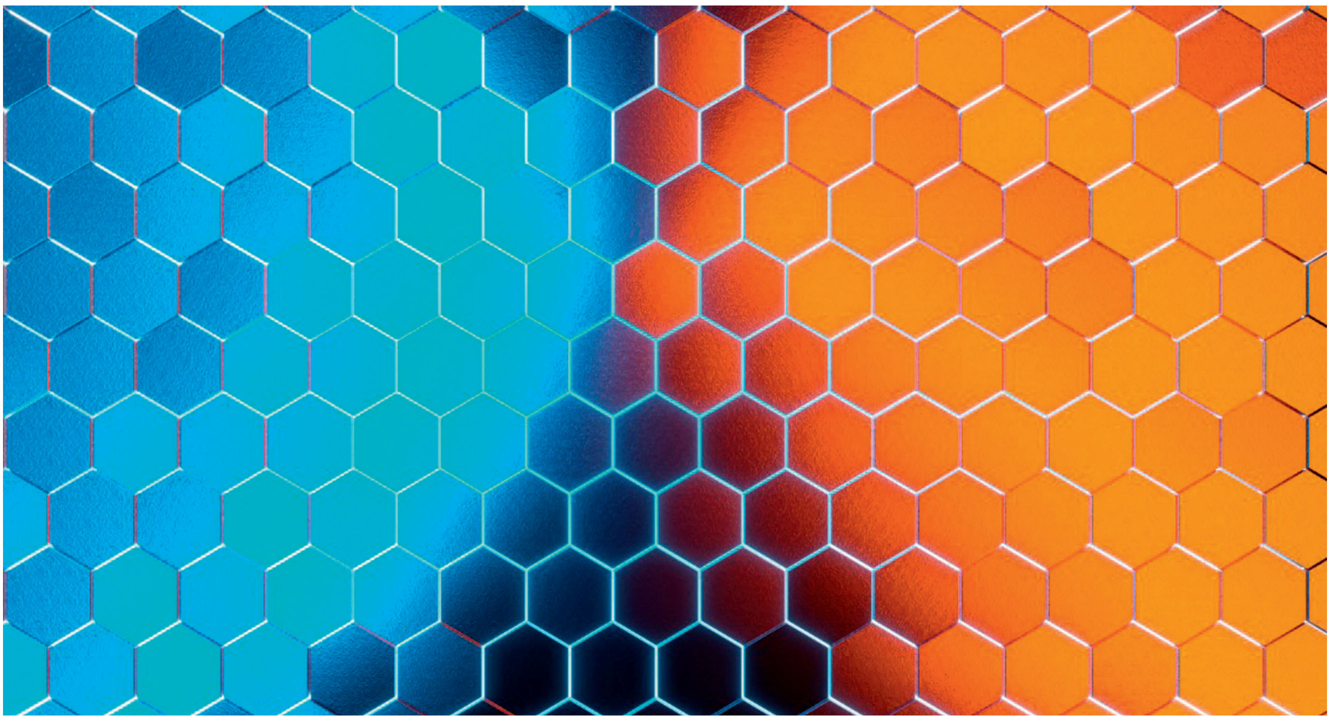
How the Particle Size of Fillers Influences Color Intensity

Thermal Management and Intensive Orange

Fillers and additives are used for targeted modification of the properties of plastics. Apart from the additive's nature, also its particle size as well as its aspect ratio play an important role. For example, the particle size of hexagonal boron nitride influences color intensity in heat-conducting plastics.



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Heat-conducting plastics are gaining in importance in the lighting, electro, and automotive fields. Important trends in these sectors are miniaturization, lightweight construction, and more complex geometries. In such applications, plastics – which generally exhibit very low thermal conductivity – usually come to their limits very soon. However, by using heat-conducting fillers such as boron nitride (BN), the thermal conductivity of plastics and thereby their functionality are greatly improved. Compared with the widely-used metallic heat conductors, BN fillers offer many advantages. These include simple processability, low density and hardness, plus high electrical insulating capability. Particularly in the field of electromobility, thermal conductance, and electrical insulation play an important role. The requirements for components in electrically powered vehicles are high and will rise further. As true multi-talents, they must exhibit heat-conducting and flame retardant properties, and frequently have a rich orange color. In electric vehicles, orange (mostly RAL 2003) serves to mark high-voltage components such as connectors, cable insulation, and battery cell holders.

