Formulating Cosmetic Emulsions: A Beginner's Guide

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ABSTRACT: *Emulsions that act as a delivery system for beneficial ingredients such as aloe, vitamins, plant extracts, etc., must also be safe, stable and cost-effective. This article discusses the ingredients that go into emulsions and why they are used.*

To most consumers, cosmetic emulsions are just "stuff" that comes in tubes, jars, pumps or bottles intended to make the consumer look, feel or smell better, but usually costing too much. The claims on the front of the package often promise miracles – and they do this very cleverly, I must add! Consumers often don't understand that those words are used by marketers to ensure that the U.S. FDA (Food and Drug Administration) leaves the manufacturer alone. Greeted with a long list of totally unpronounceable "chemicals," consumers search for the ingredients reported to have benefits. Among these "beneficial" ingredients are aloe, vitamins, minerals, jojoba, plant extracts, tea, things from the sea, and others from an endless list.

Cosmetic chemists must be concerned with formulating an emulsion that acts as a delivery system for these beneficial ingredients while being safe, stable and, need I mention, cost-effective (cheap). This article discusses those ingredients that go into emulsions and why they are used.

Definition of an Emulsion

An emulsion is a system of two (or more) immiscible materials (usually liquids) in which one material – the dispersed/internal phase – is suspended or dispersed throughout the other material (the continuous/external phase) in separate droplets. Most emulsions we will encounter will be designated as oil-in-water (O/W); thus the oil phase is dispersed in the water phase as droplets. In the United States approximately 95% of all emulsions are of this type. Water-in-oil emulsions are used in night creams, makeup remover creams and zinc oxide ointments for babies and sunscreens. Historically, they have had a greasy skin feel, but more recent advances in emollient chemistry, more specifically silicone chemistry, have changed this perception.

A final comment before we delve into the ingredients used in emulsions: Many years ago my good friend and mentor, Graham Barker, told me that all emulsions are inherently unstable. He said that all we can do is postpone the day when emulsion separation occurs and hope that in the meantime the product will have been purchased and used. One exception to this "rule" comes with microemulsions (very small particle sizes) that form spontaneously and are thermodynamically stable.

Typical Oil-in-Water Emulsions

Table 1 shows a typical O/W emulsion. Let's go over each of the "ingredients" in some detail to discuss their functions and a bit about their chemistry.

Water: This is of course the diluent/external phase. We like to use as much of it as possible because it lowers the cost of our product.

Humectant: Humectants serve several purposes in emulsions. They can bind to water (through hydrogen bonding) and are thus considered to be "moisturizers." Good examples of humectants are: glycerin, propylene glycol, m, p-diol, butylene glycol and sodium hyaluronate. Humectants can act as solubilizers for paraben preservatives and "actives." They can also help improve the rub-out characteristics of emulsions by altering spreading effects, a technique used in liquid makeups to reduce streaking. Humectants can also improve the cushion (richness during rubout) of many emulsions. Lastly, humectants can improve the freeze/thaw stability of both O/W and W/O emulsions. If you use them at too high a concentration, a sticky emulsion can be the result. As you can see they are very versatile materials.

Preservative: As the saying goes, "if there is (available) water…there should be a preservative." The list of preservatives is very long but a few of the more popular ones are: methylparaben, propylparaben, DMDM hydantoin, quaternium-15, imidazolidinyl urea, diazolidinyl urea, phenoxyethanol, benzyl alcohol, potassium sorbate and iodopropanyl butylcarbamate. Care must be taken when choosing preservatives in regards to packaging interaction, pH, interaction with other raw materials and other considerations.

Emulsifier: Generally speaking, formulators should use several emulsifiers to make a stable emulsion. One should be put into the external phase and one or two should be put into the oil phase.

Table 1. A typical O/W emulsion

Ingredient	Typical use level (%)
Water phase	
Water *(aqua)*	60.0-85.0
Humectant	2.0-5.0
Preservative	0.05-1.0
Emulsifier	0.5-1.5
Thickener	0.1-2.0
Emollient	0.5-2.0
"Whiffle dust"	as desired
Chelating agent	0.05-0.2
Oil phase	
Emollient(s)	5.0-10.0
"Actives"	as per FDA
Antioxidant	0.05-0.2
Emulsifier (primary)	1.0-3.0
Emulsifier (secondary)	0.5-1.0
Thickener	0.1-0.5
Wax	0.5-2.0
"Whiffle dust"	as desired
Miscellaneous phase	
Preservative	0.05-1.0
"Actives"	as per FDA
Fragrance *(parfum)*	0.1-0.75
Color	as needed

Emulsifier types include the following:

- Nonionic (uncharged). These are often ethoxylated.
- Anionic (negatively charged hydrophobe). These are usually soap (triethanolamine stearate).
- Cationic (positively charged hydrophobe). An example is dicetylmonium chloride.

