Everyday Emulsions

Tinkering with every day materials for better classroom experiences

RockEDU SCIENCE OUTREACH

Ice cream. Milk. Latex paint. Mayonnaise. Lotions and creams... Emulsions are all around us, but do our students know the link between these everyday materials and the amazing chemistry behind them? Through this resource, we will explore the chemistry of familiar emulsions, applying our current understandings of intermolecular forces to develop new and fun ways to present these concepts in the classroom. We will use specialized dyes to determine emulsion types, make our own lotion using accessible ingredients, and use case studies to explore how this chemistry can impact our environment.

Lotions are Emulsions

In terms of marketing and advertising, lotions are typically lumped into the "cosmetics" category. To a chemist, however, lotions represent a mixture where normally immiscible (unmixable) liquids are combined in a way that evenly distributes one of the immiscible liquids into the other, *without* dissolving it. We encounter these types of mixtures everyday -- in cosmetics, food, medicine, and some household products.

We know lotions as creamy products that feel great on our skin. As it turns out, lotions are a complex mixture of different substances that need to be combined -- in certain proportions -- in order to stably interact. We can bring the science of lotions back to the classroom in so many ways! For one, they are a great way to talk about intermolecular forces. Additionally, the molecules in an emulsion organize at scales similar to the wavelengths of light, which lead to an opaque appearance. Hence, light scattering and other "physics" concepts can be explored through lotions. You can even bring this back to our biology to understand the interplay of lotions and our skin cells.

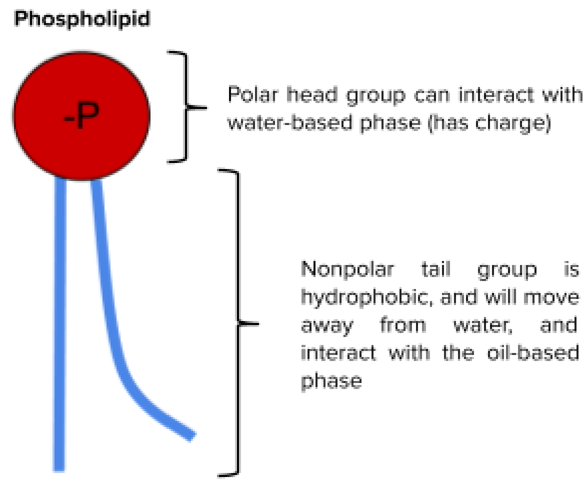
Stabilizing emulsions with surfactants

Let's go back to making a vinaigrette. We might shake vigorously to mix oil and water together, but for the reasons mentioned above, the mixture will quickly separate into two distinct phases.

However, there are many contexts that require the stabilization of oil and water mixtures. How can we lower the energy barrier to prevent separation? The answer lies in the addition of emulsifying agents, also known as surfactants.

Surfactants are molecules or molecular compounds that lower the surface tension at an interface (interfacial tension). In the case of water-oil interface, adding a surfactant will lower the energy barrier for breaking hydrogen bonds among water molecules, and allow more freedom for water molecules to interact with other types of molecules in a given system. Additionally, surfactants have the ability to form micelles, which are a type of molecular "cage" that forms around solute molecules that are normally immiscible in a particular solvent (ie nonpolar molecules can be protected inside a micelle when immersed in a polar solvent).

From a chemical perspective, surfactants solve the incompatibility between water and oil because they contain both polar and nonpolar properties, serving as a bridge between polar/aqueous and nonpolar/organic substances. A common surfactant is a phospholipid, such as lecithin, which contains a polar headgroup that interacts with water, and a nonpolar tail that interacts with oils. In an emulsion, a phospholipid would surround the dispersed droplets, creating a micelle, forming a barrier between the water and oil.



This presence of a phospholipid stabilizes the emulsion, preventing the oil and water components from separating. As described above, phospholipid molecules can help form a "molecular cage" to allow for oil phases to be separate from water phases, as shown in the schematic below.