以干涉颜料对彩色与灰色底漆进行测试对比的研究（下）

Coloured versus Grey Undercoats – Trials with Interference Colours (Part 2)

铝颜料反射光线并产生类似于高光泽的高反射效果。
自从上世纪八十年代中期以来，干涉颜料已被用于汽车涂料。顾名思义，其颜色不是通过吸收和反射产生的，而是通过光波的相互作用产生。
这个原理也在自然界中被发现，例如在甲虫和蝴蝶的翅膀上。

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测试结果

路西法红是典型的 OEM 颜色；根据配方不同，涂料中可以含有一种或几种干涉颜料。这些干涉颜料确保在更平齐对照辐射进行观测时，色彩会转变为黄

图5：样板：使用白光，由白至黑的四个增量的颜色进行颜色区分。如果用红光照射相同的样板，则黄色和红色变为白色和/或浅灰色。绿色和蓝色不反射任何红色光，所以显示为黑色。红色底涂层在彩色底涂层上显示出相似的光学反应。
Figure 5: With white light, the four increments of white to black are identifiable along with the colours. If the same sample panel is irradiated with red light, yellow and red change into white and/or light grey. Green and blue do not reflect any red light, so they appear black. A red base coat shows similar optical reactions over coloured undercoats.

Modern car paint usually consists of a 2-layer structure: the base coat contains pigments for colours and effects, whilst the clear top coat protects the base coat from mechanical and chemical influences. In addition to coloured pigments, modern car paints contain aluminium or interference pigments which create different effects. Coloured pigments absorb part of the incoming light and scatter the rest in all directions.

Results

Lucifer Red is a typical OEM colour; depending on paint formulation, it can contain one or several interference pigments. These ensure that the colour shifts through to yellow when it is viewed more flush to the radiance. This can be read from both the reflection curves and in the a*b* values. As the two aforementioned devices are not equipped to perform flush illumination, a geometry of 45°/as-15° can be used instead. It corresponds in reverse to the light beam of geometry 60°/as+15°. It must however be noted that this method depends on the application: drawdown base coats show differences to sprayout base coats. As long as application has been done in the same way, the method can be used in all cases.

Certain quite mundane facts should be considered in the assessment of the results. Firstly, the red base coat has a similar effect on the light falling on it, as a red film lets red light through. Secondly, the only light rays that can be reflected from the undercoat are those that actually reach it. Thus, the maximum is with a white undercoat and the minimum with a black undercoat. Theoretically, grey colours absorb equally across the entire spectral range. In practice however, black pigments (Carbon Black) also contain colour components: a carbon black with fine particles is bluer than one with coarser particles.

In this way, the red light of the Lucifer Red will not be reflected equally. The best result – in the sense of correlation

