Aqueous dispersions of nanodroplets containing essential oil component mixtures Title

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INTRODUCTION & AIM

This study aims to design, characterize, and evaluate simple aqueous emulsion formulations for the encapsulation of bioactive compounds. Specifically, we focus on a pseudo-ternary system consisting of water, oil, and a stabilizing agent (Pluronic F-127), with the oily phase composed of a blend of two essential oils—eugenol and thymol—at varying proportions.

Essential oils offer numerous health benefits, but their low solubility in water necessitates the development of effective delivery systems for their transport and controlled release. Emulsions provide an ideal platform for encapsulating these compounds, enabling their potential applications.

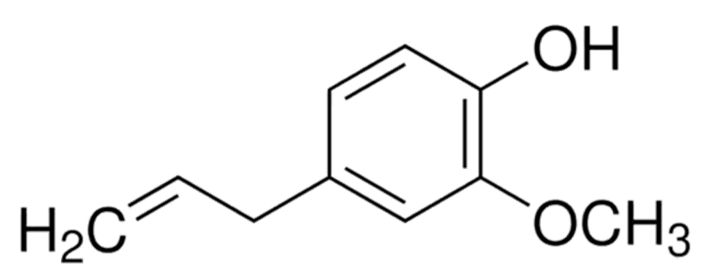
Our research explores the formulation of stable emulsions by varying both the total oil content and the composition of the oily phase. This approach will allow us to construct a phase diagram, identifying the stability regions of the system. Furthermore, we will characterize the stable formulations, focusing on droplet size and oil distribution, and assess their suitability for practical applications involving controlled release of bioactive compounds.

METHOD

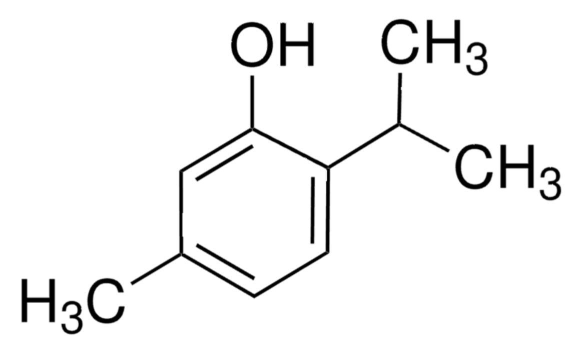
Chemicals:

Aqueous phase: Water of Milli-Q quality

Oil phase: Mixtures of eugenol and thymol with varying weight fractions of components



Eugenol



Thymol

Emulsifier: Pluronic F-127 (triblock copolymer with two terminal block of poly(ethylene oxide) and a central one of poly(propylene oxide)

$$\mathrm{H(OCH2CH2)_x(OCH2\overset{CH_3}{\overset{|}{C}}H)_y\,(OCH2CH2)_z\,OH}$$

Pluronic F-127 (x=z=100 and y=65)

Emulsion Preparation:

The preparation was conducted in 15–20 mL tubular vials. First, the calculated amount of eugenol required to achieve the desired composition was added. Next, thymol was added. As these two components form the oily phase, the liquid eugenol aids in the solubilization of solid thymol. Subsequently, the oily phase was combined with 7.5 g of a 10.25% w/w Pluronic F-127 solution, followed by the addition of the required amount of Milli-Q water (in grams) to achieve a final dispersion volume of 15 mL, corresponding to a total mass of 15 g. Homogeneous mixing of all components was ensured using a magnetic stirrer at room temperature.

Characterization:

-Determination of the compositional: varying total oil concentration on the dispersions (c_{oil}) and the weight fraction of thymol on the oil fraction (x_{thymol})

-Evaluation of the droplet size: Dynamic light scattering (DLS) for evaluation apparent hydrodynamic diameter

