

哑光效应的实验

Experiments with Matt Effects

人们对哑光涂漆汽车的兴趣像浪潮一样起伏不定。
当前，我们有少量销售数据，表明哑光油漆通常作为一种设计创新出售，
只吸引到少量的购买兴趣。

—— Werner Rudolf Cramer, Germany 德国
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对哑光涂漆汽车的存在着的细微的兴趣肯定源于心理和实践方面。人们总是重视任何闪耀的东西，闪亮表示清新干净。另一方面，哑光唤起了旧的和磨损的印象，也有一丝神秘感。涂有哑光的车辆很有吸引力，因为它们与光泽涂料相比作为特殊和独特的东西将引起路上行人的注意力，它们的涂漆不仅昂贵，而且还需要特别小心。

由于汽车制造商不仅提供完整的哑光漆，而且还提供哑光漆部件，修补漆的制造商还需要为其客户和车身油漆工提供相应的油漆组合，这些程序还提供了进行不同程度哑光测试的选项。因此，我们设计了两个测试系列，既考虑了硬化剂和稀释剂对哑光程度的影响，也考虑了哑光涂层对底涂层效果的影响。在两个系列中使用相应涂料制造商的着色混合物制造底涂层。按照涂料制造商的规定将它们涂在灰色填充的片材上，并首先用普通（光泽）2K透明涂层密封，以避免底漆上覆盖的哑光涂层的影响。这些研究的目的是记录哑光透明涂层对效果颜料的影响。

使用不同的装置BYK-mac I、X-Rite MA98和KonicaMinolta CM-512测量颜色和光泽。这些便携式设备设计用于测量效果颜料和效果着色涂料，但仅在有限条件下最佳地进行干涉颜料的测量。BYK-mac以45°的角度照射，并在距光泽角度15°、15°、25°、45°、75°和110°处测量。MA98在15°处具有额外的照度，并且具有与光泽度（非光学）相对应的角度，如ASTM 22的E2539标准测试实践中所述。第三种照明测量颜色和光泽，最初是在标准测试实践中设想的，但由于技术实施而被遗漏。还必须记住，几何形状的选择或多或少是任意的，而推断颜料的测量条件仅在一定程度上令人满意。

KonicaMinolta CM-512在25°、45°和75°以下呈现三个圆

Interest in matt-painted cars ebbs and flows like the tide. In this context, matt paintwork is more often than not sold as a design innovation that attracts little purchase interest – with correspondingly minuscule sales figures.

The slightest interest in matt-painted cars surely stems from psychological and practical aspects. People have always valued anything that shines. Shiny denotes fresh and clean. Matt, on the other hand, evokes a used and worn impression, with a hint of mysterious too. Vehicles painted matt are attractive because they draw attention on the road as something special and unique. Their paintwork is not only expensive in comparison to gloss paint, but also requires particular care.

As car makers offer not only complete matt paintwork but also matt-painted parts, the manufacturers of repair paints need to provide corresponding paint portfolios for their customers, the car body painters. These programmes also offer the option of carrying out tests with different degrees of matt. Thus, two test series were devised, which deal with both the effect of hardener and thinner on the degree of matt as well as the influence of the matt coat on the base coat effect. Base coats were created with the tinting mixes of the corresponding paint manufacturer in both series. They were applied onto grey-filled sheets as specified by the paint manufacturer and initially sealed with normal (glossy) 2K clear coat, in order to avoid influences from the covering matt coat on the base coat. The aim of these investigations was to record the influence of the matt clear coat on the effect pigments.

Different devices were used for measuring colour and gloss: BYK-mac I, X-Rite MA98 and KonicaMinolta CM-512 were used for the measurements. These portable devices are designed for measuring effect pigments and effect-pigmented paints, but only offer limited opportunities for describing

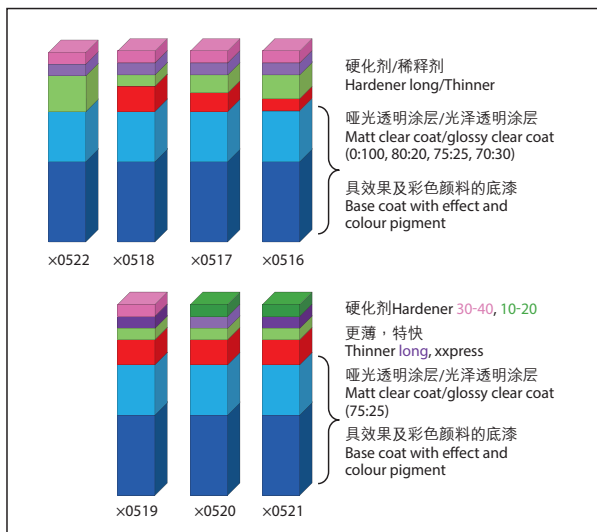


图1：Standex面板表
Figure 1: Table of Standex panels

形照明。与定向方法相比，这种测量类型具有优势，因此它也可以用于结构化表面。效果颜料也只能在这些几何形状的有限程度上测量。同时，KonicaMinolta提供了一种新型号，其具有与前述设备相同的几何形状，还使用具有球形几何形状和方向几何形状的装置进行颜色测量。在测量结果中，这两种几何形状之间的差异非常明显。

