Borosilicate Pigments – Transparency Meets Brilliance and Sparkle

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Abstract

Borosilicate pigments represent a new variety in the well-known class of pearlescent pigments. Consisting of transparent borosilicate flakes coated with high refractive metal oxides, e.g. titanium dioxide or iron oxides, these innovative pigments allow the achievement of optimum interference effects in combination with outstanding transparency. Borosilicate pigments open new styling possibilities spicing up colour cosmetics with exciting eye-catching effects.

From State of the Art to Stand-Out

A common feature of all gloss effect pigments is a flake-like structure which enables directional reflection of incoming light and hence, gloss effects[1]. Borosilicate pigments belong to the group of pearlescent effect pigments which are generally composed of low refractive transparent platelets like mica coated with high refractive metal oxides, e.g. titanium dioxide or iron oxides. This structure enables interference effects leading to selective reflection of distinct colours thereby creating the typical pearl lustre as frequently found in nature. Depending on the thickness and the type of the metal oxide coating, pearlescent pigments provide a full range of rainbow colours as well as earth tone and golden colour shades (Figure 1).

For decades natural mica, an alumosilicate mineral with an intrinsic multi-layer structure, was – and still is – used as the state-of-the-art substrate for manufacturing traditional pearlescent pigments. Due to naturally occurring deviations this material unavoidably shows some basic deficiencies. Mainly concerned are variations in the composition, irregular shaped micro-scale platelets with many scattering centres created during the milling process and, furthermore, thickness deviations within single flakes.

Mirage pigments are based on innovative artificial borosilicate platelets with well-defined characteristics. Thanks to excellent surface smoothness, uniform individual particle thickness as well as exceptional transparency, these achromatic flakes represent an ideal substrate for achieving optimum pearlescent effects.

The superior visual appearance of the new borosilicate pigments compared to traditional natural mica based pearlescent pigments stands out in a microscopic view (see Figure 2 on page 2).

The titanium dioxide coated mica pigment with red interference colour on the left hand side shows a significant colour deviation from particle to particle caused by the background colour of individual mica flakes and by inhomogeneous metal oxide coating layer thickness. In contrast, the titanium dioxide coated borosilicate flakes on the right hand side appear in an almost uniform red colour, due to the achromatic nature of the artificial substrate and due to the homogenous thickness of the metal oxide coating achieved by superior coating technology.