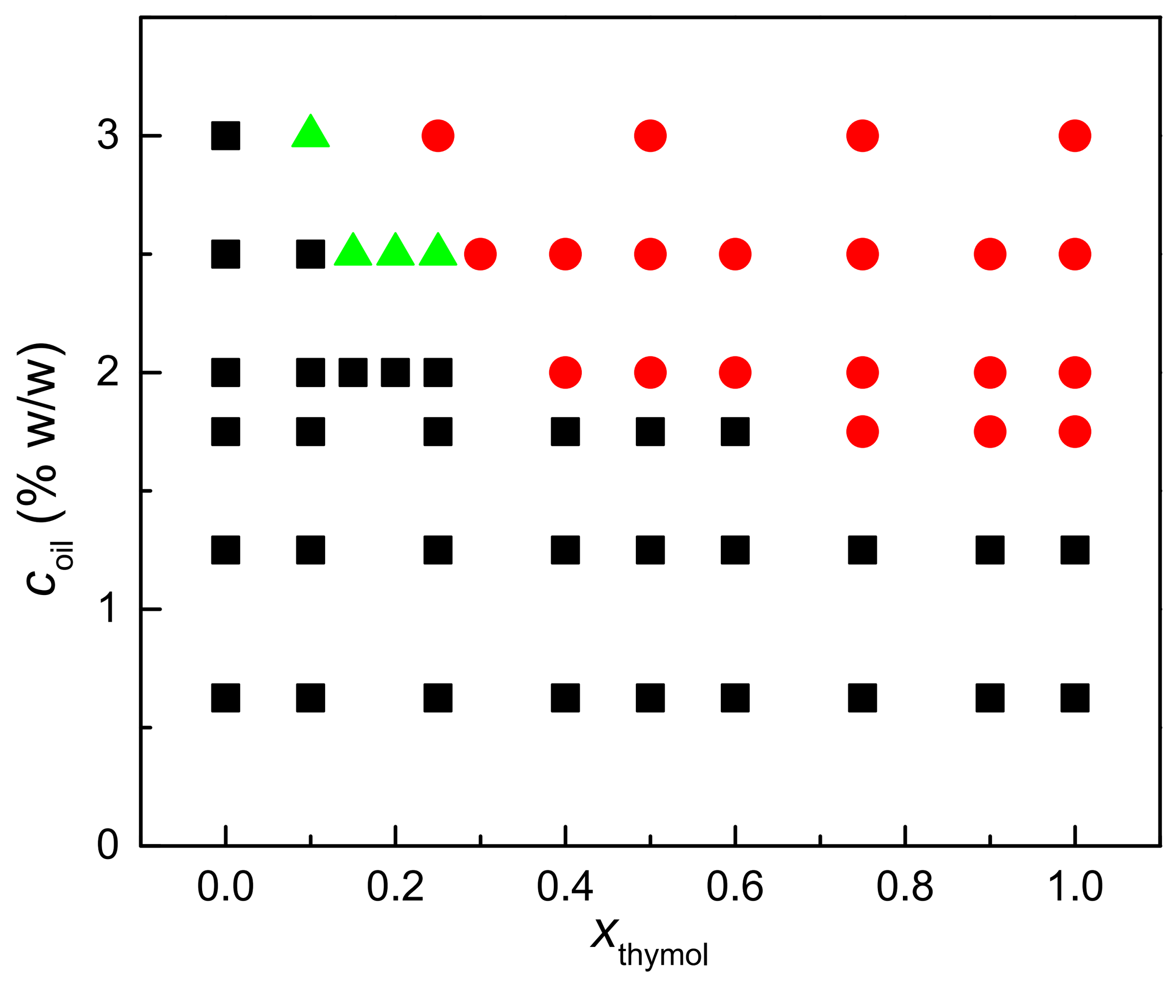
-Measurements of the antioxidant capacity of the dispersions: determination scavenging activity (RSA%) by absorbance measurements

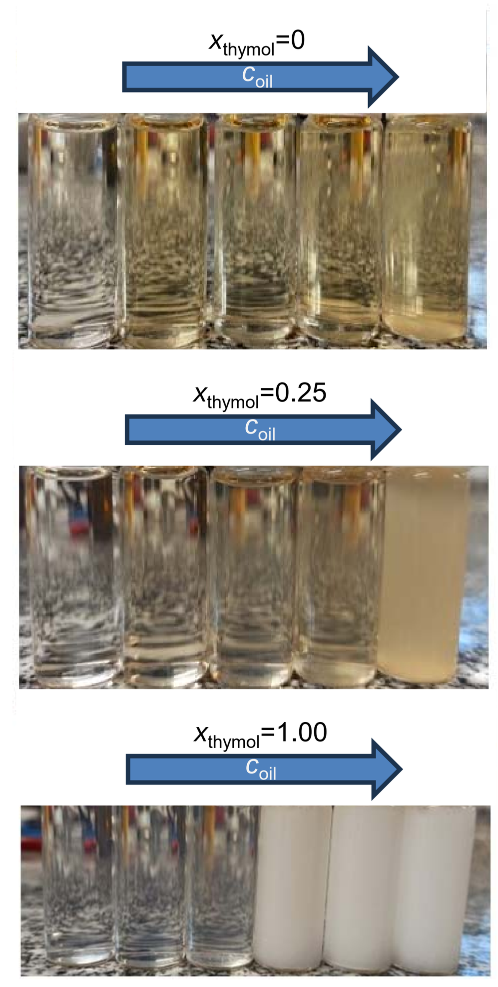
$$RSA(\%) = \left(1 - \frac{A_{\text{sample}} - A_{\text{blank}}}{A_{\text{control}}}\right) \cdot 100$$

where A_{sample}, A_{blank} and A_{control} corresponds to the absorbance of sample, blank and control, respectively

