Wetting Agents – Multifunctional Ingredients in Color Cosmetics

A. Thiemann, S. Gröne, M. Salmina-Petersen, J. Jänichen
**Wetting Agents – Multifunctional Ingredients in Color Cosmetics**

A. Thiemann, S. Grone, M. Salmina-Petersen, J. Jänichen*

**Abstract**

Multifunctional ingredients add more than one desired attribute to a cosmetic product and are therefore becoming a more and more important tool in the formulation process. So does, for instance, their application enable the more economical use of ingredients in a formulation which in consequence allows the development of highly complex cosmetic products, such as BB or CC creams. A particularly interesting group of multi-functional ingredients comprises the wetting agents, small amphiphilic surface active materials. Their multifunctional properties arise from their ability to reduce the interfacial tension between two immiscible phases in a cosmetic formulation and comprise e.g. moisturizing, refatting, viscosity regulating, and antimicrobial activities. In addition, wetting agents assist in the stabilization of micelle structures build during the emulsification and solubilization process. So far, these properties have been the focus of many research studies and are the reason for the wetting agents’ implementation in a variety of different cosmetic concepts. In this article we highlight the superior pigment dispersion properties of four commercially available wetting agents in a variety of formulation concepts, such as emulsion-based make-up foundations and sunscreens, and aqueous-free lipstick formulations. Already at low concentrations, the wetting agents effectuate a higher dispersion efficacy, in form of a more regular distribution of smaller pigment agglomerates. As a consequence, changes in color intensity and in the viscosity of the analyzed, oily pre-dispersions were observed. However, in a final formulation changes in color were less apparent, whereas the appearance and functionality of the same formulation applied to a surface, like the skin, changed noticeably. For instance, an emulsion-based formulation with low amounts of wetting agent on a surface revealed a more intense and evenly distributed color. Ultimately, this allows the formulator to implement smaller concentrations of pigments into the final formulations, without a loss in color intensity. In an aqueous-free lipstick formulation a more regular and effective pigment dispersion was shown to increase the abrasions’ color intensity and the lipsticks durability during regular usage. Especially, sunscreen formulations were demonstrated to profit from the wetting agents multiple cosmetic properties, because a more regular inorganic UV filter distribution and a smaller pigment size are assumed to be positively associated with a higher SPF of sunscreen formulations. Further, the wetting agents enhanced the sunscreens’ uniform application on the skin, a parameter important for the efficacy of a sunscreen product, under real life conditions.

---

**Introduction**

For formulators, many good reasons for the integration of wetting agents into cosmetic formulations exist. Positive effects may regard the formulation’s sensation on the skin (e.g. refatting, moisturizing, viscosity regulating), its functionality and/or the formulation’s physical and microbiological stability. The multifunctional properties of wetting agents are connected to their amphiphilic molecular structure, consisting of a polar, hydrophilic and a non-polar, hydrophobic part. This allows the wet-
Wetting agents to gravitate towards the interphase of a bi-phase system (e.g. liquid/liquid, liquid/air, solid/liquid, solid/air) and to lower the interfacial tension. As a consequence the formation of larger interfaces in form of micelles, droplets or dispersions and the stabilization of thermodynamically unstable systems are promoted. For example, the presence of a wetting agent during an emulsification process results in a more effective conversion of mechanical and thermal energy into droplet formation (1) and during solubilization wetting agents enable the incorporation of larger amounts of oil into micelles in clear cosmetic solutions (2). Macroscopic application benefits of an interfacial tension reduction are an improved spreading ability and/or absorption of the cosmetic formulation. The multitude of stabilizing, antimicrobial and sensorial cosmetic beneficial effects makes wetting agents a frequently used ingredient in almost all cosmetic formulation concepts.

