PILOT CHEMICAL COMPANY
www.pilotchemical.com
2744 East Kemper Road • Cincinnati, OH 45241

Technical Bulletin:

EMULSIONS

What is an emulsion?

An emulsion is a dispersion of one liquid in a second, immiscible liquid. Usually one of the liquids is water, the other, an oil or other water-immiscible material. Two distinct types of emulsion are possible. For example, for oil and water, the two possibilities are; an oil in water (O/W) emulsion where oil is the "suspended" phase consisting of unconnected droplets in water, the "continuous" phase. The converse of this situation is a water in oil (W/O) emulsion where the two phases are reversed.

Why are surfactants important in emulsions?

Often, emulsions are inherently unstable. The small suspended droplets first coalesce into less stable, larger droplets. This coalescence then continues until the emulsion breaks into two layers. This phenomenon can occur over a relatively short period of time. If a long emulsion lifetime is required, therefore, a stabilizer needs to be added. This stabilizer is usually a surfactant.

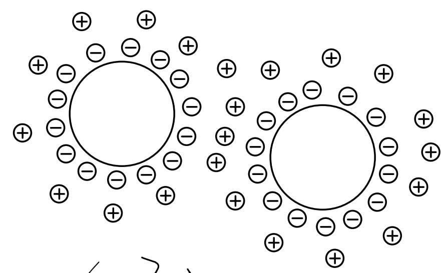
How do surfactants stabilize emulsions?

There are two stabilization mechanisms; electrostatic and steric. Which of these is present in any given system depends entirely on the type of surfactant used. Note: Pilot's products are almost exclusively used in O/W emulsions, so the following descriptions refer to those systems only.

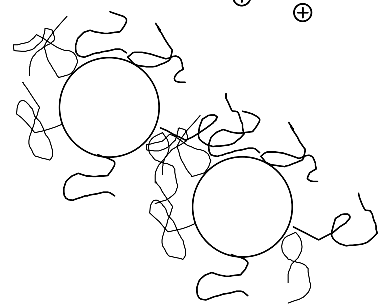
a) Electrostatic stabilization: As the name implies, this is the mechanism of stabilization involved with charged surfactants - usually anionics. On forming an aqueous solution, an ionic surfactant breaks into two components, the anionic surfactant portion (e.g. lauryl sulfate) and the cationic counterion (e.g. sodium). This process is called "ionization." In the presence of a suspended oil phase, the hydrophobic tails of the anionic portion are "dissolved" in the oil droplets leaving the charged heads on the droplet surface. This molecular orientation results in a net negative charge on the surface of the droplet. This surface charge leads to the formation of a secondary shell of dissolved countering which is positively charged. The negative surface/positive secondary shell system is known as an "electrical double layer." The end result of the double layer is emulsion stabilization as two approaching oil droplets are barred from coalescing by their mutually repulsive positively charged outer shells.

b) Steric stabilization: This mechanism of stabilization is prevalent with nonionic surfactants. As described in the surfactants bulletin, nonionics differ from anionics in two important ways. Firstly, anionics are charged, nonionics are electrically neutral. Secondly, while anionics tend to have small, compact hydrophiles (e.g. SO_4^{2-}, RSO_3^-), nonionics can have much larger, more diffuse hydrophiles (e.g. alcohol or phenol ethoxylates with 25 ethoxylate (EO) units or more in the hydrophile). Thus, when the hydrophobes of a nonionic are “dissolved” into a suspended oil droplet, the hydrophiles protrude a long way into the water medium from the droplet surface. Much as the bristles on a hair brush preclude two brushes being pushed together head to head, the protruding hydrophiles prevent the oil droplets from coalescing. This effect is steric stabilization.

Electrostatic Stabilization



Steric Stabilization



Often it proves advantageous to use both types of stabilization simultaneously. In electrostatically stabilized systems, the negative charges on the surface of the oil droplets themselves will repel each other, limiting their surface density. This in turn, leads to weaker double layers which will afford less stabilization. Addition of a nonionic surfactant to the system increases the stabilization in two ways. Firstly, it adds a steric factor to the stabilization mechanism and, secondly, the nonionics help shield the surface charges from each other, increasing the charge density available.