Reactivity of a model lipophilic ingredient in surfactant-stabilized emulsions: Effect of droplet surface charge and ingredient location

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HIGHLIGHTS

- The location and reactivity of PTMIO in emulsions is determined by EPR.
- PTMIO partitions between lipid, micelle and aqueous environments.
- The concentration of surfactant affects the reduction rate of PTMIO by ascorbate.
- The rate of PTMIO reduction is greater in DTAB than in SDS-stabilized emulsions.

GRAPHICAL ABSTRACT

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ABSTRACT

The aim of this work was to investigate the location and reactivity of a lipophilic spin probe, 4-phenyl-2,2,5,5-tetramethyl-3-imidazoline-1-oxyl nitroxide (PTMIO) in emulsion systems stabilized with anionic (sodium dodecyl sulfate, SDS) or cationic (dodecyl trimethylammonium bromide, DTAB) surfactants. The analysis of electron paramagnetic resonance (EPR) spectra of PTMIO in emulsion systems showed that probe molecules partitioned between three environments: the aqueous phase, the lipid droplet core and the surfactant micellar pseudophase. The rate of the reduction of the nitroxide group of PTMIO by ascorbate anions was much faster in DTAB-stabilized emulsions than in SDS-stabilized emulsions, showing that the droplet surface charge controlled to a large extent the probe reactivity with charged aqueous compounds. When excess surfactant was added to the emulsion aqueous phase, a displacement of a fraction of PTMIO molecules from the lipid droplet core to the micellar pseudophase was observed. The subsequent change in the probe partitioning was found to affect the probe's reduction rate, which confirms that aqueous phase micelles contribute substantially to the reactivity of lipophilic ingredients incorporated in emulsion systems.

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1. Introduction

A range of lipophilic ingredients are added in small quantities to food, pharmaceutical and cosmetic products to produce a desired functionality (e.g., flavors, pigments, vitamins, drugs, antimicrobials and phytochemicals). These ingredients are often highly hydrophobic and chemically labile so are frequently encapsulated in microemulsions or emulsions to allow dilution in water and to provide some chemical stabilization [1–5].

The composition and structure of the encapsulation system can affect the distribution, the reactivity and hence the performance of the ingredient. For example, interfacial properties are considered to be important determinants of the reactivity of lipophilic ingredients in emulsions [6,7] and surface charge in particular has been repeatedly shown to affect metal-induced lipid oxidation [8,9] and the degradation of flavor compounds [10].

Lipophilic small molecules will rapidly partition between the available phases in a delivery system and their reactivity and functionality depend on their microlocalization. O/W emulsions generally contain unadsorbed emulsifiers (e.g., surfactant micelles) that can behave as a pseudophase [11–13] and solubilize a fraction of the lipophilic molecules [14–17]. For instance, several studies...