Another practical application of wetting agents regards their use in color cosmetics and its most crucial aspect, the dispersion of cosmetic pigments. Color cosmetics represent a significant growth sector within the German cosmetic market with sales increases in 2014 of 5.5% and total sales numbers of 1.56 billion Euros. It accounts for the third largest cosmetic sector with 12% in sales numbers (3). The most important inorganic cosmetic pigments in practice are Titanium Dioxide (CI 77891), yellow Iron Hydroxide Oxide (CI 77492), red Iron Oxide (CI 77491) and black Iron Oxide (CI 77499), crystal structures usually in the form of dry powders with a certain primary particle size. During their production, heat and pressure tend to form aggregates of the primary pigment particles which are then closely attached and become very difficult to separate. Aggregates and small percentages of primary particles then again tend to form agglomerates of more than 100 µm in diameter. The main goal of the dispersion process is the disintegration of these agglomerates and the creation of a larger and stable interface between the surface of the solid pigment particles and the inner surface of the liquid dispersion medium.

Pigment dispersion relies on energy and suitable dispersing additives. First, water and air from the pigment surface and inside of agglomerates need to be replaced by the surrounding medium. This lowers the interfacial tension and is a perquisite for the subsequent dispersion process, in which energy is introduced into the system for the de-agglomeration and even distribution of the pigments. Like every bi-phase system dispersions attempt to reduce the interfacial area. This uncontrolled tendency of primary particles and aggregates to re-agglomerate is called flocculation and needs to be avoided by either non-ionic dispersants on the pigment surface through a steric stabilization or ionic dispersing agents through electrostatic stabilization.

In this article four commercially available wetting agents were evaluated, in order to check for their ability in assisting in the dispersion of inorganic pigments. Glycerol Caprylate (trade name: dermosoft® GMCY) and Glycerol Caprate (trade name: dermosoft® GMYC) two glycerin monoesters, and Caprylyl Glycol (trade name: dermosoft® Octiol) a medium size glycol are non-ionic wetting agents. Sodium Lauroyl Lactylate (SLL) (trade name: dermosoft® SLL) belongs as an ester of Lactic Acid and Lauric Acid to the group of anionic wetting agents. Glycerol Caprylate, Glycerol Caprate, and Sodium Lauroyl Lactylate moreover are available from 100% natural resources and are compliant with natural cosmetics (e.g. Ecocert). Based on the proportion between the polar and the non-polar molecule part and as well as the ionic charge, predictions regarding their functionality can be made. These parameters influence the cosmetic properties of wetting agents in that they determine how strongly they are attracted towards lipophilic or hydrophilic phases and how strongly they potentially can support the stabilization of emulsions or dispersions. In Fig. 1 their function-determining amphiphilic structure is illustrated.

### Test Methods and Results

#### Concentration-Dependent Effects of Wetting Agent on Pre-Dispersions

A fine pigment dispersion inside a cosmetic formulation relies on the kinetic energy introduced into the system and on the reduction of the surface tension outside and inside the pigment agglomerates. The tension reduction allows a more efficient transformation of kinetic energy into...
a finely distributed pigment dispersion. Wetting agents have the potential to enter the free space of the agglomerates and adhere with one side of their amphiphilic molecule structure to the pigment surface, thereby allowing the surrounding medium to wet the surface of the primary pigment particles and aggregates.

A general improvement in pigment dispersion, caused by raising concentrations of Glyceryl Caprylate is visualized in Fig. 2 for an oily pre-dispersion (Formulation in Fig. 2). The pre-dispersion in this experiment was conceived as 30% of a theoretical final formulation. The mixture of Squalane, Tricaprylin and Isoamyl Laurate inside the pre-dispersion already possesses dispersion properties by itself. The inorganic pigments applied were Titanium dioxide (CI 77891), red Iron Oxide (CI 77491), yellow Iron hydroxide oxide (CI 77492) and the brown Iron Oxide blend (CI 77491, CI 77492, CI 77499). They represent important inorganic pigments used in a large variety of cosmetic applications. For the production of the pre-dispersions the pigments were added to the oil phase under constant stirring for 2 minutes using a small dissolver (diameter: 2.5 cm).

