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Effects of Different Surfactants on Emulsion Stabilization: A Mini Review

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Abstract

Emulsions are widely used both for research and industrial purposes. Many products used in our daily life are based on emulsions, for this reason it is of great interest to determine the best conditions for stabilizing these systems. Perhaps the main factor to consider is the optimal selection of surfactants and cosurfactants to prevent the emulsion from coalescence, however, we must study the process of formation and stabilization of emulsions to gain more clarity regarding the different factors that can affect their stability.

Keywords: Colloids; Emulsions; Surfactants; Cosurfactants; Stabilization

Introduction

Colloidal systems are formed by two immiscible phases: a continuous phase and a dispersed phase. Colloids can be classified depending on the nature of its phases; however, a more general definition considers as colloidal particles those whose linear size ranks between 1nm and 1μm. Whenever the system is constituted by liquids in both the continuous and dispersed phase, it's called an emulsion [1]. Emulsions are inherently unstable due to attractive forces, which can cause the droplets on the dispersed phase to aggregate. However, kinetic stability can be induced by the addition of substances that cause repulsive interactions which compensate for the attractive interactions between particles [2]. Different mechanisms can provide kinetic stability to emulsions. This work intends to review some of them and discuss which has a better effect in emulsion stabilization through time.

Emulsion Formation

As colloids are formed by immiscible phases, there will be a region of coexistence between them, which is called interface. The main characteristic of the interface is the increase of Gibbs free energy. The concentration of particles in the interface is called adsorption and can be quantified by Γ_i, that represents the excess of moles on the interface compared to the bulk.

Therefore, in order to mix the aforementioned phases, it is necessary to apply energy to compensate the interfacial tension. The application of acoustic energy creates a phenomenon called cavitation, which provokes the formation of bubbles due to the variation of pressure throughout the liquid [3]. Cavitation causes the dispersed phase to break into small droplets, thus increasing the interfacial area. This principle is responsible for the formation of emulsions. Nonetheless, the single application of ultrasonic energy is not enough to form a stable emulsion, for the droplets would easily coalesce in this conditions [4].

Emulsion Stabilization

An important factor in the stability of an emulsion is the droplet size: the smaller the droplet size, the more stability. Initially, droplet size depends on the composition of the dispersed phase, its affinity to the medium and the power of energy applied. Surfactants and polymers are also used to stabilize emulsions by restricting the interaction between droplets. This can be caused through two different effects: electrostatic and steric stabilization [5]. The first case refers to the induction of repulsive forces by the addition of charged surfactants (ionic surfactants). While the steric stabilization is produced by the coating of droplets with non-ionic surfactants or polymers. Kind of surfactant prevents the dispersed phase to coalesce, however, there are more factors to be considered in order to determine the best surfactant for an emulsion.

Effects of Different Surfactants on Emulsion Stabilization

Surfactants play a doble role in emulsion stabilization: they prevent aggregation of particles, and they decrease the interfacial tension, thus favoring the solubilization of the droplets in the continuous phase [6].

Surfactants can be classified in 3 categories: cationic, anionic and non-ionic. While both cationic and anionic surfactants are hydrophilic, non-ionic surfactants can either be hydrophilic or lipophilic [7]. The best type of surfactant for emulsion stabilization depends on the composition of the continuous phase. Bancroft's rule states that the continuous phase is that in which the surfactant is more soluble. By this means, an o/w emulsion should have a hydrophilic surfactant and a w/o emulsion would have a hydrophobic surfactant [8].

HLB

The Hydrophilic-Lipophilic Balance (HLB) of non-ionic surfactants determines their affinity for water or oil. Values from 1 to 10 correspond to lipophilic surfactants and values from 10 to 20 correspond to hydrophilic surfactants. Normally, w/o emulsifiers have HLB values from 4 to 8, while o/w emulsifiers have a wider HLB range, from 8 to 16 [7]. In order to determine the best non-ionic surfactant for stabilizing a system, it's important to consider their HLB value, which can be easily calculated through the following equation:

$$HLB=20\times M_h/M$$

Where M_h is the molecular mass of the hydrophilic part of the surfactant and M is the molecular mass of the whole surfactant molecule. Experimentally, it's been proven that the HLB value of a surfactant has an important role in the stabilization of an emulsion and can even increase its viscosity [9,10].

Viscosity

Furthermore, the viscosity of the surfactant should also be taken into consideration. It is known that higher viscosity prevents particles from colliding and aggregation, which provides stability to the system. However, if the viscosity is too high, it can avert the optimal dispersion of particles through the continuous phase [11].

Cosurfactants can also be used in order to reach the ideal viscosity for an emulsion. As their role in the formation of the emulsion is not as important as the surfactant's, their concentration can be easily changed in order to achieve the desired viscosity [11,12]. The viscosity of the emulsion is of great importance since it can contribute to a narrower size distribution, as aggregation is one of the main factors in the obtention of polydisperse emulsions.

Conclusion

Emulsions require energy for their formation and are unlikely to remain stable for a long time. Nevertheless, stability can be induced through surfactants, which prevent the aggregation of particles. Whenever it is desired not only to stabilize the emulsion, but to improve the size distribution, cosurfactants can be used to increase the viscosity of the emulsion and therefore, provide more stability to it. The effects of surfactants can change depending on the composition of the emulsion, however, knowing how each parameter affects the emulsion's formation and stabilization can help us determine the best experimental conditions.

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