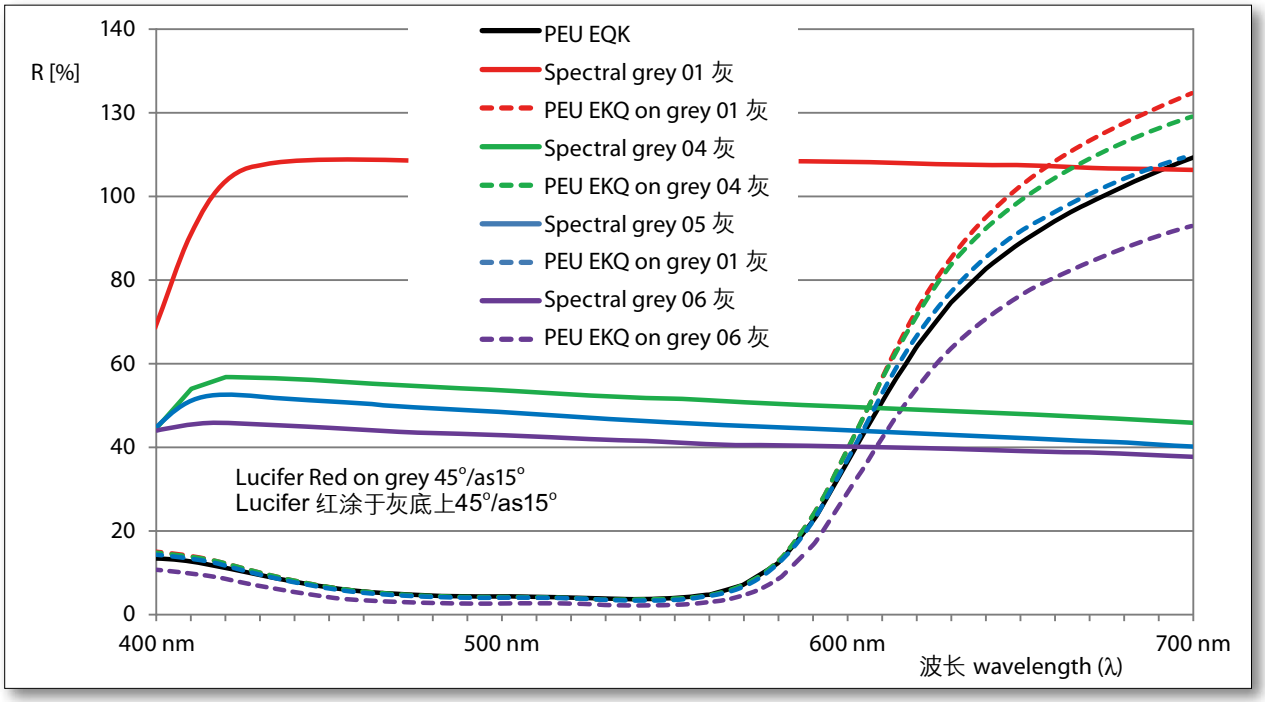

图6：灰色度的反射曲线和当将路西法红喷涂到这些色度上时的相应曲线总结。在灰色度上与参考色的偏差也是可识别的。
Figure 6: Summary of the reflection curves of the grey graduations and the corresponding curves when spraying Lucifer Red onto these graduations. Colour deviations from the reference are also identifiable over grey graduations.