The addition of Glyceryl Caprylate resulted in an enhanced microscopic image, with less agglomerates and more evenly distributed pigments (Fig. 2). Together with this superior dispersion, with raising Glyceryl Caprylate concentrations, the viscosity of the pre-dispersions decreased from 5500 mPas to 1000 mPas (Brookfield Rheometer DV3T extra). In general, the viscosity of a pigment dispersion in oil is negatively correlated to the wetting and dispersion efficacy of the dispersants. Therefore, the decreased viscosities confirm the observed microscopic results of a more homogenous and finer pigment dispersion, due to the addition of the single wetting agent, Glyceryl Caprylate.

In order to analyze the individual co-dispersant properties of all four commercially available wetting agents, pre-dispersions with either one of three widely used inorganic pigments were made and viscosities were measured. Titanium Dioxide and the yellow Iron Hydroxide Oxide were applied to the previously described pre-dispersion at a concentration of 30% (=9% in a final formulation) and the more difficult dispersible red Iron Oxide at a concentration of 3.3% (=1% in a final formulation).

The results in Fig. 3 show that each of the four wetting agents caused a significant reduction in viscosity levels of the pre-dispersions of all three pigments. These viscosity reductions implicate an interaction of all four wetting agents with the surface of the pigments. This wetting process obviously resulted in the reduction of the internal forces between the solid pigments and the oil phase by replacing air or moisture from the pigment crystal surfaces and finally in the

---

**Fig. 2** Formulation, macroscopic images, and viscosities of pre-dispersions with raising concentrations (0%, 0.5% and 1%) of Glyceryl Caprylate (7).

**Fig. 3** Viscosities of pre-dispersions with raising wetting agent concentrations (0%, 1% (0.3% in a final formulation), 3.3% (1% in a final formulation)).
size reduction of the pigment agglomerates and a more efficient and homogenous dispersion of the pigments in the oil phase.

Visualization of Pre-Dispersions

An improved pigment-dispersion and smaller particle size generally affects the surface quality and color intensity of a dispersion. For visualization, the pre-dispersions with and without wetting agents were spread on a glass surface with a constant film thickness (Fig. 4).

Despite the presence of the three oils in the pre-dispersion with already good wetting properties, pre-dispersions without wetting agents showed visible pigment agglomerates of the red Iron Oxide, streaks from larger pigment agglomerates of the Titanium Dioxide and an uneven surface in case of the more easily dispersible yellow Iron Oxide (Fig. 4). In contrast, the wetting agents led to superior dispersions with a more even, less grainy and rough film surface. Only Sodium Lauroyl Lactylate in combination with the red Iron Oxide performed similar to the placebo despite of its former observed reduction in viscosity.

Instead, Glyceryl Caprylate and Caprylyl Glycol in combination with the red Iron Oxide led with increasing concentrations to a more intense color and even surface structure. This was in accordance with the observed gradual decrease in pre-dispersion viscosities, shown in Fig. 3. For Glyceryl Caprate a similar intense color was observed for both concentrations in combination with red Iron Oxide.

---

**symbio® muls rich**

A new way to be caring – an innovative blend for natural and creamy O/W emulsions

**drstraeetmans**

intelligence behind beauty
Wetting Agents in an Emulsion-Based Foundation Formulation

In this test, wetting agent concentrations of 0.3%, 0.5% and 1% were used in the production of a final cosmetic formulation, to evaluate their dispersion aid, not only in a singular pigment pre-dispersion but in a finished complex O/W-emulsion, namely a liquid make up foundation (D044-20.ff).