Thickener: There are many thickening agents used in emulsions. At first glance it would seem that their function was to thicken emulsions. However this is usually not the case. Their primary function is to improve high temperature stability, but among their other functions are thickening, suspending particulate materials, and affecting rubout characteristics. Among thickeners most often seen are polyacrylates, xanthan gum, cellulosic gums, guar gum, magnesium aluminum silicate, carbomer and bentonites. Great care must be taken to use them at low use levels, because they often impart stickiness to the finished product.

Emollient: Emollients serve several functions. They impart lubricity to the skin and can help to solubilize drug actives such as sunscreens. They can be esters, ethers, fatty alcohols, hydrocarbons or silicones. Often they are combined to achieve unique skin feel as required by marketing. Care should be taken to insure that they are compatible/stable in the system chosen.

"Whiffle dust": Here we have an almost limitless list of ingredients from which to choose. Your choice will be controlled by marketing, the latest trends and cost.

Chelating agent: Most emulsions, and most cosmetic products in general, should contain a chelating agent. Their function is to complex with metal ions (iron, copper, etc.) to prevent them from negatively affecting your product. They can improve/help maintain color, odor and preservation. Typical of this category are the salts of EDTA.

Waxes: Waxes are used to thicken the oil phase of W/O emulsions and thus improve stability. Additionally they can reduce syneresis (oil bleeding) often seen in high oil systems by making the oil phase more coherent. They can also affect/improve the rubout characteristics of emulsions. Typically seen waxes include carnauba, ceresin, paraffin, fatty alcohols, candelilla and beeswax.

Actives: These are materials that have been labeled as drugs by the FDA. As such, we must use them at approved use levels and make claims that follow the appropriate FDA monograph. Typical of this category are octinoxate (sunscreen), oxybenzone (sunscreen), zinc oxide (sunscreen or skin protectant), petrolatum (skin protectant), benzoyl peroxide (anti-acne agent), hydroquinone (skin lightener) and dimethicone (skin protectant).

Silicones: While silicones have appeared in emulsions for many years, their use has greatly expanded over the last five years. At first glance their function seems to be emolliency, but in reality they have much broader usage than that. Dimethicones can indeed function as emollients but they also reduce skin whitening (soaping) often seen when high levels of fatty alcohols, GMS or stearic acid are employed.

Additionally, when used at 1%, they can be claimed as a Category I skin protectant (i.e., a drug)! When using dimethicones, care must be taken to insure they are coupled into the oil phase due to their limited solubility profile. Additionally, they can present some difficulty in regards to emulsification (i.e., they don't follow the HLB rules). Most used are the 100-350 cs versions. When solubility/compatibility is an issue, you should consider using one of the many alkyl modified dimethicones.

Other silicones include the cyclic versions. These silicones impart a silky skin feel and are less volatile than water. Since their heat of vaporization is quite low (they don't take much energy from the skin to volatilize), they feel very dry to the skin. It must be pointed out that these materials have come under attack for potential safety issues, particularly with the tetramer version.

Other silicones are modified by adding EO/PO (ethylene oxide/propylene oxide) that will allow them to function as emulsifiers, solubilizers or emollients. Lastly, there are a series of new silicone elastomers that can act as delivery vehicles or dramatically improve skin feel. The world of silicones is truly amazing.

Fragrance: Almost all emulsions will contain a fragrance. Often it is the main reason a consumer repurchases the product. Care must be taken to not use them at too high a use level or discoloration and/or irritation may result. Additionally, they will have a significant effect on the raw material cost of the product.

Color: While many emulsions are white, there are quite a few that have added color. The purpose of the color may be to mesh with the product function. A cooling aftershave balm may be colored blue or light green. Or, color may be added to hide a discoloration due to the inclusion of a needed ingredient (green tea for example).

Conclusion

This has been a short introduction to the world of emulsions. To become an expert in this most difficult field does indeed require many years of hard work and many failed emulsions.

References

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