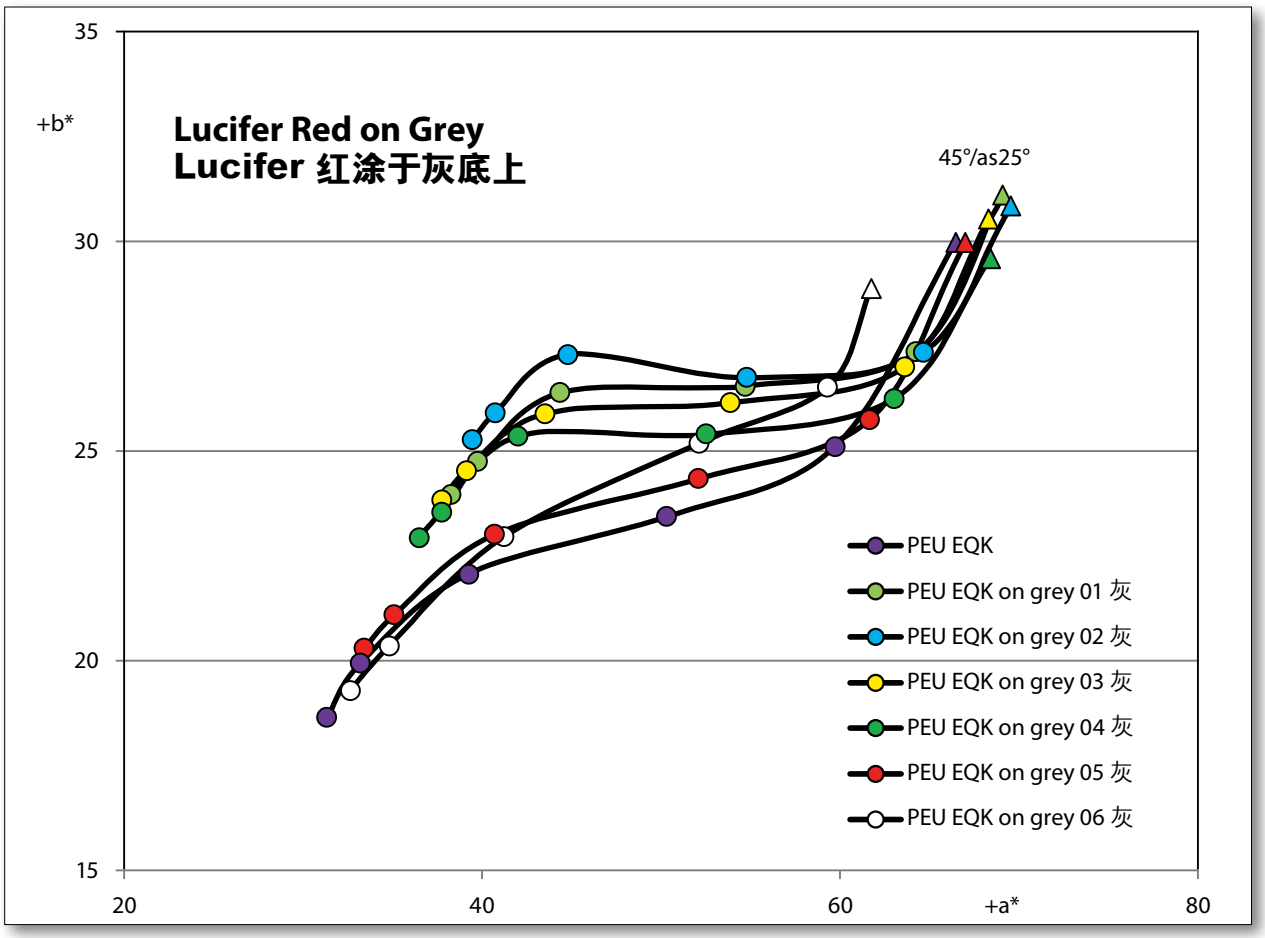

图7：在灰色度上，样品的颜色线（镜面反射线）也偏离参考样品颜色。
Figure 7: The colour lines (aspecular lines) in the sample also deviate from the reference sample over the grey graduations.

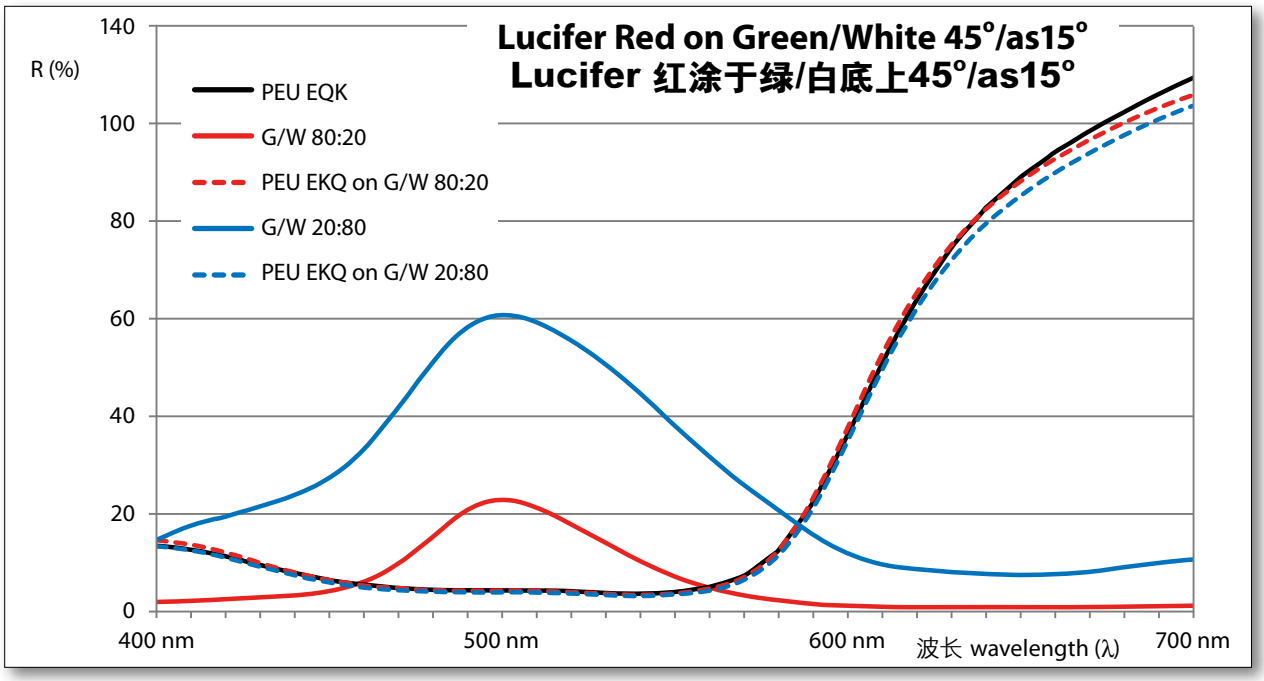

图8：所选择的绿色样品（80:20和20:80带有白色）在红色光谱范围内反射较少。当将底涂层施加到其上时，与参考样对比，反射几乎没有不同。
Figure 8: The selected green samples (80:20 and 20:80 with white) reflect less in the red spectral range. The reflections barely differ from the reflections of the reference when the base coat is applied onto it.

