

Kolliphor® CS 12 and Kolliphor® CS 20

The science behind emulsifier functionality

Emulsifiers are surface-active substances that reduce the interfacial tension between the oil and water phase of an emulsion. Emulsifiers are adsorbed at the interface, creating a film between the immiscible phases, thus preventing the coalescence of droplets. Due to the amphiphilic structure of an emulsifier, the polar component has an affinity to the water phase whereas the non-polar component has an affinity to the oil phase.

Kolliphor® CS 12 and Kolliphor® CS 20 as non-ionic emulsifiers

Kolliphor® CS 12 (macrogol cetostearyl ether 12) and Kolliphor® CS 20 (macrogol cetostearyl ether 20, polyoxyl 20 cetostearyl ether) are ethoxylated emulsifiers that are composed of a lipophilic C₁₆ or C₁₈ chain in addition to 12 to 20 hydrophilic ethylene oxide (EO) units, respectively. These emulsifiers come in the form of solid white or yellowish white waxy powders at room temperature. While Kolliphor® CS 12 has a hydrophilic-lipophilic balance (HLB) value of 13, Kolliphor® CS 20 has an HLB value of 15. These emulsifiers are commonly used at a percentage of 0.5 – 5.5% in a pH working range of 2 – 12. Kolliphor® CS 12 and Kolliphor® CS 20 are non-ionic emulsifiers that are ideal for a variety of topical applications including but not limited to aerosols, foams, creams, gels, lotions, and sprays.

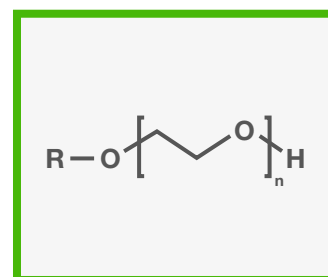


Figure 1: Chemical structure of Kolliphor® CS 12 and Kolliphor® CS 20.

| Product | R-Lipophil | N-Hydrophil |
|------------------|------------|-------------|
| Kolliphor® CS 12 | C16, C18 | 12 x EO |
| Kolliphor® CS 20 | C16, C18 | 20 x EO |

Table 1: Chemical properties of Kolliphor® CS 12 and Kolliphor® CS 20.

Formulating with Kolliphor® CS 12 and Kolliphor® CS 20

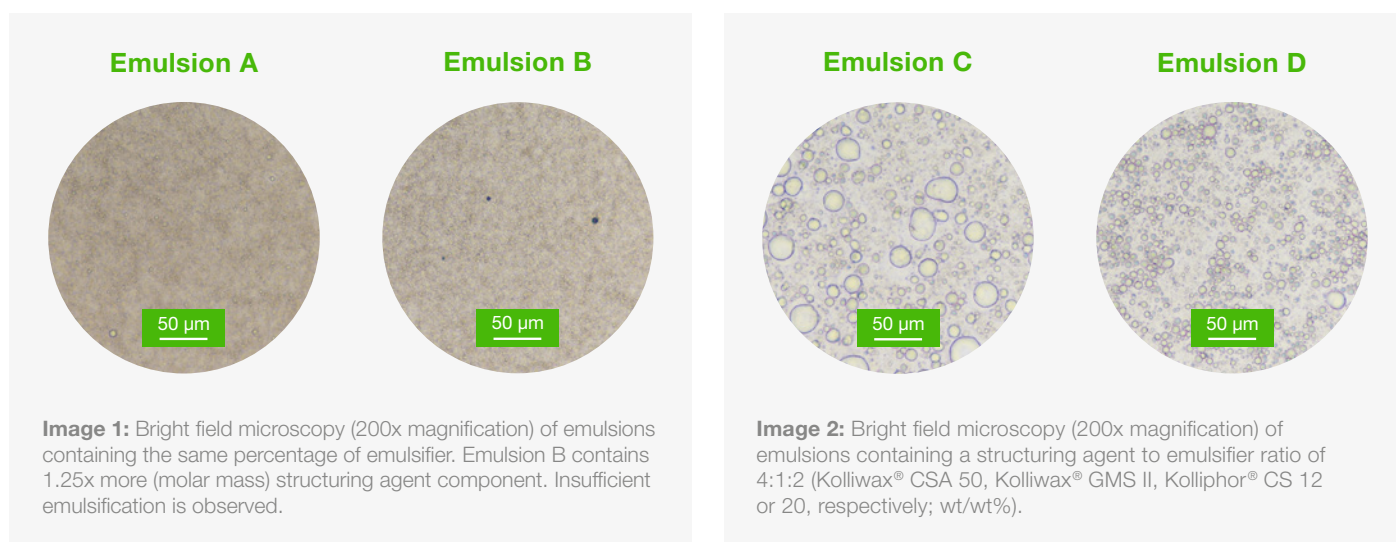
Kolliphor® CS 12 and Kolliphor® CS 20 are applicable for oil-in-water emulsions. These ethoxylated emulsifiers utilize phase inversion technology (PIT) to form emulsions with very small droplet sizes which lead to the formation of stable emulsions. PIT is a processing technology in which temperature dependency of the non-ionic emulsifier is used to change solubility behavior with elevated temperatures. When formulating oil-in-water emulsions with Kolliphor® CS 12 and Kolliphor® CS 20, it is recommended to heat the water and oil phases to approximately 80°C to achieve enhanced stability.