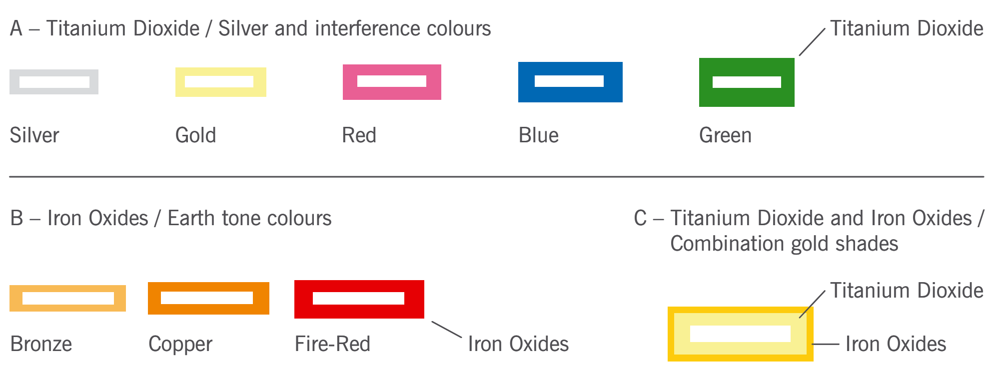

Figure 1. Pearlescent pigments – a kaleidoscope of colours

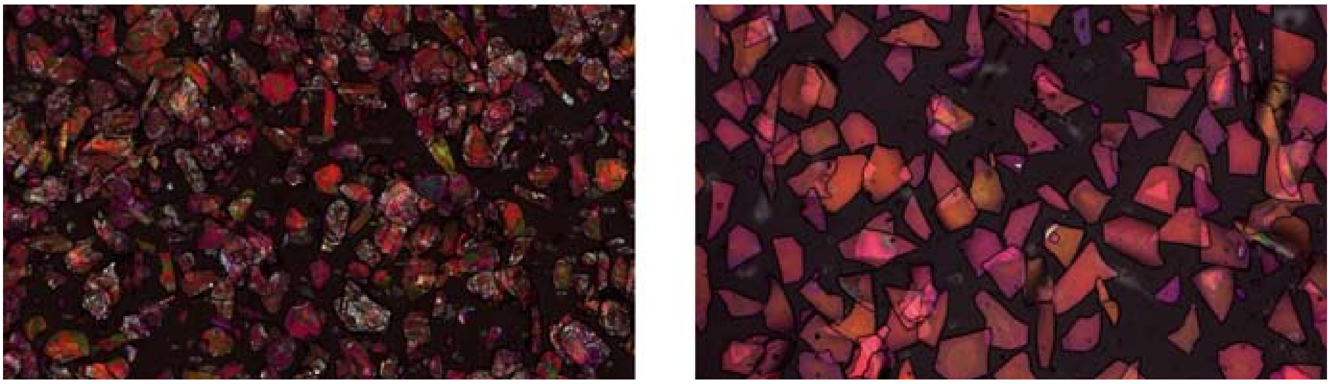

Figure 2. Traditional pearl pigment (left) vs. Mirage high performance pigment (right) in microscopic view

New Borosilicate Pigments vs. Corresponding Customary Grades

Taking a closer look it becomes obvious that new Mirage borosilicate pigments from our company do not only outperform traditional mica based pearlescent pigments but also other comparable state-of-the-art borosilicate grades. This milestone in effect pigment performance goes back to proprietary technology leading to extremely smooth pigment surfaces which allow optimum gloss combined with unique colour purity (see Figure 3).

The microscopic view of Mirage Glamour Blue particles (right hand side) versus a corresponding state-of-the-art borosilicate grade (left hand side) with blue interference colour clearly illustrates these advantages in performance of Mirage pigments. In contrast, the effect of the customary grade shown left is weakened by the colour deviations clearly visible in the microscopic scale. The same principles apply for other interference colours of the new advantageous Mirage product line, such as Glamour Red, Gold or Green, each offering unique colour intensity and purity due to the homogenously coloured single particles.

Another important parameter contributing to the outstanding visual properties of the new borosilicate pigments is their narrow particle size distribution. Careful removal of the finest particles is essential for creating an optimum lustre and eye-catching effects as these small particles contribute especially strongly to the creation of undesirable diffuse scattered light. Thorough separation of coarse particles is essential for achieving an excellent skin feeling. Concerning sensory effects, even a small amount of oversized particles can negatively impact the skin feel.

Mirage Pigments – Exceptional Sparkle

In general, the visual perception of effects strongly depends on the illumination conditions. Especially for the visibility of sparkle, the illumination angle plays an important role. To visualise strong sparkle effects, direct illumination is essential.

The four pictures shown in Figure 4 (on page 3) are taken from customary cream eye shadow applications in direct illumination. Cream eye shadow represents a waxed-based system with random orientation of the pigments in the mass.

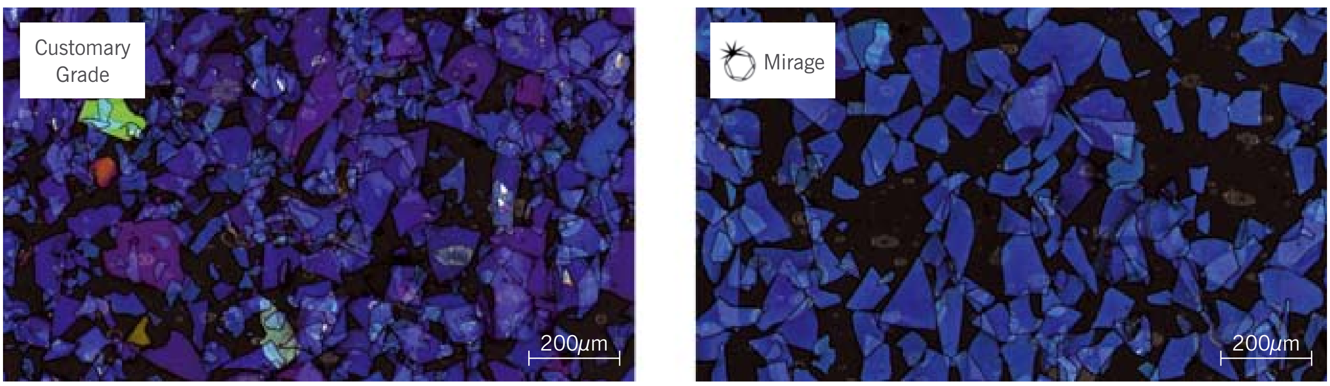

Figure 3. Mirage vs. standard borosilicate pigments (microscopic view)

Three of those samples contain interference blue borosilicate pigments, one contains a mica based pearlescent pigment at the same pigmentation level. All pigments in this comparison have comparable particle size.

