

How to Make Water-in-Oil (W/O) Emulsions

Formulating water-in-oil (W/O) emulsions is inherently more difficult than oil-in-water (O/W) emulsions. But what is the difference between W/O and O/W emulsions? - By definition, if oil is dispersed in water, it is an oil-in-water emulsion. And vice versa, when water droplets are dispersed in oil, the resulting emulsion is called a water-in-oil emulsion. Although often heard and read, it is not true that emulsions must be water-in-oil emulsions when the water phase has been added into the oil phase. It also not true that the ratio between water and oil determines whether you have an oil-in-water or water-in-oil emulsion. For example, an emulsion that contains 15% of oils and 75% of water is not automatically an oil-in-water emulsion. The amount of oil and water is basically the same whether you have an oil-in-water or water-in-oil emulsion! As a rule of thumb, the amount of water is always approximately 60 - 80 %. So, what is it that determines whether you have a O/W or W/O emulsion? - It is the type of emulsifier that determines the type of emulsion!

Definition of Water-in-Oil Emulsion

In W/O emulsions water droplets are dispersed in oil. This process is dependent on the type of emulsifier, and not the water-to-oil ratio!

Where are W/O Emulsions Useful

Whereas water-in-oil emulsions have enjoyed a long tradition and a widespread use in Europe, they have become popular in the United States only in recent years due to rising popularity in the sunscreen market. - Why sunscreens? It is well known that W/O emulsions are more efficient with a higher SPF (sun protection factor) for the same percentage of sunscreen. In addition, W/O emulsions are preferred in sunscreen products since they are better water-resistant than O/W emulsions.

W/O emulsions are also often used in makeup products as this will ensure smooth application and a great skin feel and also prevent smudging if volatile solvent are used.

Although most moisturizers (incl. day and night creams) are O/W emulsions, a W/O emulsion is preferred if the product is intended for very dry, sensitive and compromised skin. W/O emulsifiers are often milder than O/W emulsifiers and do not disturb the lipid bilayers in the skin. In addition, they may minimize the trans-epidermal water loss.

Manufacturing of W/O Emulsions

When making an O/W emulsions you can easily add the oil phase to the water phase (or vice versa), or dump everything into one container and heat to 66 - 80°C (150 - 176°F). - This will not work with W/O emulsions! For making W/O emulsions you have to add the water very slowly to the oil phase (which must contain the emulsifier), making sure that the water does not pool up excessively on the surface. Hence, you have to keep stirring continuously while adding the water.

Use the Right Emulsifiers

Often, O/W emulsions are made with more than one emulsifier. By combining emulsifiers, the oil-water interface is strengthened resulting in a more stable product. This is not necessarily the case for W/O emulsions. Often adding a second emulsifier may stabilize the system. For W/O emulsions only a limited number of emulsifiers are available since the entire range of ionic emulsifiers (with their typically high HLB) value will not work. For W/O emulsions a very low HLB (hydrophilic/lipophilic balance) of 3 - 6 is required. The table below shows some of the important W/O emulsifiers.

Typical W/O Emulsifiers

- Sorbitan Stearate (HLB 4.7)
- Polyglyceryl Oleate (HLB 5.0)
- Lecithin (HLB approx. 4.0)
- Sorbitan Monooleate
- Glyceryl Monooleate
- Lanolin & Lanolin Alcohols

How to Stabilize W/O Emulsions

Since it is relatively difficult to obtain stable W/O systems, stabilizers and sometimes also absorption bases are needed. Absorption bases are pre-mixtures that are able to bind relatively high amounts of water. Typical absorption bases are mineral oil mixed with decyl oleate or lanolin alcohol. A relatively simple way to stabilize W/O emulsions is to use salts as sodium chloride or magnesium sulfate. Which one of the two is more appropriate for a particular emulsion needs to be tested. Another way of obtaining stability is to add a glycol like propylene glycol or glycerin. However, the combination of salts and high levels of glycols may destabilize your emulsion. The addition of certain copolymers (e.g. PEG-45 dodecyl glycol polymer) can also be used for stabilisation.

How to Thicken W/O Emulsions

Typical water phase thickeners like gums (guar gum, xanthan gum) and carbomers must be added only to the water phase as they are not suitable to thicken the external phase (oil-phase) of W/O emulsions. Both gums and carbomers, however, can improve the spreadability of W/O emulsions. To thicken the oil-phase of W/O emulsions, waxes and other oil-soluble compounds (e.g. silicones like dimethicone) must be used.



Moisturizers based on water-in-oil emulsions are excellent products for dry and sensitive skin.

Preservation

It is well-known that W/O emulsions are less prone to bacterial contamination than O/W emulsions since the water which promotes bacterial growth is "packed" with a layer of emulsifying molecules and not readily accessible for bacteria. They have to "swim" in the oil. Nevertheless, there is still enough organical material in the oil phase (waxes etc.) for bacteria to feed on. Therefore, W/O emulsions also need to be preserved with an appropriate amount of a wide-spectrum preservative like parabens, phenoxyethanol/sorbic acid or cinnamom cassia.

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References:

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