RESULTS & DISCUSSION

Compositional map

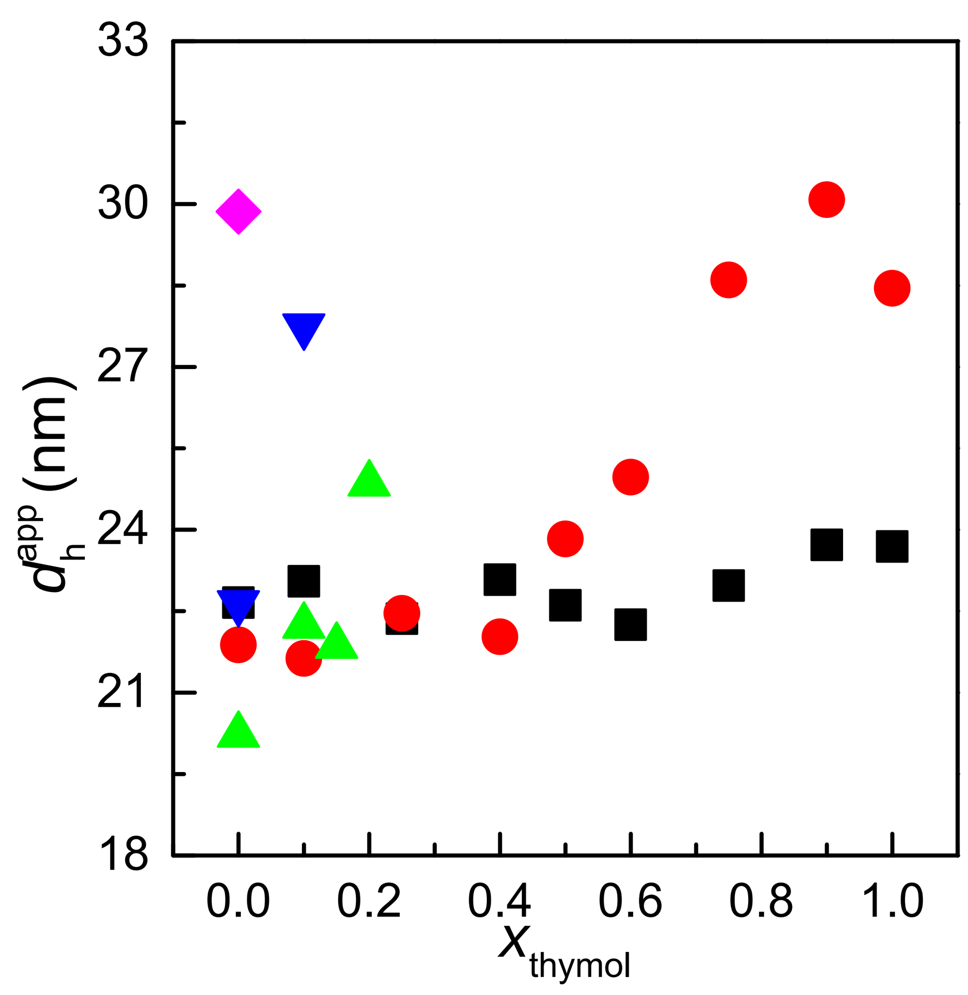




-An increase in the total concentration of the oil phase tends to reduce the compositional range within which stable emulsions can be achieved. This is explained by considering that it is required an appropriate hydrophobic environment to ensure oil stabilization

-Decrease in dispersion stability with increasing thymol content in the oil phase can be attributed to a critical compositional balance that guarantee thymol solubilization within the oil phase.