Looking at the pictures, it is obvious that there are specific differences with respect to the sparkle performance of the pigment grades compared, but a ranking based only on the visual impression is at least somewhat challenging.

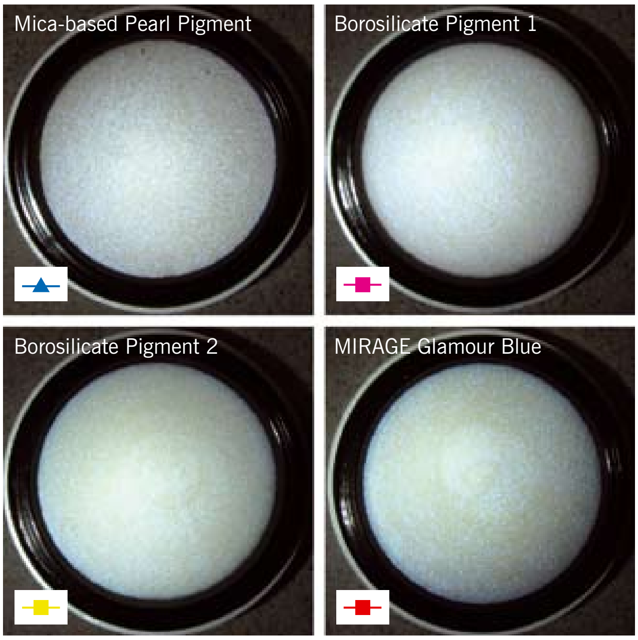

Figure 4. Comparison of customary cream eye shadow

Recently, a new instrument, the so called BYK-Mac was introduced. This device can analyse three important characteristics of effect pigments which are colour, graininess and sparkle. For application oriented measurements in cosmetics, a special sample holder is available. This tool enables non-contact measurements even on sticky or viscous formulations like lipstick or cream eye shadow as shown in Figure 4.

The results of the corresponding measurements can be visualized in a two dimensional plot with the sparkle area as abscissa and the sparkle intensity as ordinate (Figure 5).

In this plot, the application featuring Mirage borosilicate pigments (marked with a red square) has a sparkle area of approximately 23 and an intensity of about 7. The two customary borosilicate pigments (pink and yellow squares) posses less sparkle intensity and also significantly smaller sparkle area.

The mica based pearl pigment marked with a blue triangle shows the lowest sparkle grade and intensity. This observation is not surprising considering the limitations of a natural mica substrate mentioned before.