Enhancing emulsion stability by combining Kolliphor® emulsifiers and Kolliwax® structuring agents

Because emulsions are heterogenous systems composed of at least two immiscible phases, formulators often face challenges associated with achieving formulation stability. To uniformly disperse the oil phase within the water phase of an emulsion, non-ionic emulsifiers such as Kolliphor® CS 12 and Kolliphor® CS 20 can be employed in conjunction with Kolliwax® structuring agents to synergistically enhance emulsion stability.

It is important to consider the ratio of the structuring agent to the emulsifier to achieve a stable formulation. While increasing the percentage of the structuring agent in a formulation can shift this ratio upwards, the seemingly apparent enhancement in macrostructural stability and viscosity may only be temporary. Microstructural analysis can be utilized to predict formulation stability and detect early signs of physical instability including creaming, coalescence, or phase inversion. In emulsions A and B shown below, both emulsions experienced phase separation within one week under accelerated conditions (40°C) despite emulsion B containing a higher ratio of structuring agent to emulsifier in comparison to emulsion A.



When Kolliphor® CS 12 and Kolliphor® CS 20 work synergistically with structuring agents such as Kolliwax® CSA 50 (cetostearyl alcohol) and Kolliwax® GMS II (mono- and di-glycerides; glyceryl monostearate 40-55 [type II]), these non-ionic emulsifiers facilitate the formation of stable emulsions. Because Kolliwax® GMS II also contains a co-emulsifier effect, this material can be combined with Kolliphor® emulsifiers to further enhance formulation stability. The molar mass ratio of the Kolliwax® structuring agents to the Kolliphor® emulsifiers need to be strategically balanced so that formulation stability is achieved at both a macroscopic and microscopic level. As demonstrated by emulsions C and D shown above, complete emulsification leads to uniform dispersion of the inner oil phase within the continuous water phase.

Emulsion Rheology (Fresh)

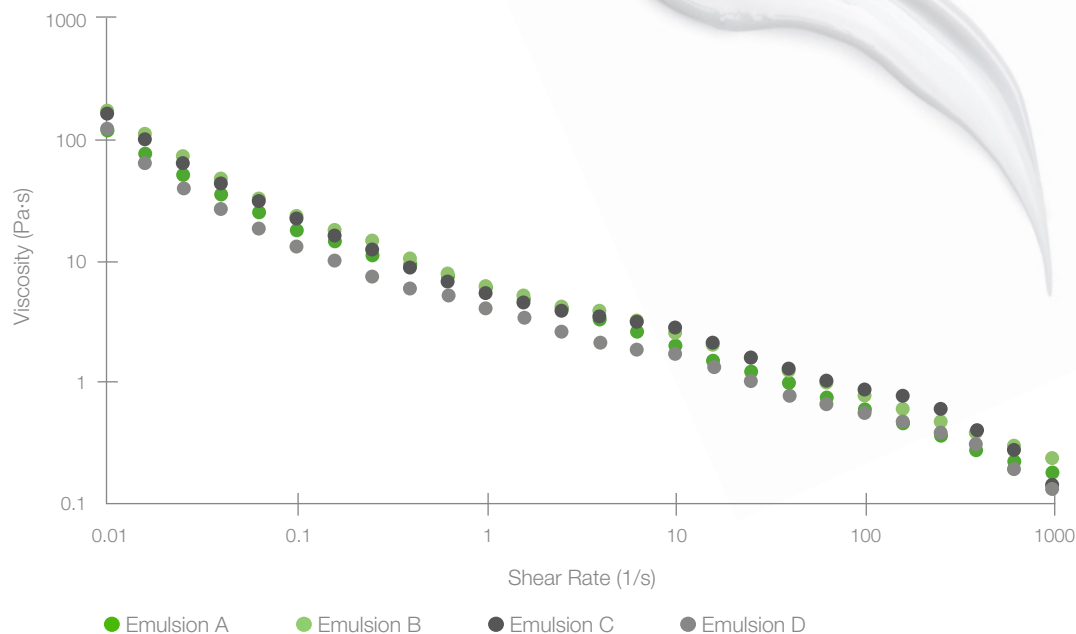


Figure 2: Initial rheology profiles of emulsions A – D demonstrate minor differences. While emulsions C and D were stable following 1-month accelerated stability (40°C), emulsions A and B exhibited early signs of physical instability followed by phase separation.