After manufacturing, only marginal differences in color, intensity and shine between the different formulations were detected (Fig. 5). However, color differences between thin films of the formulations on a white paper sheet were more apparent. The thin film of the Placebo formulation without any wetting agent appeared less intense in color than of a formulation containing 0.5% Caprylyl Glycol. Moreover, the pigments of the Placebo formulation on the white paper sheet were less evenly distributed and therefore the contrast between areas of dark pigmentation and areas of light pigmentation was apparently high.

Based on this observation we presumed that wetting agents might allow for the more economic use of pigments in cosmetic formulations. This assumption was confirmed in the fact that the thin film of the Placebo formulation without any wetting agent appeared less intense in color than of a formulation containing 0.5% Caprylyl Glycol. Moreover, the pigments of the Placebo formulation on the white paper sheet were less evenly distributed and therefore the contrast between areas of dark pigmentation and areas of light pigmentation was apparently high. Based on this observation we presumed that wetting agents might allow for the more economic use of pigments in cosmetic formulations. This assumption was confirmed in the fact that the thin film of the Placebo formulation, despite its irregularities, appeared similarly intense in color compared to the 0.5% Caprylyl Glycol formulation with 10% less pigments (Fig. 5). However, it is important to keep in mind that the effects of wetting agents on the color are formulation dependent, especially regarding the amounts of pigments applied. So for instance, in our lab we have seen formulations, in which the wetting agents intensified or even shifted the color of a final formulation. In some cases they even added a shine effect to the final cosmetic formulation.

One of the wetting agents’ properties comprise the stabilization of emulsions as a co-emulsifier (1). However, while small concentrations of wetting agents stabilize emulsions, higher concentrations trigger the opposite effect and tend to destabilize them, an effect which needs to be considered by the formulator. This was also true for the liquid make up foundation in this experiment. The placebo and the 0.3% and 0.5% wetting agent formulations were stable after 2 weeks at 50°C, while the formulations with 1% wetting agent were unstable and separated after this time.

Wetting Agents in an Aqueous-Free Lipstick Formulation

In contrast to emulsions, the stability of an aqueous-free formulation is not impaired by the concentration of wetting agents. Therefore, formulators have the freedom to alter the amount of wetting agents, depending on the desired effects. This is why we applied relatively high concentrations of 1% wetting agents (Glyceryl Caprylate, Caprylyl Glycol) in the analysis of the abrasive behavior of lipstick formulations (D044-3.ff).

Color abrasion is an essential quality characteristic of lipsticks. To analyze if a superior dispersion due to wetting agents might influence the abrasion appearance on the lips, three lipsticks of the same formulation were clamped into a custom-made device (Fig. 6). The lipsticks were then adjusted with a defined pressure on a paper background. The pressure resembled the average force close to real-life lipstick application conditions. For the regular application of the three lipsticks on the white paper background, an underlying table was moved with a constant speed. Each abrasion run was repeated 20 times and the weight of the lipsticks was measured before and after 5, 10, 15 and 20 runs.

As a result, the addition of one of the two wetting agents markedly improved the color intensity and regular distribution of transferred lipstick to the paper carrier. The weight loss measurements of the lipsticks before and after the abrasion, demonstrated that the ob-

![Fig. 6 Lipstick abrasion test device. Lipsticks were fixated with a defined pressure on the white paper background.](image-url)
served higher color intensity could not be explained by larger amounts of lipstick on the paper carrier. On the contrary, the weight loss after abrasion of lipsticks containing a wetting agent, were even slightly lower compared to lipsticks without a wetting agent. This and the constant pressure applied during abrasion point into the direction of harder lipsticks, due to the wetting agents. For that reason the color intensity of the abrasion on the paper carrier is likely to be solely the result of a more homogenous and finer pigment dispersion in the formulation. Consequently, lipstick formulations with wetting agents perform better, and by trend last even longer than lipsticks without.