使用由Rhpoint和TQC在20°、60°和85°制造的装置以及上述具有60°球形和45°/0°几何形状的装置进行光泽度测量。基本上可以确定测量结果在装置之间是可比较的并且是一致的，在这方面，测量仪器的细节比较是非常清楚的。

用固化剂和稀释剂进行测试

哑光透明涂层以及当前光泽透明涂层选自Standex涂料程序（相当于施比快和杜邦），这些已由该制造商代表，两种透明涂层以（哑光：光泽）70:30、75:25和80:20的混合比使用。此外，从Standex计划中选择了所谓的短而正常的固化剂，以及短（特快）和长的稀释剂。将这些混合物与具有光泽2K透明涂层的样品进行比较，该透明涂层具有正常的硬化剂和长的稀释剂，使用气动喷涂将所有透明涂层施加到具有相同水基涂层的样品板上，选择类似于蓝色系列颜色的涂料配方作为底涂层（图1）。

关于样品片亮度的测量显示球形几何形状的值几乎相同，而在具有较高百分比的无光泽涂层的定向几何形状的情况下，其亮度会增加。如、图2所示，不同的硬化剂和稀释剂在方向几何形状45°/0°的情况下仅对亮度有轻微影响，同时对光泽度有影响：短硬化剂会降低光泽度（样品x0520与样品x0517），而短稀释剂增加光泽度（样品x0519和x0521与样品x0517相比）（图3）。

根据光泽范围确定不同测量角度的光泽度是正常的：在10到70 GU（光泽度单位）的范围内，建议60°光照角度，其角度高于20°且低于85°测量角度。对于蓝色样品片，60°和85°的

interference pigments optimally. The BYK-mac illuminates at an angle of 45° and measures at -15°, 15°, 25°, 45°, 75° and 110° from the gloss angle. The MA98 has additional illumination at 15° and the corresponding angles from the gloss (aspecular), as also described in the E2539 standard test practice of ASTM. A third illumination was originally conceived in the standard test practice, but was left out owing to technical implementation. It must also be borne in mind that the choice of geometries was more or less arbitrary, while the conditions for the measurement of inference pigments are only satisfactory to a certain extent.

CM-512 from KonicaMinolta exhibit three circular illuminations below 25°, 45° and 75°. This measurement type has the advantage compared with the directional methods whereby it can also be used for structured surfaces. Effect pigments can also only be described to a limited extent with these geometries. KonicaMinolta meanwhile offers a new model with the same geometries of the devices described. Colour measurements were also carried out with devices exhibiting spherical geometries and a directional geometry. The differences between these two types of geometry are clearly apparent in the measuring results.

Gloss measurements were conducted with devices made by Rhpoint and TQC at 20°, 60° and 85°, as well as the above devices with spherical and 45°/0° geometry at 60°. It can basically be determined that the measuring results were comparable between the devices and are consistent. A detailed comparison of the measuring instruments was sufficient in this regard.

Tests with hardener and thinner

The matt clear coat, as well as a current gloss clear coat, were selected from the Standex paint programme (equal to SpiesHecker and DuPont), these having been represented by this manufacturer. The two clear coats were used in the mixing ratios 70:30 (matt:glossy), 75:25 and 80:20. Furthermore, a so-called short and normal hardener, as well as a short (Express) and long thinner, were selected from the Standex programme. These mixtures were compared with a sample with glossy 2K clear coat, which was provided with a normal hardener and

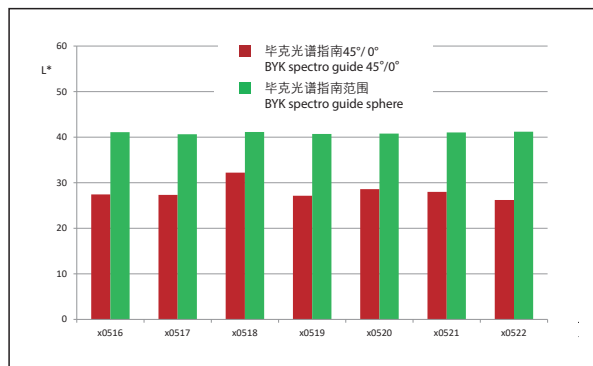


图2：球形测量的结果显示这些哑光板的亮度几乎没有差异，45°/0°时差异很明显。
Figure 2: Results of the sphere measurement show nearly no differences in lightness of these matt panels. Differences are obvious with 45°/0°.

