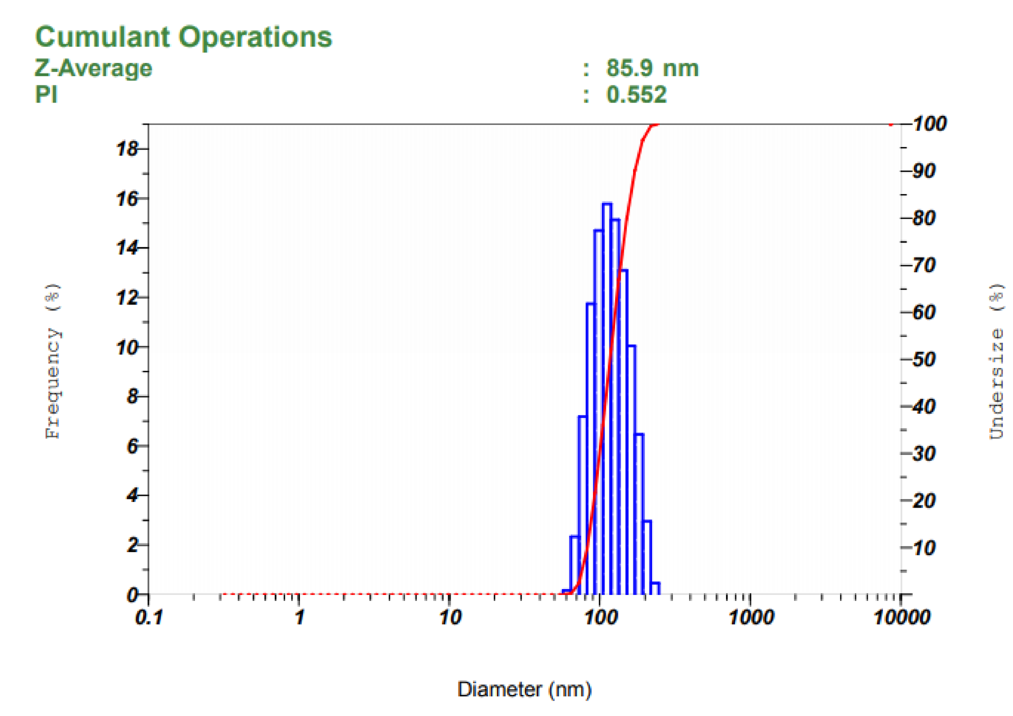
To optimize essential oil content within the emulsion, two coconut oil ratios were investigated: 2:8 and 4:6 (essential oil to coconut oil). The influence of oil phase composition on particle size is depicted in Chart 1. Our findings align with previous research indicating that smaller particles tend to form at low to intermediate lipid phase concentrations within systems.

The pre-treatment method significantly influences both nanoemulsion formation and particle size. This study compared three methods for producing stable nanoemulsions. While the phase inversion temperatures (PITs) of the three methods were comparable, the heating processes of the second and third methods resulted in superior transparency.

The results depicted in Figure 6 indicate a significant increase in mean droplet diameter following both centrifugation and 30 days of storage. A notable enlargement of the mean droplet diameter was observed during the storage period (Chart 2).



a)



b)

Chart 1. Effect of rosemary essential oil to coconut oil ratio in the lipid on the mean particle diameter of nanoemulsions.
(a): 2% coconut – 8% rosemary oil; (b): 4% coconut – 6% rosemary oil.

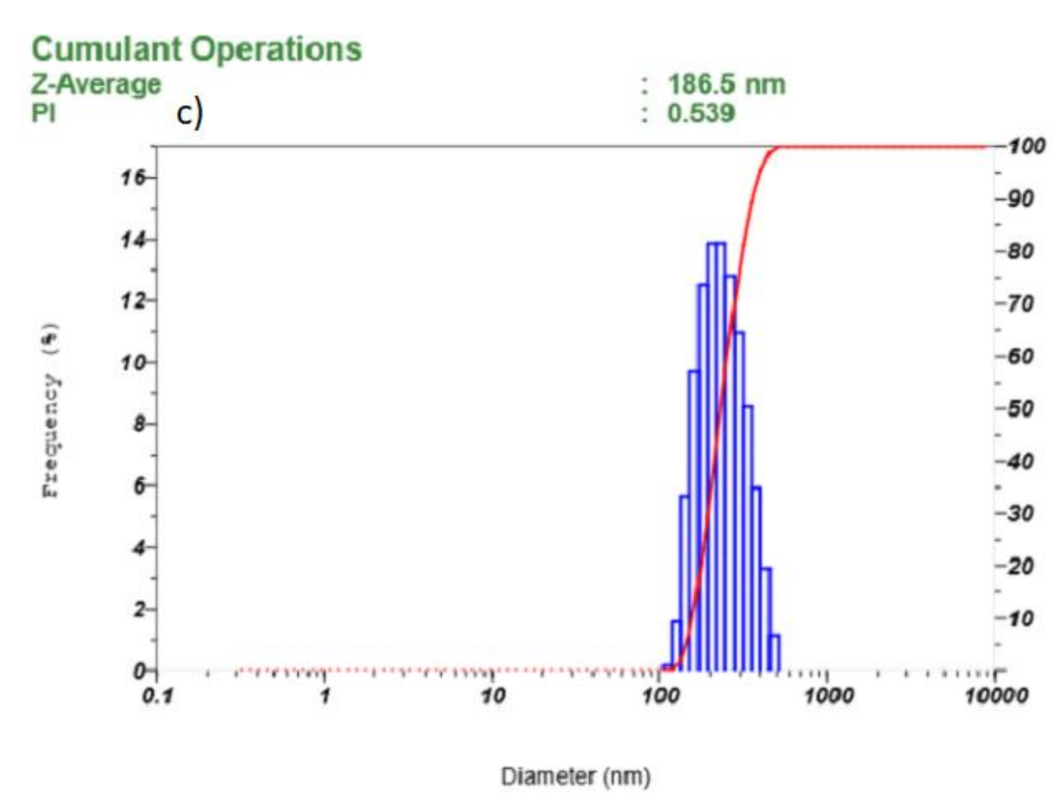


Chart 2. The mean particle diameter of rosemary essential oil nanoemulsions after 30 days of storage

Conclusions

Rosemary essential oil nanoemulsions were successfully fabricated using the phase inversion temperature method, a technique that has proven effective in creating stable oil-in-water dispersions. Optimization of formulation parameters led to the identification of an optimal composition, characterized by a notably small particle size distribution. This optimal formulation was achieved by maintaining a constant surfactant concentration of 10% while employing an oil phase consisting of a precise ratio of 8% rosemary essential oil and 2% coconut oil.

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