HLB – The Easiest Way to Create An Emulsion
by Kelly Dobos

As a cosmetic chemist you will undoubtedly be asked to make products that require you to combine materials that aren’t easily compatible. Fortunately, there is a system that can help you get started.

Cosmetic Emulsions
Emulsions are one of the most common forms of cosmetic products. You find them in skin lotions, make-up, and even hair products. By definition an emulsion is a dispersion of two or more immiscible materials, where one phase, also know as the internal phase, is dispersed in the continuous or external phase. Cosmetic emulsions are classified as oil in water (O/W), water in oil (W/O) and water in silicone (W/Si). Multiple emulsions such as oil in water in oil (W/O/W) are also possible. Oil in water emulsions are the most common due to preferable cost and light skin feel.

In order to create an oil in water emulsion (one that remains stable for a long enough time), work must be done to overcome the interfacial tension between the two phases. This can be achieved by mixing; however mixing even at very high rates is not enough to provide long term stability. An emulsifier or combination of emulsifiers is needed to stabilize droplets of the dispersed phase. For example, simple oil in vinegar salad dressings will separate rapidly without the use of an emulsifier like mustard.

Using Surfactants
In this industry, we use surfactants to create emulsions. Surfactants are molecules that have a hydrophobic (oil soluble) and an effective hydrophilic (water soluble) portion. They act as emulsifiers by significantly lowering the interfacial tension and decreasing the coalescence of dispersed droplets.

HLB Formulating
Figuring out what surfactant to use for any specific formula will be a challenge you face as a cosmetic chemist. There is a great deal of research on surfactants and their behavior. But studying the thermodynamic equations and phase diagrams associated with surfactants can be a daunting task, not to mention the number of surfactants available to the formulator is vast. Luckily for us, William C. Griffin developed a way to streamline the selection of surfactants by utilizing the ratio of the hydrophobic to the hydrophilic portion of the molecule. This method is referred to as the HLB (Hydrophile Lipophile Balance) method. Griffin first presented this method at meeting of the Chicago Chapter of the Society of Cosmetic Chemists in 1949 and it is still widely used today. He published the method shortly there after.1 (A bit of trivia for you, the Chicago Chapter was the first chapter formed in Society of Cosmetic Chemists)

The HLB method applies to nonionic (uncharged) surfactants but attempts have been made to broaden the concepts to other surfactant types including silicone surfactants. And using the HLB system to create emulsions is quite simple. All you have to do is calculate the HLB number of your surfactant, then the required HLB for the oil phase and match the two numbers.

Determining the HLB of a surfactant
A typical nonionic emulsifier (e.g. Laureth-4) contains an ethylene oxide groups or polyhydric alcohol hydrophilic portions with a fatty alcohol hydrophobic portion. The HLB for a nonionic surfactant can be calculated as follows:

\[ \text{HLB} = \frac{\text{Weight % Hydrophilic}}{5} \]

Example 1: HLB calculation for Laureth-4
Molecular weight of ethoxylate portion = 176
Molecular weight of lauryl alcohol = 186
\[ \text{Wt. % Hydrophilic} = \left(\frac{176}{(176+186)}\right) \times 100 = 48.6\% \]
\[ \text{HLB} = \frac{48.6}{5} = 9.7 \]
Based on the calculation, surfactants with high HLB values will be more water soluble and those with low HLB values are more oil soluble. Division by 5 just allows for a compact, easy to use scale. The calculation is simple, but you won’t usually have to figure it out since most surfactant HLB values are readily available through literature references and surfactant suppliers.

**Calculating HLB of oil phase**

Each lipophilic ingredient in the oil phase has its own required HLB. These required HLB values are determined experimentally, however a method utilizing solubility parameters has been proposed by Vaughan and Rice. Required HLB values for some common oil phase ingredients are available to the formulator in literature. The Req’d HLB values are approximate and can vary by about ± 1 unit. It is also important to keep in mind that cosmetic emulsions often have complex oil phases with several components. The required HLB of an oil phase mixture can be calculated by first calculating the percent of the oil phase each ingredient contributes. This percentage is then multiplied by the required HLB for each of those ingredients and the results are summed.

**Example 2: Calculation of required HLB for an oil phase mixture**

The oil phase is 10% of the total formulation and consists of:

- 4% Shea butter, 40% of the oil phase. Req’d HLB of 8.
- 3% Jojoba oil, 30% of the oil phase. Req’d HLB of 6.5.
- 3% Sunflower seed oil, 30% of the oil phase. Req’d HLB of 7.

Total required HLB:

Shea butter contribution 0.4 x 8 = 3.20
Jojoba oil contribution 0.3 x 6.5 = 1.95
Sunflower oil contribution 0.3 x 7 = 2.10
Total Req’d HLB = 7.25

You can now select emulsifiers to match the required HLB of the oil phase and create an emulsion. A blend of high and low HLB surfactants is often used to achieve the desired value in part because of demonstrated effectiveness and efficiencies in packing at the interface. The HLB for the surfactant blend is calculated in same manner as the required HLB for a blend.

**Example 3: Calculation of HLB for a surfactant mixture**

The surfactant mixture is a 70/30 blend of Steareth-2 and Steareth-21.

Total HLB:

Steareth-2 contribution 0.7 x 4.9 = 3.43
Steareth-21 contribution 0.3 x 15.5 = 4.65
Total HLB = 8.08

In order to match the HLB of a particular oil phase, it is easiest to set up a spreadsheet with the calculation and vary the percentages of each emulsifier in increments of 5% to find the right ratio.

**Limitations of HLB**

Although a very useful tool, the HLB system does have some limitations. For example additional water phase ingredients are not considered but still may impact the stability. The method also does not provide information as to how much surfactant is needed, but 2 to 4% surfactant is a good starting point to begin further optimization for stability. So it is important to keep in mind that the HLB system is not absolute in prediction of your formulations behavior, but a very good starting point for achieving emulsification.

**References**


To ask Kelly a question go to http://chemistscorner.com/hlb-the-easiest-way-to-create-an-emulsion/