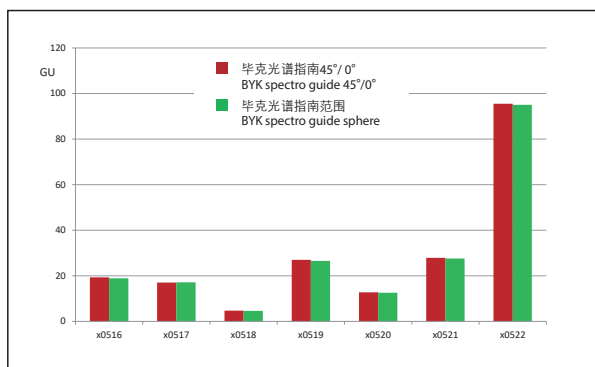


图3：比较光泽和哑光面板的色度：减少光泽面板的色度偏离光泽。无光泽面板的色度首先增加到45°/25°，然后进一步降低光泽度。

Figure 3: Comparing chroma of the glossy and matt panels: Decreasing chroma of the glossy panel going off gloss. The chroma of the matt panel firstly increases to 45°/25° and then decreases further off gloss.

光泽度测量结果清楚地反映了上述关于光泽度的说法。

当使用多角度仪器并在45°照明下以指定的光泽角度进行测量时，哑光样品显示出与角度相关的行为：接近光泽角度，这些哑光样品显示出明显更高的亮度值，哑光样品显示为白色且具有比光泽参考样本更高的反射。在所有测试的哑光样品中，色度值从-15°（非垂直）经15°增加到25°然后再次减小。光泽样品通常在-15°的反射角下显示出最高的色度值，即接近光泽角。如果测量远离光泽度，则光泽度样本中的色度值将从该值减小。哑光样品在光泽角附近呈现「乳白色」，即它们的亮度类似于白色，而且它们的色度相应地低，该反应是由哑光透

a long thinner. All clear coats were applied to sample sheets with the same water base coat using pneumatic spraying. A paint formulation similar to a blue series colour was chosen as base coat (Figure 1).

Measurements regarding the brightness of the sample sheets revealed almost the same values for the spherical geometry, while it increased in the case of the directional geometry with a higher percentage of matt coat (Figure 2). Different hardeners and thinners only have a slight effect on the brightness in the case of directional geometry 45°/0°, while exhibiting an influence on the gloss: The short hardener reduces the degree of gloss (sample x0520 in comparison to sample x0517), while the short thinner increases the degree of gloss (sample x0519 and x0521 in comparison to sample x0517) (Figure 3).

It is normal to determine the gloss with different measuring angles depending on the gloss range: In the range from 10 to 70 GU (gloss units), the 60° illumination is recommended above the 20° and below the 85° measuring angle. With the blue sample sheets, the results of the gloss measurements at 60° and 85° clearly reflect the above statements concerning the gloss level.

When using a multi-angle instrument and measuring at 45° illumination with the specified gloss angles, the matt samples reveal an angle-dependent behaviour: Close to the gloss angle, these matt samples exhibit significantly higher brightness values: Matt samples appear white and have a higher reflection than the glossy reference sample. In all matt samples examined, the chroma values increase from as-15° (aspecular) via as15° to as25° and then decrease again. The glossy sample typically reveals the highest chroma value at an aspecular angle of -15°, i.e., close to the gloss angle. The chroma values decrease from this value in the glossy samples if