Droplet size

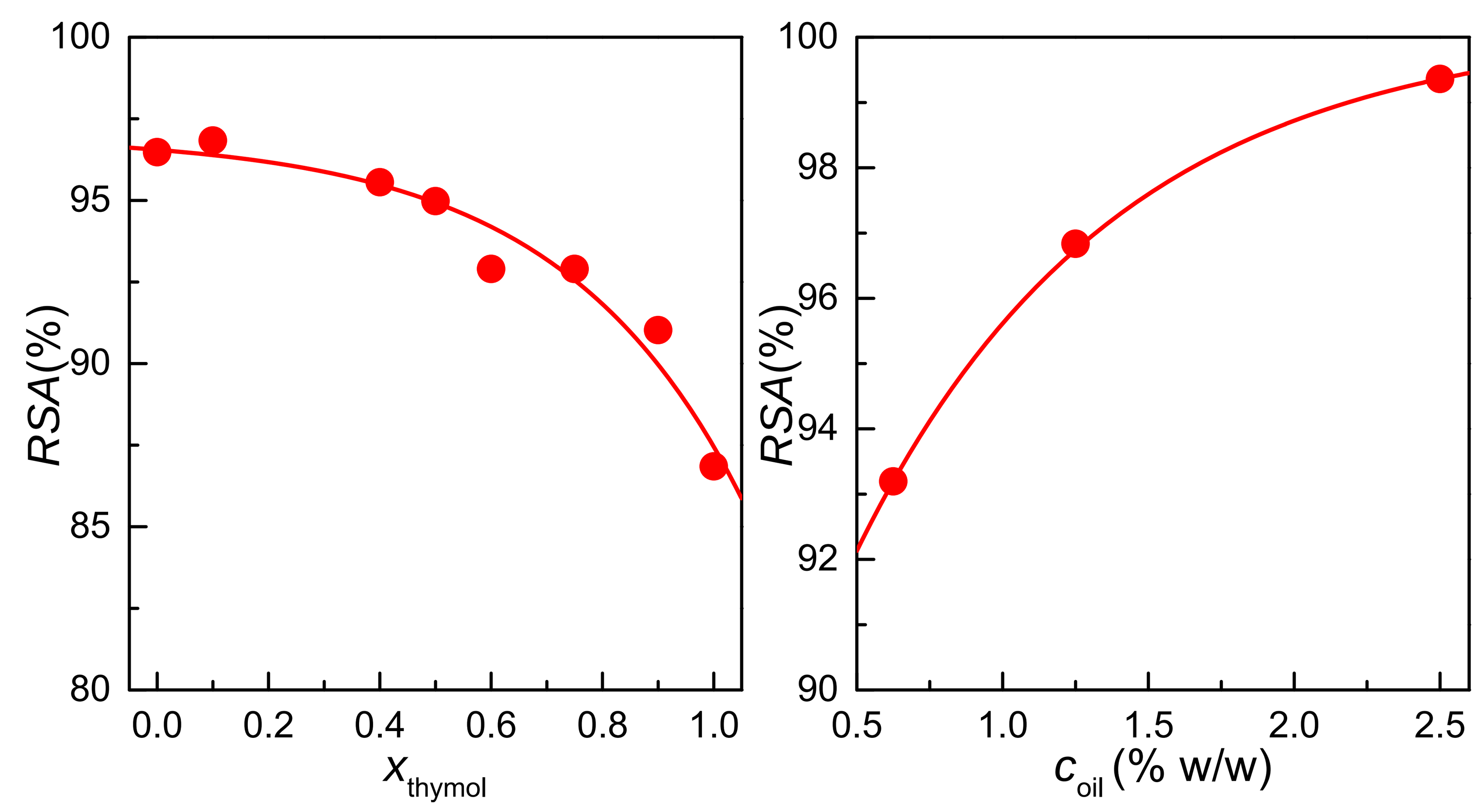


-Dispersions with eugenol as the sole component of the oil phase, or as the main when there is a low total oil concentration, present a constant average hydrodynamic diameter within the 20–22 nm range.

-Increasing either the weight fraction of thymol in the oil phase or the total oil concentration leads to larger droplet sizes.

-This size growth results from a reduction of the stability of the dispersions

Antioxidant capacity



CONCLUSION

- Stable oil-in-water emulsions were successfully formulated using Pluronic F-127 as a stabilizer, incorporating varying oil fractions and thymol/eugenol ratios.
- Increasing the total oil fraction pushed the system toward instability, driven by a higher oil-to-stabilizer ratio, which hindered effective stabilization of the oil nanodroplets within the aqueous phase.
- Fluorescence emission spectra revealed the coexistence of two distinct microenvironments in the nanodroplets: one within the bulk of the droplets and another associated with the polymer shell stabilizing the interface.
- Encapsulation of essential oil compounds within the nanodroplets' internal core provides a promising strategy to preserve their antioxidant capacity, which depends on the oil phase composition and concentration.