Novel Multipurpose PEG-free W/O Silicone Emulsifier with Performance Benefits in Color Cosmetics
Abstract

Among the recent global cosmetic trends are products like Serums, BB- or CC-Creams. One joined characteristic of these modern multifunctional formulations is the increasing number of different ingredients. This fact implies increasing performance demands for the emulsifier as all ingredients have to be stabilized properly.

The new PEG-free silicone-based W/O emulsifier Bis-(Glyceryl/Lauryl) Glycerol Lauryl Dimethicone (and) Caprylic/Capric Triglyceride was developed to cope with these challenges. This versatile emulsifier is applicable for formulating all types of W/O systems. It is especially suitable to stabilize pigment-containing emulsions where it additionally provides enhanced color trueness due to improved pigment dispersion properties. The macroscopic effect of enhanced color trueness can directly be linked to the homogeneous pigment distribution within the emulsion structure. Microscopy images and analysis of scanning electron microscopy data are revealing the differences in terms of pigment distribution compared to a reference system. Therefore this emulsifier is perfectly matching the needs for formulating state-of-the-art cosmetic products.
with all types of cosmetic emollients it also effectively disperses pigments. Hence, this emulsifier is not only applicable for emulsifying white emulsions but also for pigmented formulations as e.g. liquid foundations, BB or CC creams. In such systems, additional co-emulsifiers or pigment dispersant additives are not needed which is also contributing to minimize complexity and costs. Compared to standard W/O emulsifiers it enhances the color trueness of pigment containing colored cosmetic formulations. The term «color trueness» describes a minimized deviation of the color of a foundation before application versus the color of the foundation on the skin after distribution.

**Color trueness evaluation in make-up formulations**

It can be shown that ABIL® EM 120 supports the color trueness of a formulation while applying on the skin resulting in no perceivable color difference. The evaluation was done using the L-a-b color space for describing color parameters (1). Values were measured in emulsions and on skin, respectively. Every emulsion was applied under well-defined conditions on the forearm of ten panelists. In Fig. 2 the setup of a performance comparison regarding color trueness is shown. Part a) of the figure contains the make-up foundation test formula which was identical in terms of emulsifier and pigment content in all cases. The five single emulsions based on the five different tested emulsifiers (listed in section b) have been adapted to similar viscosities by adjusting the oil phase ratio to obtain comparable test conditions. The processing of the test formulas was identical for all emulsions and is briefly described in part c) of Fig. 2. The measurements were performed after a three months storage period at room temperature.

Macroscopic color effects...

The chart displayed in Fig. 2d) shows the outcome of the comparison. For all five make-up foundations the color parameters L, a and b were measured before and after application on the skin. The bars are indicating the calculated color difference of the respective parameters. The overall color difference is condensed in the ΔE value illustrated by the grey bars (2).
It can clearly be seen that the differences of $L$, $a$ and $b$ and therefore also $\Delta E$ are minimal for the emulsion based on emulsifier 1. All other emulsifiers show higher color deviations after distribution. This is illustrated by the higher values of $\Delta L$, $\Delta a$, $\Delta b$ and $\Delta E$.

These differences in color trueness of make-up formulations are not only detectable by using color measurement techniques. If the differences are big enough they are noticeable as well by naked eye. It has become generally accepted that a color deviation bigger than a $\Delta E$ value of 2.3 is visually recognizable (2). This value is therefore also called »JND« (Just Noticeable Difference). Thus, test system 1 based on Bis-(Glyceryl/Lauryl) Glyceryl Lauryl Dimethicone is the only formulation out of this range with a JND clearly below 2.3 resulting in no perceivable color difference during application.

**... linked to microscopic causes**

In order to evaluate the reasons for such a different behaviour regarding color trueness, the emulsifiers Bis-(Glyceryl/Lauryl) Glyceryl Lauryl Dimethicone and Cetyl PEG/PPG-10/1 Dimethicone have been compared and evaluated in more detail in a second test system (Table 1). Light microscopy as well as electron dispersive x-ray (EDX) analysis of scanning electron microscopy (SEM) images has been used for detailed evaluation (3). The direct visual comparisons of the two formulas as well as microscopy images of the respective emulsions are combined in Fig. 3. Illustrations a) to c) contain the images taken of the make-up foundation based on Cetyl PEG/PPG-10/1 Dimethicone, illustrations d) to f) the corresponding ones for the same emulsion but based on Bis-(Glyceryl/Lauryl) Glyceryl Lauryl Dimethicone.