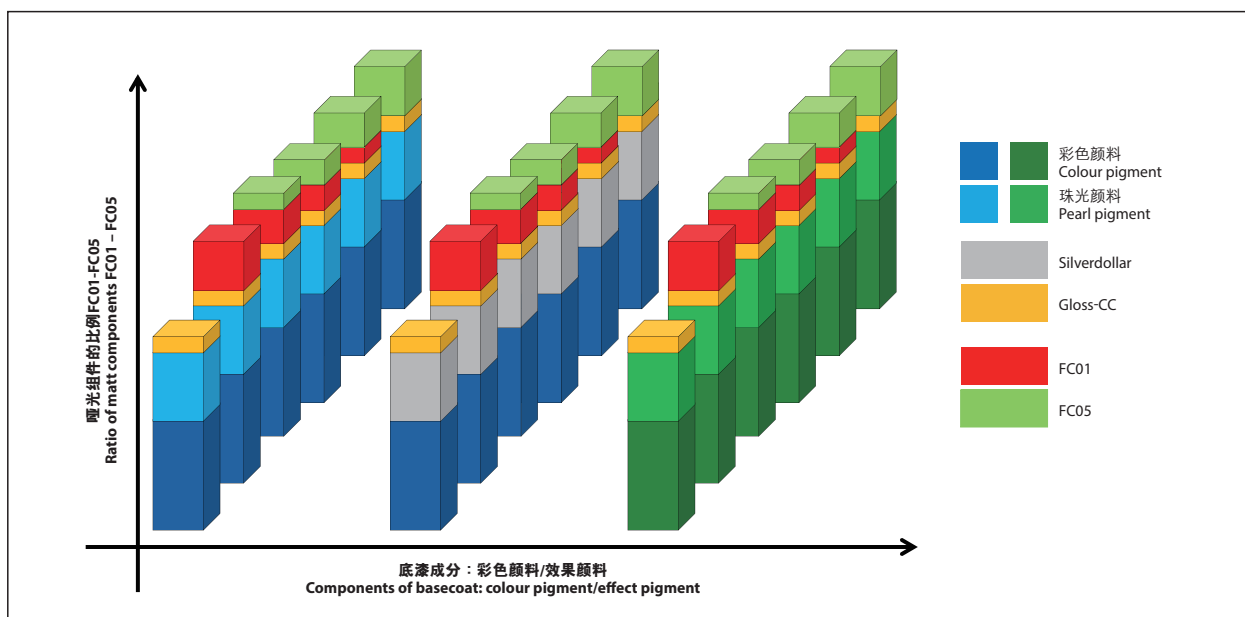


图4：FC01是一种哑光透明PPG涂层，FC06是一种半光泽透明涂层。FC02至FC05是比率为70:30、50:50和30:70的两者的混合物。为这些实验选择三种效果颜料。将光泽面板设定为标准。

Figure 4: FC01 is a matt clear coat of PPG, FC06 a semi-gloss clear coat. FC02 to FC05 are mixtures of both in ratios 70:30, 50:50 and 30:70. Three effect pigments for chosen for these experiments. Glossy panels were set as standards.

明涂层中的漫反射引起的。

相应的行为反映在 $a^* b^*$ 图中：如果底漆用光滑的透明密封，效果颜料表现出非垂直线的独特进展（光泽几何形状的 $a^* b^*$ 值的连接线）涂层。彩色干涉颜料逆时针转动这个「手臂」与光滑的透明涂层。这是由于如果干涉颜料被更平坦地照射，则反射最大值向更短波长的移动。白色干涉颜料和铝颜料不显示臂的「转动」。在这些中，非垂直线从 $45^\circ/25^\circ$ 经 $45^\circ/15^\circ$ 延伸到 $45^\circ/15^\circ$ 直线方向。在无光泽样品的情况下，「手臂」从 $45^\circ/15^\circ$ 顺时针转动到 $45^\circ/-15^\circ$ ，朝向具有这些蓝色值的消色差点。这种反向行为通过哑光透明涂层中的散射来证实，由此上述「臂」转向白色。这里也发生反射最大值的偏移，这意味着光谱的低反射区域也增加。

测试不同程度的哑光

在另一个测试系列中定义了三种水基底涂层。将PPG涂料与其自身制备的效果颜料混合，在此特定比例混合（等于Nexa）。用制备的粘合剂施加效果颜料，该粘合剂包含在PPG混合系统中。

为了制备样品，使用制造商规定的喷枪将填充有深灰色的样品片与底涂层一起施加。然后为所有片材提供有光泽的透明涂层，以便在此处从随后施加的无光透明涂层中排除效果。选择具有光泽透明涂层的片材作为参考样品。

PPG提供两种可以相互混合的哑光透明涂层。哑光透明涂层具有最高的哑光度，半光泽透明涂层最低。PPG指定水平为FC01（100%丝般光泽），FC02（70：30丝光泽：哑光），FC03（50：50）和FC04（30：70）至FC05（哑光）；然而，也可以在这两个透明涂层之间产生任何中间水平，以使哑光度适应修复条件。然而，丝光泽和光泽透明涂层之间不能混合刻度，我们将哑光样品直接与该测试系列中的光泽样品进行比较。哑光透明涂层的油漆工作非常谨慎，因为初步测试显示了哑光度对应用条件的依赖性，因此，涂层的油漆工作是短时间内连续进行。此外，通风和干燥时间取决于涂料制造商的规格（图4）。

measuring far from the gloss. Matt samples appear "milky and white" close to the gloss angle, i.e., their brightness is similar to that of white, and their chroma is correspondingly low. This reaction is caused by diffuse reflections in the matt clear coat.

A corresponding behaviour is reflected in the a^*b^* diagram: Effect pigments exhibit a unique progression of the aspecular line (connecting line of the a^*b^* values of the geometries of the gloss) if the base coat is sealed with a glossy clear coat. Colourful interference pigments turn this "arm" anticlockwise with the glossy clear coat. This is due to the shift in the reflection maxima to shorter wavelengths if the interference pigment is illuminated more flatly. White interference pigments and aluminium pigments do not exhibit "turning" of the arm. In these, the aspecular line continues from $45^\circ/as25^\circ$ via $45^\circ/as15^\circ$ to $45^\circ/as-15^\circ$ in a straight direction. In the case of matt samples, the "arm" turns from $45^\circ/as15^\circ$ to $45^\circ/as-15^\circ$ clockwise towards the achromatic point with these blue values. This inverse behaviour is substantiated by the scatter in the matt clear coat, whereby the above "arm" turns towards the white. A shift of the reflection maxima also occurs here, which means the low reflection areas of the spectrum are also increased.