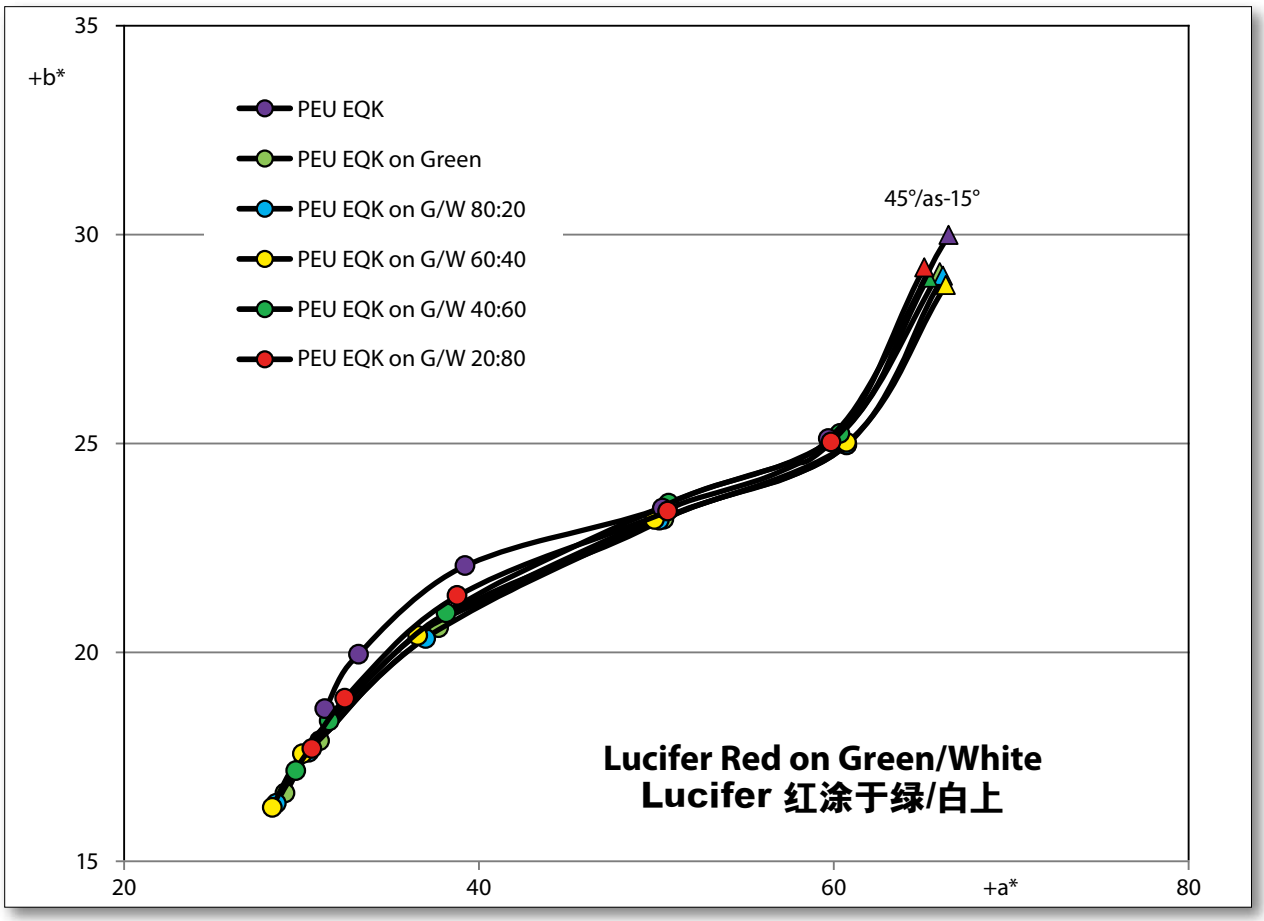

图9：当路西法红喷涂于绿色上时，出现最佳相关性。绿色与白色的所有混合物显示为具有强烈接近参考样品颜色值的底色。
Figure 9: The best correlations arise when Lucifer Red is applied over green. All mixtures of green with white show as undercoat colours with colour values strongly approaching the value of the reference sample.