Wetting Agents in a W/O Emulsion Sunscreen Formulation

Sunscreens are available in different application forms and in different viscosities. Not only the base and production technologies vary, but also the UV filters. Most of the sunscreens include a mixture of physical and chemical UV filters. Physical filters act as a kind of mirror on the skin and reflect the light immediately after application. The chemical UV filters, however, absorb the light rays, but require an exposure time of about 30 minutes before being fully active. Sunscreens for children are usually devised as a W/O emulsion, since children are very active and water would eliminate the desired effect of an O/W emulsion-based sunscreen quickly. Important for an ideal sunscreen is also the spreading ability of the formulation. The more efficiently the sunscreen spreads, the better the distribution of the filters on the skin. It was even stated, that under real outdoor sun exposure conditions, a regular application of even a moderate SPF (sun protection factor) sunscreen may positively influence skin photo-ageing by a measurable amount (8). In accordance with this statement a study revealed that with increasing primary particle size of Titanium Dioxide, even below 100 nm, the effectiveness of the UV filter was measurably reduced (9).

In this study, W/O emulsion-based sunscreen formulation (D045-7.1.ff) with Titanium Dioxide, a physical UV filter, and either one of the four wetting agents were produced. In contrast to the placebo formulation the final formulations with wetting agents imparted a slightly blue color by themselves and on the skin. This was due to the Tyndall effect, in which the short blue wavelength light gets reflected by small particles via scattering. Moreover, when applied to the skin, formulations with wetting agents revealed a reduced foaming effect on the skin, also known as whitening effect.

The spreading properties of sunscreen formulations with and without wetting agents on the skin were analyzed in a standardized test with three repetitions. Therefore, 0.02 g of a formulation was applied to the skin of the forearm. After two minutes the sunscreen from the skin was transferred onto a filter paper and the circular spreading area was measured. As a result (Fig. 8), all sunscreens containing a wetting agent revealed at least a 20% larger spreading area on the skin. This effect appeared to be highly concentration-dependent - the higher the concentration the larger the spreading area. Nevertheless, a formulator needs to consider that the W/O emulsions with 1% wetting agent were not stable at 50°C after 2 weeks of storage.

### Conclusion

Multifunctional wetting agents, such as Glycerol Caprylate (dermosoft® GMCY), Glycerol Caprate (dermosoft® GMC), Caprylyl Glycol (dermosoft® octiol), and Sodium Lauroyl Lactylate (dermosoft® SLL) are real cosmetic all-rounders. They can be used in many kind of cosmetic applications like emulsions, solubilisations, and surfactants. In this article it was demonstrated that the four commercially available wetting agents promote the formation of more homogenous, stable and finer pigment dispersion.
dispersions. Possible outcomes of an improved dispersion efficacy comprise increased color intensities, especially when a formulation is applied to a surface, like the skin or a paper sheet, and the more economic use of pigments in a formulation. Such a reduction of pigments saves costs and makes room for other ingredients in the formulation. Moreover, due to the good dispersion results of Titanium Dioxide, the wetting agents could successfully be used to wet UV physical filters in sunscreen formulations. Because wetting agents were shown to enhance the spreading rate of formulations, they support the regular distribution of the UV filters on the skin inside a thin and even film. Potential effects on the SPF of sunscreens, like suggested, need to be confirmed in future tests.

References


*Authors’ address:
Dr. Alexander Thiemann
(alexander.thiemann@dr-straetmans.de)
Sabrina Gröne
(sabrina.groene@dr-straetmans.de)
Manuela Salmina-Petersen
(manuela.salmina-petersen@dr-straetmans.de)
Dr. Jan Jänichen
(jan.jaenichen@dr-straetmans.de)
Dr. Stratmans GmbH
Merkurring 90
22143 Hamburg, Germany

(1) Thiemann A. et al. Wetting agents – Their concentration-dependent effects on the energy demand in the formation of stable emulsions. SOFW, 141 (3-2015).

(2) Thiemann A. et al. Wetting agents: Friends or Enemies of Solubilizers. SOFW, 140 (11-2014).