![In photo a), an evident color difference between before (left) and after (right) distribution of the foundation on the skin is observable. In opposite, photo d) shows the same color in emulsion (right) and distributed on skin (left). The reason behind the different color trueness effects can be seen on the microscopic level of the respective emulsions shown by the images b) and e) in this figure. While the iron oxide pigments are equally distributed in the outer oil phase in image e), pigment agglomerations can be observed in image b) highlighted by arrows. Beside agglomerations, an uneven pigment distribution can also be determined: the brown color is more pronounced at the oil-water interface where the iron oxide pigments are predominantly located (exemplified highlighted by circles). Examining the foundations by SEM with subsequent EDX analysis, the difference...](image-url)

### Table 1 Color trueness test formulation, tested emulsifiers (INCI name) and procedure for emulsion preparation.

<table>
<thead>
<tr>
<th>Phase</th>
<th>SZ 34/12-9 &amp; SZ 34/12-50</th>
<th>[w/w %]</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Emulsifier</td>
<td>4.00</td>
</tr>
<tr>
<td></td>
<td>Dimethicone (ABIL® 350)</td>
<td>1.50</td>
</tr>
<tr>
<td></td>
<td>Isohexadecane : Diethylhexyl Carbonate (TEGOSoft® DEC) (ratio 1:1)</td>
<td>10.50</td>
</tr>
<tr>
<td></td>
<td>CI 77891, Titanium Dioxide, Alumina, Triethoxy-caprylsilane (HOMBITAN AC 360, Sachtleben)</td>
<td>4.00</td>
</tr>
<tr>
<td></td>
<td>CI 77491, CI 77492, CI 77499 (iron Oxide, Sicovit Brown 70 E 172, Rockwood Pigments)</td>
<td>2.50</td>
</tr>
<tr>
<td></td>
<td>Talc</td>
<td>2.00</td>
</tr>
<tr>
<td>B</td>
<td>Activated Hectorite*</td>
<td>2.00</td>
</tr>
<tr>
<td></td>
<td>Aluminum Starch Octenylsuccinate (Dry-Flo PC, AkzoNobel)</td>
<td>1.50</td>
</tr>
<tr>
<td></td>
<td>Nylon-12 (TEGOLON® 12-10)</td>
<td>1.50</td>
</tr>
<tr>
<td></td>
<td>Wax-oil-mixture**</td>
<td>3.50</td>
</tr>
<tr>
<td></td>
<td>Total oil phase</td>
<td>33.00</td>
</tr>
<tr>
<td>C</td>
<td>Glycerin</td>
<td>3.00</td>
</tr>
<tr>
<td></td>
<td>Sodium Chloride</td>
<td>1.00</td>
</tr>
<tr>
<td></td>
<td>Thickener Gel Preparation***</td>
<td>6.00</td>
</tr>
<tr>
<td></td>
<td>Water</td>
<td>56.30</td>
</tr>
<tr>
<td>D</td>
<td>Phenoxethanol, Methylparaben, Propylparaben, Ethylparaben (Phenonip XB, Clariant)</td>
<td>0.70</td>
</tr>
<tr>
<td>Z</td>
<td>Perfume</td>
<td>q.s.</td>
</tr>
</tbody>
</table>

*Activated Hectorite: charge 1.7 parts Diethylhexyl Carbonate (TEGOSoft® DEC), add 0.2 parts Disteardimonium Hectorite (Bentone 38 VCG, Elements Specialties) while stirring, add 0.1 part Ethanol and stir until homogeneous.

**Wax/oil mixture: 0.25 parts Microcrystalline wax, 0.25 parts Hydrogenated Castor Oil, 1.5 parts Diethylhexyl Carbonate (TEGOSoft® DEC), 1.5 parts Isohexadecane; Processing: melt all ingredients, cool down, next day stirring (MFR stirrer) resulting in homogeneous paste suitable for cold processing.