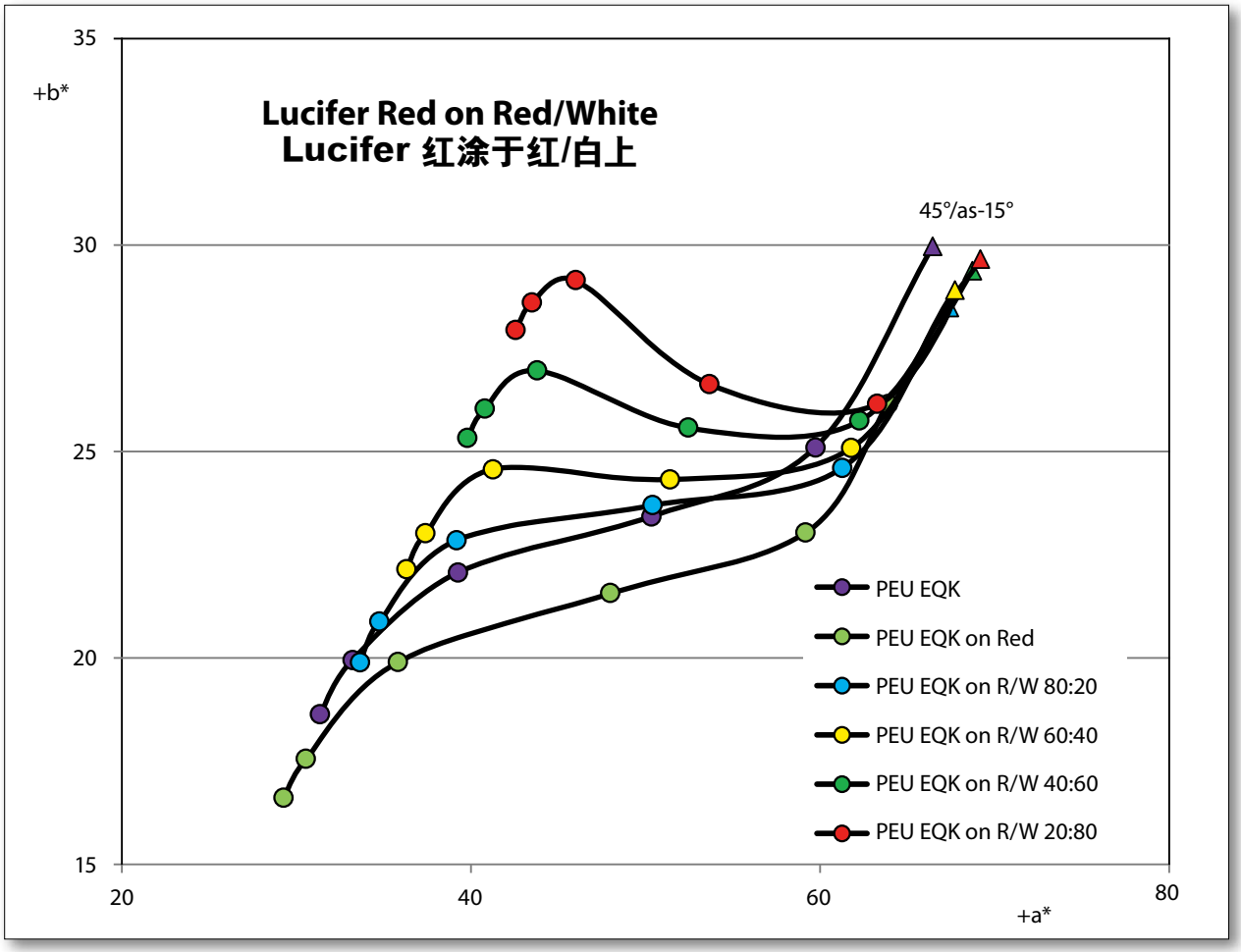

图10：从45° / as-15° 至45° / as110° 的光线被视为颜色值。从参考颜色路西法红可以看出显著的偏差，特别是在远离辐射区域。

Figure 10: The colour values are summarised as lines from 45°/as-15° to 45°/as110°. Significant deviations can be seen from the reference colour Lucifer Red, particularly in the area far from the radiance.

色。这种现象可以从反射曲线和 a * b * 值中读取。由于上述两个装置未配备成可进行齐平照明，因此可以使用 45°/ -15° 的照射参数进行替代。其与几何参数为 60°/ +15° 的光束相反。然而必须注意的是，该方法取决于涂布方式：拉伸的底涂层与喷涂的底涂层显现出差异。只要涂布以相同的方式完成，该方法可以在所有情况下使用。

在评估结果时应考虑某些非常平常的事实。首先，红色底涂层对落在其上的光具有类似于使红色光通过的红色膜的效果。第二，可以从底层反射的唯一光线是实际到达它的那些光线。因此，最大值为白色底漆，最小值为黑色底漆。理论上，灰色在整个光谱范围内会均匀吸收。然而，在实践中，黑色颜料（炭黑）还包含颜色组分：具有细颗粒的炭黑比具有较粗颗粒的炭黑更蓝。

按这种方式，路西法红的红光将不会被同等地反射。当对样品进行观察和测量的角度为接近辐射度（45°/15°）时，针对深灰色—从与反射曲线相关性的意义方面 - 发现最佳结果（**图 6**）。较浅和较深的灰色与参照的反射曲线发生了显著的偏差。对 a * b * 颜色值的评估进一步显示了在与辐射相差较大的差值角处

with the reflection curves – was found with Dark Grey, when the sample was viewed and measured close to the radiance (45°/as15°) (**Figure 6**). The lighter and darker grey colours resulted in significant deviations from the reflection curve of the reference. The assessment of the a*b* colour values furthermore showed the side drifts of the colour value at larger differential angles from the radiance (**Figure 7**).