Tests with different degrees of matt

Three water-based base coats are defined in a further test series. PPG paint mixes with their own prepared effect pigments were mixed in specific ratios here (equal to Nexa). The effect pigments were applied with a prepared binder, which is contained in the PPG mixing system.

To produce the samples, sample sheets that were filled dark grey were applied with the base coats using a spray gun as specified by the manufacturer. All sheets were then provided with a glossy clear coat in order to rule out an effect here from the matt clear coat that was applied subsequently. A sheet with a glossy clear coat was chosen as the reference sample.

PPG supplies two matt clear coats that can be mixed with one another. The matt clear coat has the highest degree of matt, the semi-gloss clear coat the lowest. PPG specifies levels from FC01 (100% silky gloss) via FC02 (70:30 silky gloss:matt), FC03 (50:50) and FC04 (30:70) to FC05 (matt); nevertheless, any



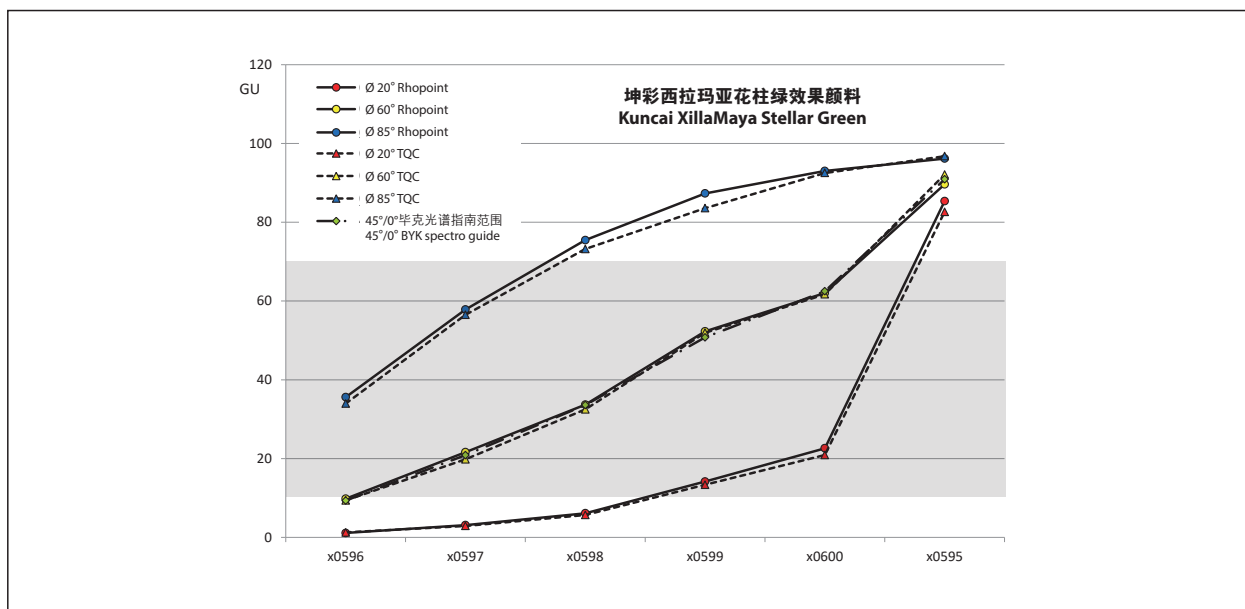


图5：60°的光泽度测量几乎最合理。在测量85°几何形状的情况下，光泽样品和丝光泽样品的结果在光泽度方面几乎相同。它们在测量几何形状20°处相距太远。灰色区域是60°测量的正常区域。

Figure 5: The gloss measurements at 60° appear most plausible. In case of measuring geometry 85°, the results for the glossy sample and silk glossy samples are almost identical in respect to gloss. They are too far apart at measurement geometry 20°. The grey area is the normal area for measurements at 60°.

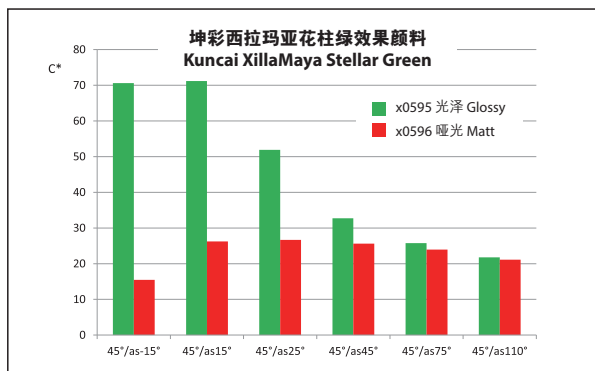


图6：将色度从近光泽度增加到45°/25°，然后将色度降低到偏光。光泽面板显示近光泽度下的光泽度降低。

Figure 6: Increasing chroma from near gloss to 45°/25° and then decreasing chroma to off-gloss. The glossy panel shows decreasing gloss from near gloss.