Boron Nitride Not Only Improves Thermal Conductivity

BN is mainly used as filler in such components to improve thermal conductivity, but also influences the component's mechanical properties and its color intensity. In the field of thermal management, the family-owned company Henze BNP offers various BN powder qualities as filler. They differ in morphology and in other specific characteristics, which results in different influences in a compound's processability, coloring, and thermal conductivity. Together with Kunststoff-Zentrum SKZ, Henze has investigated the effect of particle size on the coloring of a compound. In view of current developments in the electromobility field, an orange color body was used for the analysis.

To investigate the effects of particle size on the color of an epoxy resin, »

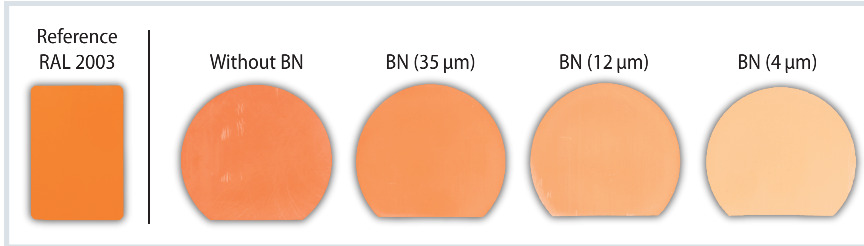

Fig. 1. Depending on particle size of the BN powder, the orange tone of the manufactured sample bodies can vary. © Henze BNP

	L*	a*	b*	dL*	da*	db*	dE*
Reference (RAL 2003)	64.67	37.69	47.11	-	-	-	-
Without BN	56.43	37.31	49.56	-8.24	-0.38	-2.45	8.77
BN (35 µm)	63.38	31.56	41.01	-1.29	-6.13	-6.10	8.74
BN (12 µm)	69.56	26.86	38.78	4.89	-10.83	-8.33	12.56
BN (4 µm)	77.00	20.81	32.44	12.33	-16.88	-14.67	25.54

Table 1. Results of the color measurements on color bodies with and without boron nitride: RAL 2003 was used as reference color. Source: Henze BNP

three BN powders with different particle sizes were selected. Powder 1 has a medium particle size (D50) of 35 µm, powder 2 a size of 12 µm, and powder 3 a size of 4 µm. For the measurements conducted by SKZ, comparable sample bodies were produced (**Fig. 1**). The recipe of the sample bodies was kept constant, and only the BN type and thereby the particle size varied. For production, a 2-component epoxy resin, an inorganic orange color body with RAL 2000, and 30 wt.% for each of the BN powders 1 to 3 were used. The overall loading ratio was 20 vol.% – distributed as 19 vol.% BN and 1 vol.% colorant. For the plastic matrix, Araldit G2 casting resin with the associated Aradur H2 hardener from Carl Roth was used.

In the first step, resin, BN, and color body were mixed and de-aerated in a mixer (type: Speedmixer DAC.600.2 VAC-P, manufacturer: Hausschild). In the second step, the hardener was worked into the filled compound under the same conditions. Subsequently, the sample was cured at room temperature for 6 h, and finally hardened at 60 °C for further 12 h. To ensure a homogeneous surface and thereby a uniform color measurement, the measurement surfaces of the sample bodies were polished.

The cured colored sample bodies were analyzed at the SKZ by means of a Ci7860 spectrophotometer (manufacturer: X-Rite). For the measurement, the di:8°-mode with inclusion of the gloss component, a 25 mm aperture, D65 standard lighting, and the 10° viewer mode were used. Color platelets with the reference color RAL 2003 served as refer-

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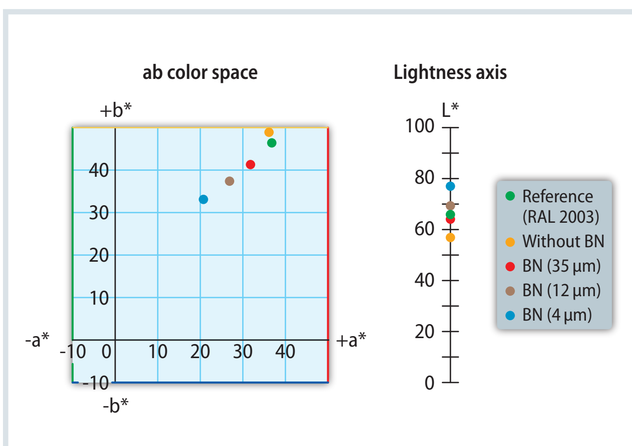

Fig. 2. Sample values on the color axes and the lightness axis: without BN, the values on the color axes deviate less from the reference. But with the filler, the lightness values are closer to the reference. Source: Henze BNP; graphic: © Hanser

ence. Due to the translucence of the platelets, two platelets were always placed on top of each other for the measurements, so that opacity was ensured. Measurements were made at two measurement points per platelet, and the values averaged over three platelets. The epoxy resin samples with and without BN were opaque, and three measurement points per sample were averaged via dual measurements (results are shown as CIELAB color values in the **Table 1**).