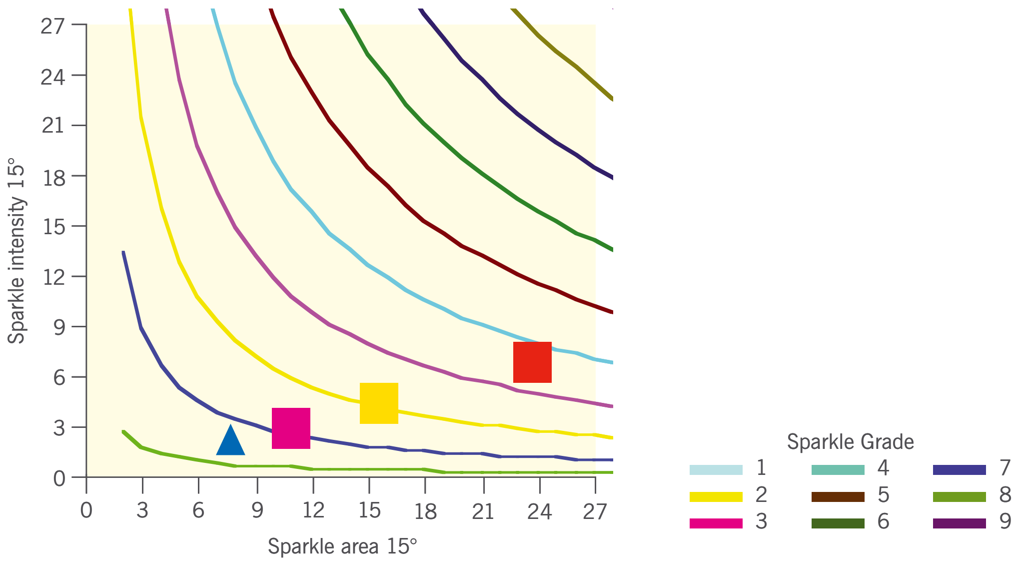

Figure 5. Sparkle measurements

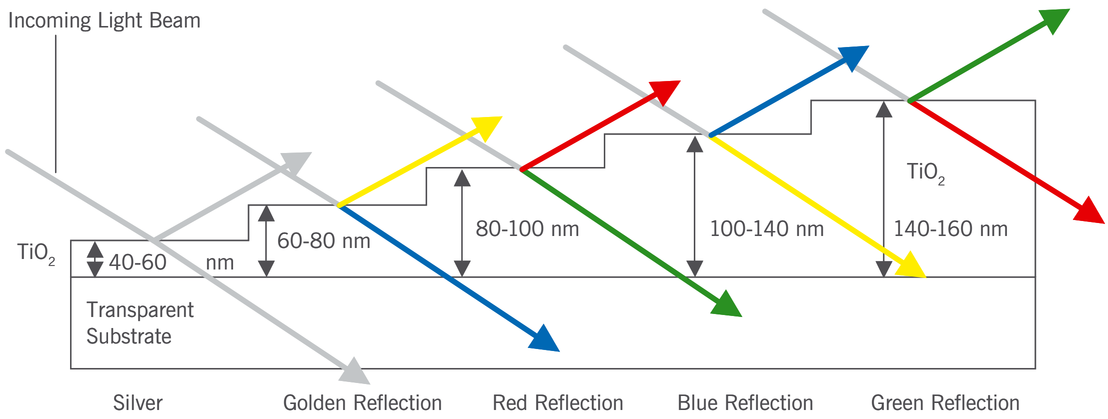

Figure 6. Interference colour in dependence of layer thickness

These results demonstrate that besides gloss and colour purity, excellent sparkle is a key characteristic of Mirage borosilicate pigments.

In general, sparkle measurements help to evaluate the performance of effect pigments in colour cosmetic applications. From this point of view, in cosmetic manufacturing the assessment of sparkle could as well be used as inspection criterion in quality control.

The Real Gold Effect

Pearlescent pigments offering a "real gold" effect – meaning a neutral to slightly greenish gold shade – are highly desired by cosmetic formulators for adding a luxurious touch.

In general, golden effects can be achieved by interference or by a combination of interference and absorption effects. If transparent substrates like mica or glass flakes are coated with a single layer of high reflective but achromatic titanium dioxide of controlled thickness (approx. 60 – 80 nm, see fig. 6), "golden" light is reflected towards the observer. The bulk colour of these pigments is white.

Alternatively, a combination of a titanium dioxide and an iron oxide layer can be deposited on the platelets (see Figure 1). By the iron oxide coating the golden interference colour effect is intensified. These pigments usually have a pale red to ochre powder colour.

Nevertheless, none of the two options described affords pigments that can mimic a "real gold" shade. The effect is either too weak as e.g. observed for a pure TiO_2 coating or the shade is already reddish due to the absorption colour of iron oxide in case of the combination gold grades.

Latest progress in research and development based on advanced multilayer technology now enables the achievement of the desired "real gold" effect. Tailor-made calcium sodium borosilicate flakes are coated with a metal oxide layer system consisting of titanium dioxide, silica and iron oxides. The resulting unique pigments exhibit outstanding colour strength and purity which transforms into the most luxurious golden shade ever seen (see Figure 7).