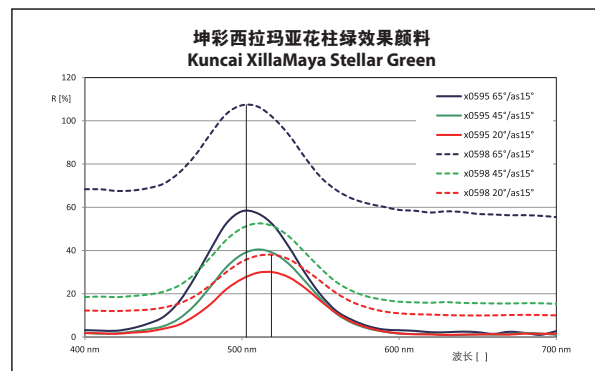


图7：哑光透明涂层增加了恒星绿的低反射光谱范围。但是当照射角度更水平时，仍然会有较短波长的颜色偏移。

Figure 7: The low reflection spectral ranges of Stellar Green are increased by the matt clear coat. But still there is a color shift to shorter wavelengths when illuminated flatter.

选择由坤彩制造的效果颜料西拉玛亚花柱绿和西拉玛亚银河蓝以及中等尺寸的Silverdollar颜料，它们在混合物中的百分比约为2%。前两种颜料代表一种新的干涉颜料，其颜料片涂有二氧化钛。它们表现出与入射光相关的典型色移。当以恒定角度照射并从光泽角度以各种角度测量时，仅在有限程度上记录干涉色。这些测量角度足以在这些测试中获得结果。

在上述样品中，具有球形几何形状的测量结果在样品之间没有表现出任何差异，也没有在光泽样品和哑光样品之间表现出任何差异。另一方面，如果以45°/0°的几何形状定向测量，则具有最高哑光特性的样品的亮度会降低到另一个样品和光泽样品的亮度。

intermediate levels can also be created between these two clear coats in order to adapt the degree of matt to the repair conditions. However, no graduations can be mixed between the silk glossy and glossy clear coat, which means the matt samples were compared directly with the glossy sample in this test series. The paintwork of the matt clear coat was carried out with the utmost care, as preliminary tests had revealed the dependency of the matt degree on the application conditions. The painting was therefore performed within a short time in succession. Plus the ventilation and drying times are oriented to the specifications of the paint manufacturer (Figure 4).

The effect pigments XillaMaya Stellar Green and XillaMaya Galaxy Blue made by Kuncai as well as a Silverdollar

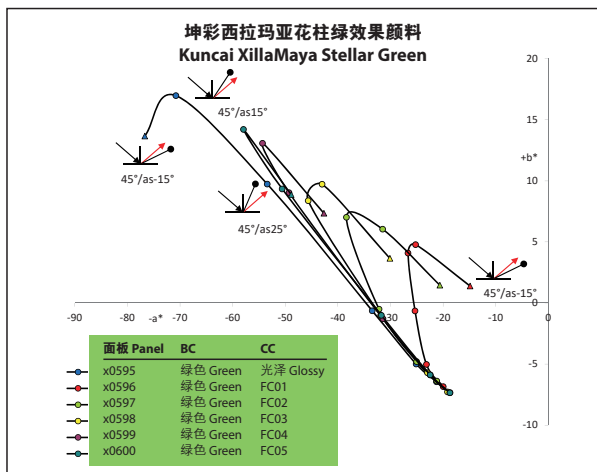


图8：非对称测量值的扩展「臂」通常从45°/到25°逆时针弯曲45°/到15°至45°/到-15°。使用哑光透明涂层，此弯曲顺时针转动到消色差点。

Figure 8: The extended "arm" of the aspecular measurement values bends normally from 45°/as25° via 45°/as15° to 45°/as-15° anticlockwise. With matt clear coat, this bending turns clockwise to the achromatic point.