Larger Particles, More Intensive Color

It was shown that, when compared with the reference color RAL 2003, the RAL 2000 colorant used without BN exhibited a slight deviation on the color axes (a* and b*), but in the epoxy resin it has a lower lightness (L* axis) (**Fig. 2**). If BN is added, the values for lightness as well as the color axes are changed. The increasing values on the lightness axis, as well as the decreasing values on the color axes indicate that the BN leads to increased scatter. For the observer, this results in the impression of a color reduction. But the larger the particles are, the more intensive the color remains.

Boron Nitride for Striking Orange

The measurements illustrate the influence of BN particles on the colorant's color value in the epoxy resin – particularly the influence of BN particle size. The smaller the particles, the less intensive does the orange of the sample bodies appear. Presumably, this is because the BN acts as white pigment, whose hiding power decreases with increasing particle size. This means that the colorant's saturation increases with increasing particle size, whereby more intensive orange tones can be achieved. However, the color value of reference color RAL 2003 cannot be fully achieved with the colorant used.

Apart from a rich color, the use of large BN particles offers further benefits. Processing is simplified due to a lower increase of the compound's viscosity, and a larger aspect ratio increases thermal conductivity. Moreover, it is likely that the mechanical and electrical properties are also improved by the use of larger particles. But these influences must still be verified and investigated. ■

Hexagonal Boron Nitride

Hexagonal boron nitride (BN) – isoelectronic with graphite – is a high-performance technical ceramic with a special combination of properties. It combines good separating and lubricating effects, very good thermal conductivity, low thermal expansion, thermal shock resistance, plus low density and hardness with good electrical insulation. Thanks to these properties, BN is used in many different fields: in sintered form for precision components in high-temperature furnaces and PVD plants, as powder in suspensions – e.g. as coating for aluminum processing – and as filler in plastics. With the latter, the main focus is on improved thermal conductivity.

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Additive Improves Mechanical and Optical Properties

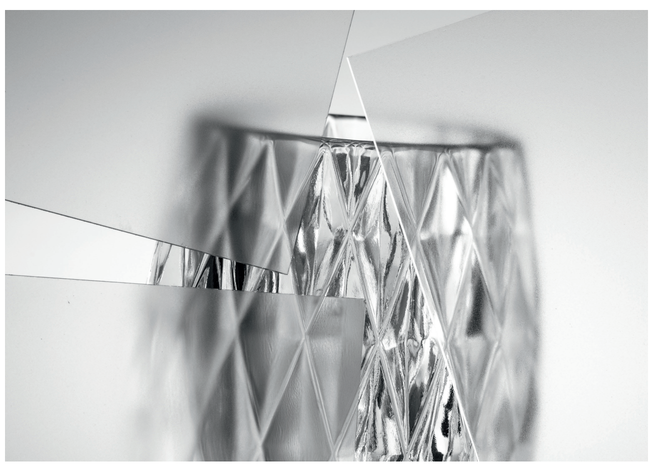
Scratch Resistance and Milk Glass Effect

The Eckart company has launched an additive which optimizes the mechanical as well as the optical properties of plastics and coatings. Named SynAdd, the additive is easy to process, highly transparent, and very color-pure, says the manufacturer. It serves to improve technical properties such as weather, moisture, and scratch resistance.

In lacquers and plastics, the synthetic additive prevents surface microcracking. This improves the product's technical properties. For example, anti-stick coatings become scratch resistant. Moreover, the product's haptics benefits from the surface texture.

The additive can also be used to achieve optical effects such as matting. It is also possible to create milky glass effects in plastics and lacquers. According to Eckart, the powder is also suitable for use in aqueous and solvent-based systems.

www.eckart.net



The additive can be used to achieve optical effects such as matting and milky glass. © Eckart