Developing topical formulations with Kolliphor® CS 12 and Kolliphor® CS 20

Light cream

Creams are complex systems that require complete emulsification of their oil and water phases to achieve formulation stability. Composed of emollients, solvents, penetration enhancers, structuring agents, and emulsifiers, creams are generally the most popular dosage form due to their emollience and soft texture. The light cream is a smooth cream with easy distribution, medium viscosity (50 Pa·s @ 1s⁻¹), and a glossy finish. The HLB value resulting from the blend of Kolliphor® CS 12 and Kolliphor® CS 20 can be adjusted to maximize emulsion stability.

| Phase | Ingredient | Chemical name | Role | Mass (wt/wt%) |
|-------|-------------------|-------------------------------|----------------------------------|---------------|
| A | Kolliwax® CSA 50 | Cetostearyl alcohol | Structuring agent | 4.00 |
| | Kolliwax® GMS II | Mono- and di-glycerides | Structuring agent, Co-emulsifier | 5.00 |
| | Kolliphor® CS 20 | Polyoxyl 20 cetostearyl ether | Emulsifier | 2.00 |
| | Kolliphor® CS 12 | Macrogol cetostearyl ether 12 | Emulsifier | 0.80 |
| | Kollicream® CP 15 | Cetyl palmitate 15 | Emollient | 0.80 |
| | Kollicream® IPM | Isopropyl myristate | Emollient, Penetration enhancer | 7.40 |
| B | Water | Water | Solvent | 74.30 |
| | Glycerin | Glycerin | Humectant | 5.00 |
| C | Euxyl® PE 9010 | Phenoxyethanol | Preservative | 0.70 |

Procedure

1. Weigh out phases A and B into appropriately sized beakers.
2. Place the mixtures under overhead mixers and set to 50 rpm. Heat the mixtures to 80°C.
3. Add phase A to phase B. Homogenize at 5000 rpm for 10 minutes.
4. Place the mixture under an overhead mixer and set to 200 rpm for 15 minutes.
5. Decrease mixing speed to 125 rpm. When the formulation has cooled to 45°C, add in phase C (preservative).
6. Continue mixing until formulation has cooled to room temperature.

Film Forming Foam

Growing in popularity, topical foams can sometimes be preferred over a cream due to their pleasing sensory profile. While foams made with Kolliphor® CS 20 tend to feel lighter and softer, those formulated with Kolliphor® CS 12 typically demonstrate a higher viscosity and stiffness. To create richer, creamier foams, poloxamers such as Kolliphor® P188 (poloxamer 188) or Kolliphor® P 407 (poloxamer 407) can also be added as needed. In the formula shown below, the addition of high molecular weight polymers such as Kollidon® 90 F (povidone) yields a rich, cohesive film forming foam with favorable sensory properties and a fast dry time.

| Phase | Ingredient | Chemical name | Role | Mass (wt/wt%) |
|-------|------------------|-------------------------------|-------------------|---------------|
| A | Kollicream® 3C | Cocoyl caprylocaprate | Emollient | 3.00 |
| | Kolliwax® CSA 50 | Cetostearyl alcohol | Structuring agent | 3.00 |
| B | Water | Water | Solvent | 72.00 |
| | Kolliphor® CS 20 | Polyoxyl 20 cetostearyl ether | Foaming agent | 5.00 |
| C | Kollidon® 90 F | Povidone | Film former | 10.00 |
| D | Euxyl® PE 9010 | Phenoxyethanol | Preservative | 1.00 |
| E | A-46 | Isobutane/Butane | Propellant | 6.00 |

Procedure

1. Blend Kolliphor® CS 20 in water and heat blend to 80°C for 20 minutes (Phase B).
2. At the same time, blend Kolliwax® CSA 50 and Kollicream® 3C and heat to 80°C for 20 minutes (Phase A).
3. Add Phase A to Phase B and quickly stir by hand.
4. Immediately homogenize blend at 3000 RPM for 10 minutes.
5. Place formulation under propeller stirring apparatus and continue to stir as the formulation cools to room temperature.
6. Slowly add Kollidon® 90 F to the formulation while cooling.
7. When formulation has reached approximately 45°C, add any preservatives or plasticizers.
8. Once the formulation has cooled to room temperature, charge the formulation in an aerosol foam dispenser and fill with propellant.



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