光泽度测量结果在意料之中，在三种光泽几何形状20°、60°和85°的情况下，光泽值随着哑光级别的降低而增加，60°的结果最合理，85°几何形状测量情况下，光泽样品和丝光泽样品光泽度方面的测量结果几乎相同，在测量几何形状20°处光泽度有一定差距（图5）。

比较亮度相对于光泽角时，接近光泽样品的光泽度的测量值明显高于光泽样品的光泽度。反射曲线也解释了这一点：低反射光谱范围得到补偿，从而限制了哑光透明涂层的白色效果。

色度还揭示了这样一种现象，即其几何形状接近光泽的值从光泽度增加到25°，然后再次降低到远离光泽的几何形状。（图6）。接近光泽的「增白」导致色度降低；远离光泽，对低反射光谱范围的补偿较少，导致样品看起来更「丰富多彩」（图7）。

虽然在干涉颜料中，非光谱测量值的扩展「臂」从45°到25°，逆时针方向弯曲45°/15°到45°/15°，但这些样本很明显的会产生这些线条顺时针「消失」到消色差。由于上面的「美白」接近光泽，这里比远离光泽的几何形状更大，底漆的颜色会发生变化。

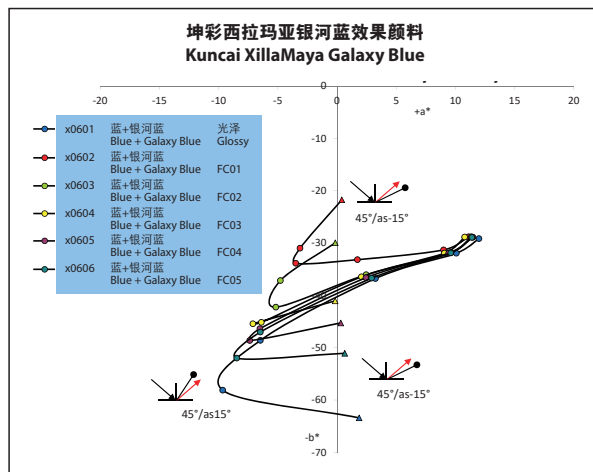


图9：银河蓝与绿色效应颜料的测试结果：非对称测量值的扩展「臂」从45°/到25°弯曲45°/到15°至45°/到-15°顺时针弯曲，光泽值降低（GU）。

Figure 9: Corresponding behaviour of Galaxy Blue to that of the green effect pigment: The extended "arm" of the aspecular measurement values bends from 45°/as25° via 45°/as15° to 45°/as-15° clockwise with decreasing gloss values (GU).

pigment of medium size were selected. Their percentage was about 2% in the mixtures. The first two pigments represent a new interference pigment whose pigment flakes are coated with titanium dioxide. They exhibit typical colour shifts in relation to the incident light. When illuminating at a constant angle and measuring at various angles from the gloss angle, the interference colour is only recorded to a limited extent. These measuring angles are sufficient to attain the results in these tests.

As in the above samples, the measurements with the spherical geometry do not exhibit any differences between the samples, nor between the glossy sample and matt one. If measuring directionally with the geometry 45°/0° on the other hand, the brightness of the sample with the highest matt property decreases to the other sample and to the glossy one.

The gloss measurements do not reveal any surprises: In the case of three gloss geometries 20°, 60° and 85°, the gloss values increase as the matt level decreases. The results at 60° appear most plausible. In case of measuring geometry 85°, the results for the glossy sample and silk glossy samples are almost identical in respect to gloss. They are too far apart at measurement geometry 20° (Figure 5).

When comparing the brightness in relation to the gloss angle, the measured values close to the gloss for the matt samples are significantly higher than that of the glossy samples. The reflection curves also explain this: The low reflection spectral ranges are compensated and thus limit the whitish effect of the matt clear coat.

The chroma also reveals the phenomenon that its values from the geometries close to the gloss increase to 25° from the gloss and then decrease again to geometries far from the gloss (Figure 6). The "whitening" close to the gloss causes the chroma to decrease; away from the gloss, there is less compensation of the low reflection spectral ranges, with the result that the samples appear more "colourful" (Figure 7).

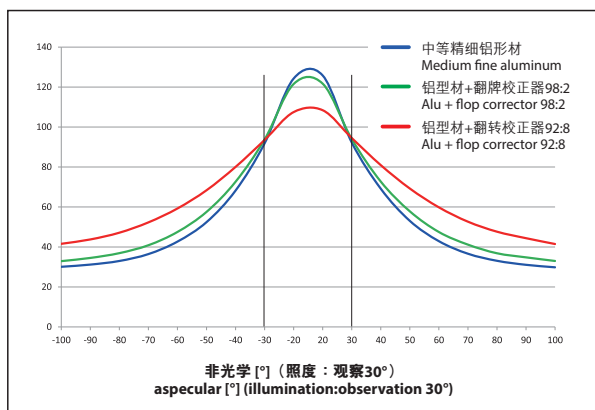


图10: 哑光膏可降低透明涂层的光泽。当添加到底漆中时, 它还可用于改变效果薄片的取向: 亮度较低L* 接近光泽但L* 偏光泽较高。

Figure 10: Matt paste reduces the gloss of a clear coat. It can also be used to change the orientation of the effect flakes when add to the base coat: Less brightness L* near gloss but higher L* off gloss.