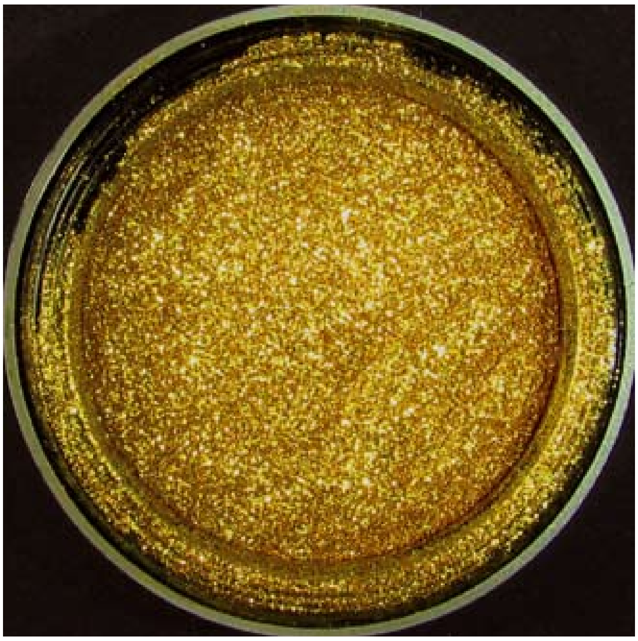

Figure 7. Real Gold Effect

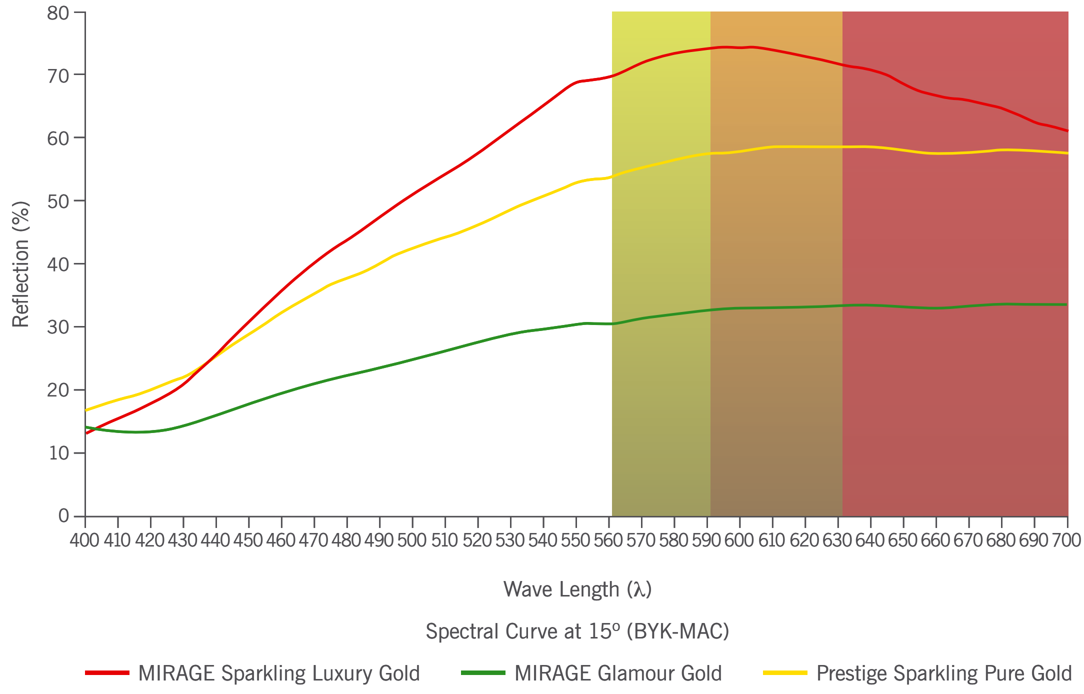

Figure 8. Spectral curve comparison

Comparing the spectral curves of different gold type pigments (new "real gold" effect Mirage Sparkling Luxury Gold – red curve, interference gold borosilicate pigment Mirage Glamour Gold – blue curve, golden mica based pigment Prestige Sparkling Pure Gold – yellow curve) by means of measuring the light reflectance in the visible UV-range in dependence of the wavelength using a colorimeter (BYK-Mac) clearly illustrates the advantages of this innovation – see Figure 8. (Measurements have been carried out on draw-down applications of the corresponding pigments in a nail-polish related solvent system.)

Interference gold pigments (blue curve) show a small increase in reflectivity in a certain range of wavelength (500 – 700 nm) and exhibit their maximum reflection within the orange to red portion of visible light.

However, customary mica-based combination gold pigments (yellow curve) already show a much higher reflection of light with a peak within the yellow to red spectrum of light. Overall a less preferred reddish gold effect is achieved.

In contrast, the spectral curve of the new "real gold" pigment with multilayer structure (red curve) exhibits its peak exactly in the yellow band of light. This observation explains the so far unreached "real gold" appearance.

With a particle size range of 15 – 120 μm the Mirage "real gold" shade provides amazing sparkle as well as colouring effects which can be attractive pure or in combination with other pigments to enhance especially colour cosmetics with a luxurious look.

Borosilicates in cosmetic applications

In principal, the colouring options of Mirage borosilicate pigments are comparable to mica based pigments, but especially in transparent systems like lip glosses and gels they exhibit much better colour purity and higher gloss. Thanks to their physiological harmlessness, borosilicate pigments are well suited for the use in any kind of colour cosmetic or personal care application. The Mirage pigment range offers a large palette of various optical effects. In order to benefit from this versatility, particle sizes and colours should be jointly considered (see Figure 9 on page 6).