The rather mundane facts also apply to a coloured undercoat: the only parts that can be reflected are those that are not absorbed. A green undercoat colour reflects in the green spectral range while it absorbs the light rays in the red area. If the reflection curves in the green trial colours are compared with those of the reference colour, it becomes clear that less is reflected in the red area (**Figure 8**). The a*b* colour values of the sample over the green undercoat show good correlations with the colour values of the reference at all measured geometries (**Figure 9**).

In contrast to this, great deviations arise when the base paint is over red and the mixtures with white. This is particularly true for geometries far from gloss. It can be seen here that different reflection parameters influence the overall colour impression significantly, i.e. when the red of the undercoat deviates from the red of the base coat, there is a colour shift. The mixtures of red mixed paint with white

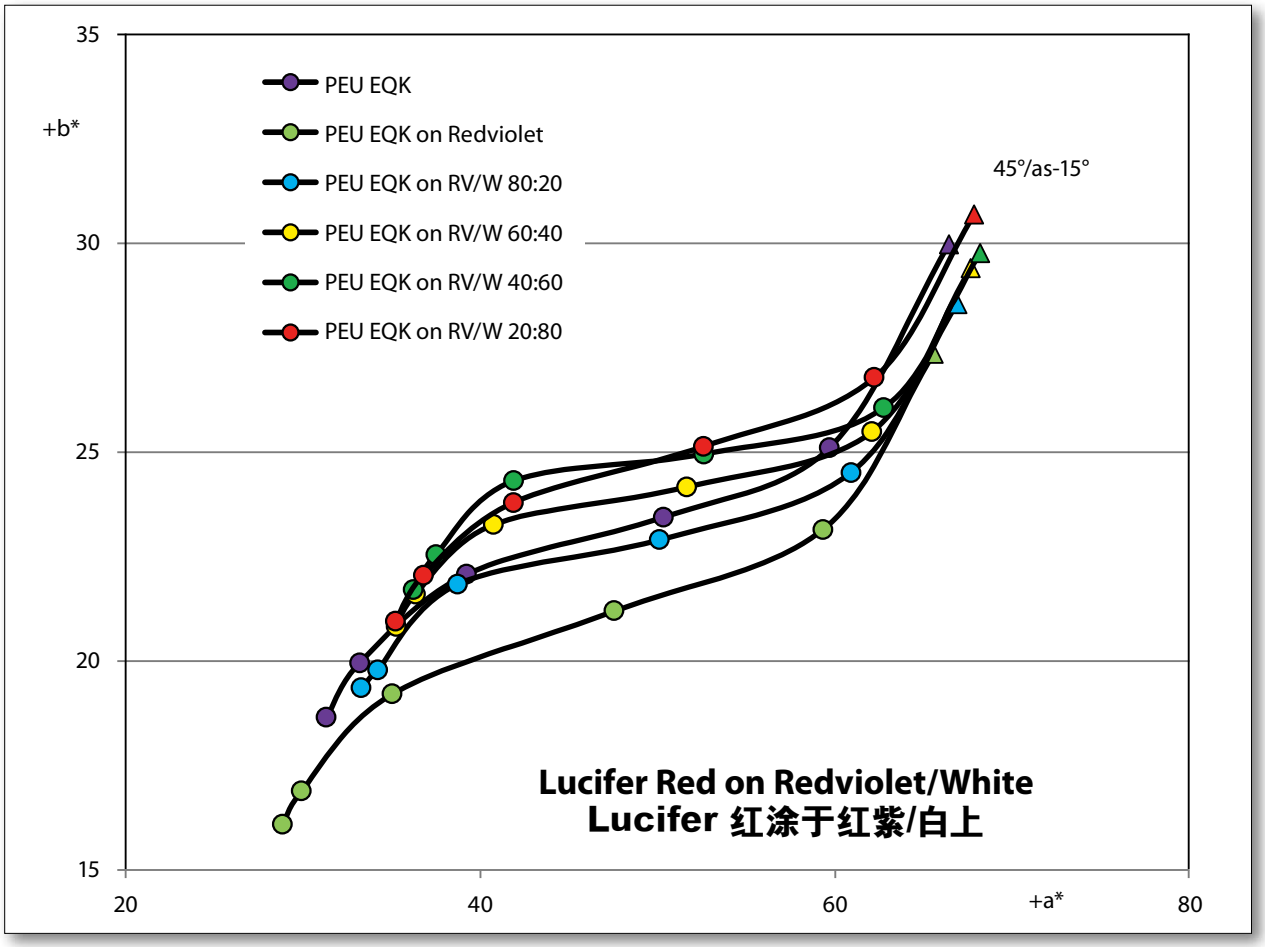

图11：同样，红 - 紫色底涂上的样品颜色线（镜面反射线），在远离光泽度处，与参考颜色相比发生偏移。与红色相比，偏差较小。原因在于红紫色样品在较低光谱带发生反射。
Figure 11: Also the colour lines of the sample (aspecular lines) over the red-violet undercoat drift from the reference colour at geometrics far from gloss. The deviations are less in comparison to those over red. The reason lies in the lower spectral band in which the red-violet sample reflects.

颜色值的侧向偏移（**图 7**）。

相当平凡的事实也适用于彩色底漆：可以反射的唯一部分是那些不被吸收的部分。绿色底涂的颜色在绿色光谱范围内反射，同时吸收红色区域中的光线。如果将绿色试验颜色中的反射曲线与参考颜色的反射曲线进行比较，可以清楚地看出红色区域反射较少（**图 8**）。绿色底涂层样品的 a * b * 颜色值在所有测量的参数中与参考样的颜色值均显示出良好的相关性（**图 9**）。

与此相反，当底涂层颜色过红并且混合物具有白色时，会产生大的偏差。这对于远离光泽度参数尤其如此。这里可以看出，不同的反射参数显著地影响整体的色彩印象，即当底涂层的红色偏离底层的红色时，存在色移。红色混合涂料与白色混合后显示出发光范围的典型行为：首先随著白色的添加量在混合涂料中的添加比例增加至 60:40，色度会发生增长。同时，黄色的颜色比例降低。生成的颜色明显偏离参考样本（**图 10**）。

当使用红紫色和具有白色的混合物作为底涂颜色时，会产生类似的结果。使用红紫色时，当红－紫混合颜料用白色淡化时，颜色会向蓝色偏移。与红色色度相比，蓝－紫色色度的反射在底涂层的反射范围之内。同

show the typical behaviour of a lightening range: the chroma increases with the addition of white firstly up to a weight ratio of the mixed paint of 60:40. At the same time, the yellow proportion of the colour decreases. The resulting colours deviate significantly from the reference sample (**Figure 10**).

Similar results arise when using red-violet and the mixtures with white as an undercoat colour. With red-violet too, the colour drifts towards blueish when the red-violet mixed paint is lightened with white. In contrast to the red graduations, the reflections of the blue-violet graduations are within the reflections of the base coat. Also with red-violet, the resulting colours deviate from the reference sample, particularly in

图12：雨滴中的颜色被折断和反射控制。这是干涉色的典型行为。
Figure 12: The colours in the raindrops are manipulated by breaks and reflections. This is typical behaviour for interference colours.