色度和光泽度值之间的相应变化关系, 也发生在蓝色底涂层样品中, 蓝色底涂层样品含有蓝色颜料和昆莱西拉玛亚银河蓝的混合物, 也同样适用于那些绿色效果颜料。在这种程度上, 可以认为基本可以应用于所有彩色效果颜料。与哑光透明涂层结合的特殊行为不是由于干涉颜料对其颜色偏移的反应, 而是由于在哑光涂层内的上述反射。如果样品被照射的角度越水平, 则也会发生向较短波谱的色移, 但是这种反应在视觉上不太明显。(图9)。

第三系列的测试揭示了这些结论可以应用于不同的颜色系统。在该系列中, 蓝色干涉颜料被中等尺寸的Silverdollar铝颜料代替。如果铝颜料照射角度更小时, 则铝颜料不会出现任何颜色偏移。这里强调的是, 如果在与固定照明下的光泽度不同的角度测量颜料, 则亮度会发生变化。具有最高哑光水平样品的结果为, 在接近光泽度的几何形状下亮度明显高于光泽参考样品。在具有铝颜料的样品中也重复色度的反应: 如果在几个角度以下测量样品, 则接近光泽的色度值显著低于光泽样品的色度值; 对于几何形状45°到25°, 它们在远离光泽的几何形状中增加并达到与光泽样品相同的水平。「无光泽性质」的行为与具有干涉颜料的上述样品的行为没有区别(图10)。

通过梳理各种哑光透明涂层, 可轻松设计哑光层, 这种方式是修补涂有哑光的车辆或车辆部件的最佳解决方案。然而, 也可以使用具有哑光浆料的系统, 可以添加用来调节所需的哑光水平。所有系统中的颜色都「变白」, 在光泽度附近显得最强。这里低反射光谱范围的反射增加。色度降低, 而亮度增加, 其原因是哑光或哑光透明涂层内的散射效果是其原因。在具有干涉颜料的底涂层的情况下, 如果用哑光透明涂层密封保留它们反射最大值到短波光谱变化的光学性质, 这同样适用于铝颜料, 由于它们的效果也取决于角度, 哑光透明涂层将对光泽度和颜色产生相应的影响。根据消光程度, 颜色向消色差点移动。以这种方式, 在具有干涉颜料的底涂层中, 接近光泽的色度也降低。它增加到几何形状45°到25°, 然后再次朝着远离光泽的几何形状减小。

Although the extended "arm" of the aspecular measurement values bends from 45°/as25° via 45°/as15° to 45°/as-15° anticlockwise among the interference pigments, a clear "twisting" of these lines clockwise to the achromatic point is also apparent with these samples. Owing to the above "whitening" close to the gloss – it is greater here than with geometries far from the gloss – the colour of the base coat changes.

The corresponding behaviour in respect to the chroma and gloss values also occurs among the blue base coat samples. This contains a mixture of blue-coloured pigments with Kuncai XillaMaya Galaxy Blue. The procedure and application correspond to those for the green effect pigment. To this extent, the basic statements can be applied to all colourful effect pigments. The particular behaviour in conjunction with matt clear coats is not due to the reaction of the interference pigments with respect to their colour shift either, but the above reflections within the matt coat instead. A colour shift to the shorter wave spectrum also occurs if the sample is illuminated more flatly, but this reaction is much less noticeable visually (Figure 9).

The third test series reveals that the statements can be applied to different colour systems. In this series, the blue interference pigment was replaced with a Silverdollar aluminium pigment of medium size. Aluminium pigments do not exhibit any colour shift if they are illuminated more flatly. The emphasis here is on the change in the brightness if the pigment is measured at different angles from the gloss at fixed illumination. In the case of the sample with the highest matt level, the brightness is significantly higher at geometries close to the gloss than the glossy reference sample. The reaction of the chroma is also repeated among the samples with the aluminium pigment: If the samples are measured below several angles, the chroma values close to the gloss are thus significantly lower than those of the glossy sample; to geometry 45°/as25°, they increase and attain the same level as among the gloss samples at geometries far from the gloss. The behaviour in respect to the "matt property" does not differ from that of the above samples with interference pigments (Figure 10).

The matt level can be easily set by combing various matt clear coats. This procedure represents the optimal solution for the repair of vehicles or vehicle parts painted matt. However, systems with matt pastes are also available, which are added to adjust the desired matt level. The colour "whitens" in all systems, whereby this procedure appears strongest close to the gloss. Low reflection spectral ranges are increased in their reflection here. The chroma decreases, while the brightness increases. Scatter effects within the matt or matted clear coat are the reason for this. In the case of base coats with interference pigments, their optical properties – a shift in the reflection maxima to the short-wave spectrum – are retained if these are sealed with matt clear coat. The same also applies for effects with aluminium pigments. As their effect also depends on the angle, a matt clear coat will have a corresponding effect on the gloss level and colour. Depending on the degree of matting, the colour shifts towards the achromatic point. In this way, the chroma close to the gloss also decreases in the base coats with interference pigments. It increases to geometry 45°/as25° and then decreases again towards the geometries far from the gloss. □