*** Thickener Gel Preparation: charge 0.3 parts Xanthan Gum (Keltrin CG-SFT, CP Kelco) , add 1.5 parts Glycerin and stir manually until Xanthan Gum is homogenously distributed. Add 4.2 parts water slowly while stirring and stir until Xanthan Gum is dissolved.

**Remarks:**

- Mixed phase A until uniform.
- Add phase B to phase A and stir until homogeneous.
- Add phase C to phase A/B slowly while stirring.
- Add phase D and mix until uniform.
- Homogenize.
in iron oxide distribution can be visualized by localizing the iron atoms. These are indicated by the blue coloring in images c) and f). In correlation to the light microscopy images, a more homogeneous iron atom distribution can be observed in image f) compared to image c).

The most relevant consequence of pigment agglomerations is the noticeable color difference. This is because agglomerates are differently interacting with light compared to the same amount of non-agglomerated pigment particles. Thus, during distribution of the emulsion on the skin the pigments are getting distributed resulting in an observable undesired color shift. An example of such a negative occurrence is shown in photo a) of Fig. 3. However, if the pigments are already homogeneously distributed in the emulsion, the application process of the cosmetic product on the skin has no effect on the observable color as the pigments are already nicely dispersed. This is resulting in no color difference and therefore good visual color trueness which can be observed in Fig. 3 d).

■ Beneficial application effects in color cosmetic emulsions

The enhanced pigment dispersion properties of this novel emulsifier also have direct impact on the formulation of emulsion-based color cosmetic products. As the emulsifier is already stabilizing both the oil-water interface as well as the pigments no additional co-emulsifiers or pigment dispersing agents are necessary. Immediate consequences are reduced formulation complexity and simplified processing leading to cost reduction as well as to a more sustainable product. In Fig. 4, a CC (Color Control) Fluid is shown as formulation example for the current trend towards multifunctional cosmetic products. Besides the emulsifier Bis-(Glyceryl/Lauryl) Glyceryl Lauryl Dimethicone and the hectorite as viscosity modifier no additional polymeric ingredients for pigment and emulsion stabilization are necessary. Thus, the CC Fluid provides quick absorption resulting in a very nice, non-tacky skin feel. Also remarkably is the fact that the incorporated iron oxide pigments are not hydrophobized which is very unusual for water-in-oil formulations.

In standard systems, hydrophobically modified iron oxide pigments have to be used to obtain the required emulsion stability. In contrast, this CC Fluid is also stable using non-coated iron oxide pigments as Bis-(Glyceryl/Lauryl) Glyceryl Lauryl Dimethicone is also able to stabilize this type of pigments in a W/O emulsion. In addition to the color pigments, UV filters and several active ingredients are nicely tolerated in the multifunctional lotion based on this high performance PEG-free emulsifier.

■ Summary

The multifunctional character of modern cosmetic formulations requires high performance emulsifiers having the ability of effectively stabilizing different kind of ingredients. Besides that, the current trend towards eco-optimized formulas needs such efficient ingredients in order to minimize production efforts and formula complexity.

The innovative water-in-oil emulsifier Bis-(Glyceryl/Lauryl) Glyceryl Lauryl Dimethicone was developed with regard to these requirements and therefore it is able to deal with the current formulation challenges. In color cosmetics, it additionally supports
equal pigment distribution within formulas leading to enhanced color trueness of such emulsions. Due to that ability and its flexibility, it is especially suitable for products with multiple benefits like CC creams or other pigment based emulsion systems like primers, concealers or foundations. As the performance challenges for such kind of complex formulations will continue to grow, this new high performance emulsifier can be seen as a versatile tool for formulators to realize innovative color cosmetic products.

References


*Authors’ address:
Dr. Achim Friedrich
Petra Biehl
Sebastian Zimmermann
Dr. Alexandra Trambitas
Dr. Jürgen Meyer
Evonik Industries AG
Goldschmidtstraße 100
45127 Essen
Germany

Fig. 4 Formulation example Color Control Fluid SPF 25.