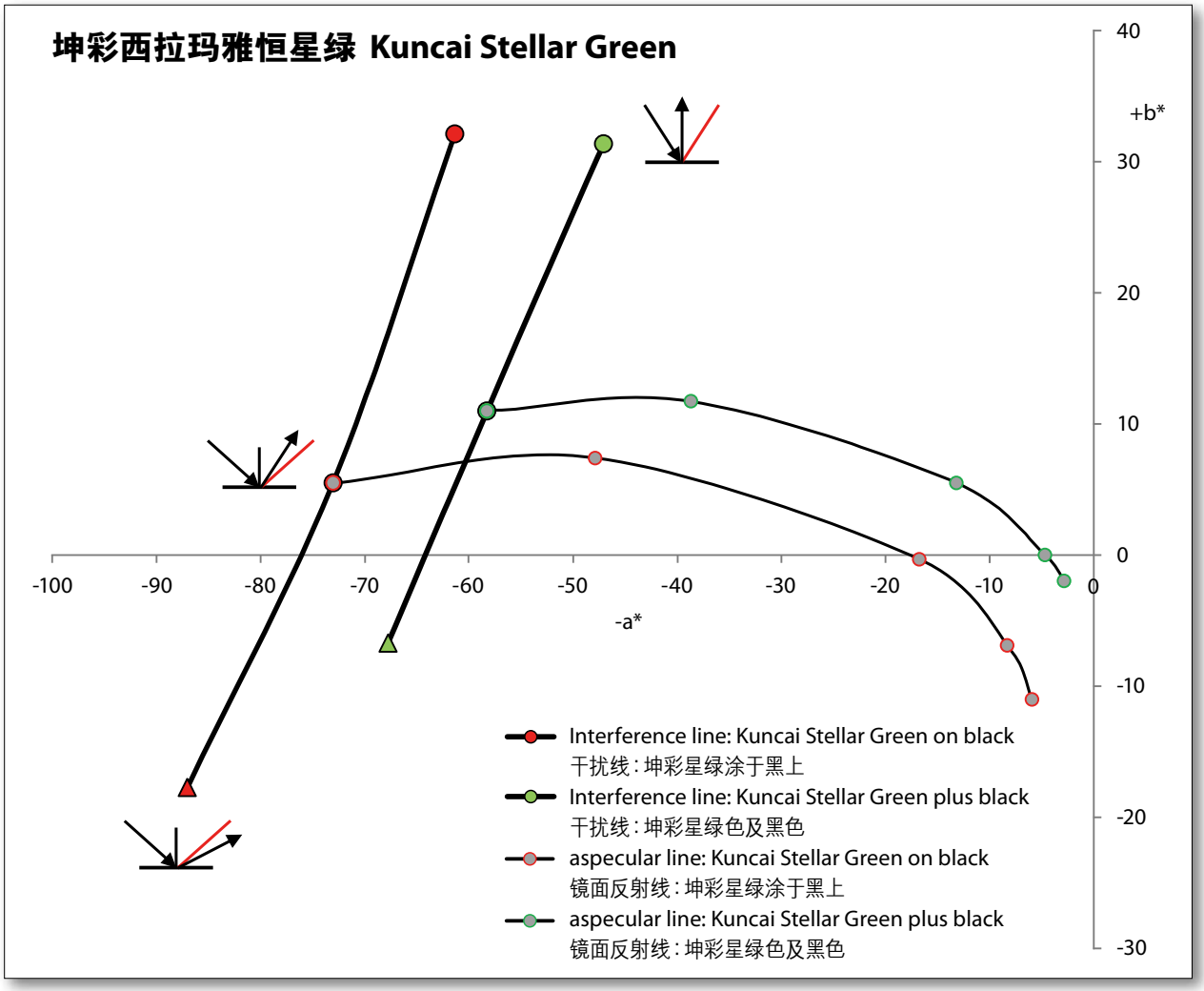

图12：两种不同的程式：坤彩星绿色在黑色底涂上作为纯色调及坤彩星绿色与黑色混合。在与黑色的混合物中，反射光的一部分被吸收，而黑色底涂层仅吸收到达其上光。
Figure 12: Two different procedures: Kuncai Stellar Green as a pure tone on a black undercoat and alternatively Kuncai Stellar Green mixed with black. In the mixture with black, parts of the reflected light are absorbed, while the black undercoat absorbs only the light that reaches it.

样对于红紫色，所得的颜色偏离参考样品，特别是在远离辐射的测试角度中。然而，总的来说，偏差小于红色混合物的偏差（**图 11**）。

结论

底涂层—例如填料的颜色—当其上的涂层为透明时，对整体颜色印象具有决定性的影响。这种类型的涂料系统通常应用于汽车涂料中。其中，底涂主要采用灰色或有色填料。

整体颜色印象取决于颜色的选择以及灰色调的选择。如果填料的颜色与底涂的颜色不完全对应，颜色会发生改变。填料只能根据其色度形成反射光线。在绿色填料上应用红色底涂看似很荒谬。但是，由于绿色填料在红色光谱范围内反射一样很小，所以在该范围内几乎不影响底涂层的颜色。红色或红紫色填料颜色对红色底涂层具有更强的影响并且改变整体颜色印象。

the geometries far from the radiance. Overall however, the deviations are less than with the red mixtures (**Figure 11**).

Summary

The colour of an undercoat – for example of a filler – has a decisive influence on the overall colour impression when the paint layer over it is transparent. This type of paint system is often found in automotive applications. There, base coats are used on grey or coloured fillers.

The overall colour impression then depends on the choice of colour and also on the choice of grey tone. If the colour of the filler does not correspond exactly to the colour of the base paint, the colour changes.

A filler can only reflect light rays in accordance with its pigmentation. Applying a red base coat on a green filler at first seems absurd. But as the green filler reflects equally little in the red spectral range, it barely affects the colour of the base coat in this range. Red or red-violet filler colours have a stronger influence on the red base coat and shift the overall colour impression.