Depending on the preferred particle size, one can achieve very elegant and graceful effects when using particle size fractions around 15-70 μm and, in contrast to this, very luxurious and glittery effects when using coarse fractions containing particles with up to 150 μm in dimension. The final visual effect in the cosmetic application not only depends on the chosen particle size fraction, but also on the pigmentation level as well as on the characteristics of the application system. Very low pigmentation

Particle size	Effect	Silver effects	Interference effects
15 – 70 μm	Graceful effects	Mirage Bright Silver	
15 – 120 μm	Sparkle effects	Mirage Sparkling Silver	Mirage Sparkling Luxury Gold
35 – 150 μm	Luxurious effects	Mirage Glamour Silver	Mirage Glamour Gold Mirage Glamour Red Mirage Glamour Blue Mirage Glamour Green
100 – 700 μm	Glitter effects	Mirage Twinkling Silver	

Figure 9. Particle sizes and effects

levels (0.01% – 0.6%) can be used in transparent systems, whereas higher pigment concentrations (1% – 3%) have to be used in opaque systems like waxes, lotions and the like.

For lipstick and lip gloss applications, borosilicate pigments can be used in any system to enhance the optics without regulatory limitations. Smaller particle size borosilicates can be used alone or in combination with other pigments at low use levels around 5% to increase and support the lustre of lip glosses or lipsticks leading to a "water-shine" effect. Another exciting styling option creates liquid metal appearances in elegant silver and bright gold shades with very homogeneous and elegant surfaces. This is especially of interest as the new trend colours for autumn/winter 2010/2011 feature liquid metal appearance superseding currently popular sparkling and glittering effects (see Figure 10).

If coarser particle size fractions are used instead, the resulting effect on the skin is highly sparkling and of less homogeneous shine as single pigment particles can be resolved by the human eye.

Figure 10. Lip gloss: Stunning Canola

In emulsion systems, Mirage borosilicate pigments are recommended in order to create highly glamorous and exceptional effects. Due to their synthetic origin, interference borosilicate pigments consist of a purely white powder and therefore do not influence the bulk colour of the final emulsion. However, the pigment loading strongly depends on the opacity of the emulsion and has to be adjusted accordingly. Transparent systems afford low pigment concentrations, higher pigment concentrations should be used in opaque systems. It should be considered that the use of scattering ingredients like titanium dioxide could, depending on the pigmentation level, decrease or even destroy the shimmer effects achieved by borosilicate pigments.

If working with clear gels instead of opaque emulsion systems, the beauty about utilising borosilicate pigments is that in most cases very low use levels of about 0.1% will already exhibit eye catching effects. Hence Mirage pigments are, for example, ideally suited to formulate glittering and sparkling hair gels or body highlighting gels (see Figure 11).

Figure 11. Body Highlighting Gel

Conclusion

Advanced Mirage borosilicate pigments offer superior colour purity, gloss and sparkle effects which are highly relevant for transparent or glossy application systems in colour cosmetics like lip stick or lip gloss. Thanks to their excellent transparency and neutral powder colour Mirage interference pigments are ideally suited for numerous cosmetic applications giving formulators the choice to add exciting eye-catching effects without affecting the bulk colour.

References

1. Pfaff, G., Spezielle Effektpigmente, Vincentz Verlag Hannover, 2007.

Authors' Biographies

Katrin Steinbach studied technology for cosmetics and detergents at the University of Applied Sciences in Lemgo, Germany. In 2003, she joined the application engineering team (AETS) for personal care of Dow Corning in Seneffe, Belgium, in charge of technical service for customers from Germany and Eastern Europe for all cosmetic related applications. In 2006 she joined the Cosmetic Team of Eckart GmbH and is the responsible technical service manager for Europe. Since October 2008 she additionally holds a Master of Business Marketing diploma obtained from the Free University of Berlin.

Ulrich Schmidt studied chemistry at the University of Wuerzburg, Germany. After his doctorate in the field of organometallic chemistry, he joined the R&D team of Eckart GmbH, Hartenstein, Germany, in 2001. He was responsible for the investigation of new methods for the stabilisation and surface modification of pearlescent pigments. In 2007 he joined the Cosmetic Team of Eckart GmbH in charge of research and development and pigment related technical service.