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MEASURING EFFECTS

Analysing effect pigments and sheen: a complex process. By Werner Rudolf Cramer.

Effect pigments and the resulting effects are still hard to measure. Influence factors like hardeners or gloss levels of clear coat on effect pigments are discussed and and results in gloss and chroma are presented.

Interest in matt-painted cars ebbs and flows like the tide. For cars matt paintwork is often sold as a design innovation that attracts little purchase interest – with correspondingly minuscule sales figures. Low 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 mystery too. Vehicles painted matt are still 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 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 repair systems are the products of choice for this work with different matt levels. We devised two test series that demonstrate how hardeners and thinners affect the degree of matt and measure the effect of matt coat on the base coat. Base coats were created with the tinting mixes of the corresponding paint manufacturers in both series. They were applied onto grey-filled panels as specified by the paint manufacturer and initially sealed with normal (glossy) 2K clear coat, to avoid influences from the covering matt coat on the base coat matrix. The aim of these investigations was to record the influence of the matt clear coat on the effect caused by the pigments.

DEVICES AND STANDARDS

Devices used for measuring colour and gloss were: "Byk-mac I", "X-Rite MA98" and "KonicaMinolta CM-512". These portable devices are designed for measuring effect pigments and effect-pigmented paints, but only offer limited opportunities for describing interference pigments optimally. The "Byk-mac I" illuminates at an angle of 45° and measures at -15°, 15°, 25°, 45°, 75° and 110° from the gloss angle. The "X-Rite MA98" has additional illumination at 15° and the corresponding angles from the gloss (aspecular), as described in the E2539 standard test practice of ASTM. The choice of geometries during designing the devices was more or less arbitrary, and therefore the measurement conditions for inference pigments only partially satisfactory.

The "KonicaMinolta CM-512" exhibits three circular illuminations at 25°, 45° and 75° angles. This measurement type has the advantage over directional methods as it can also be used for structured surfaces. Effect pigments can only be described to a limited extent with these geometries. KonicaMinolta now offers a new model with the same geometries as the devices described. Colour measurements were also carried out with devices exhibiting spherical geometries and a directional geometry. The results show differences between these two types of geometry.

RESULTS AT A GLANCE

➞ Results show clear differences between spherical and directional geometries.

➞ Varying hardener and thinner affects gloss only with directional geometry 45°/0° (illumination/observation).

➞ Matt samples show angle-dependent behaviour when using a multi-angle instrument and measuring at 45° illumination.

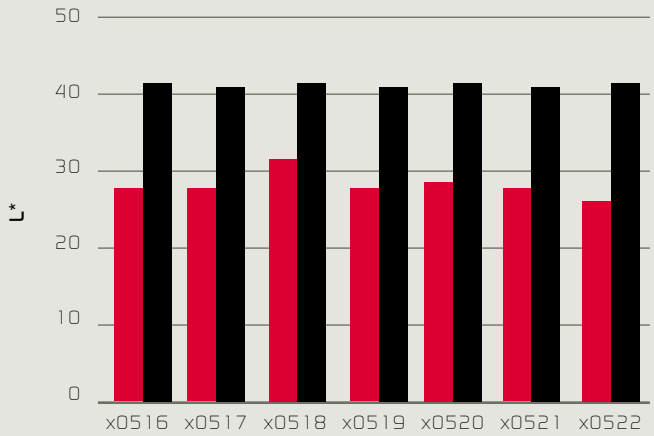
➞ In all matt samples examined, the chroma values increased from as-15° (aspecular) via as15° to as25° and then decreased.

➞ Chroma close to the gloss also decreased in base coats with interference pigments.

Figure 1: Table of Standox panels.

Panel	Matt coat	Clearcoat	Hardener (4:1)	Thinner
x0516	70 p.	30 p.	30 - 40	Long
x0517	75 p.	25 p.	30 - 40	Long
x0518	80 p.	20 p.	30 - 40	Long
x0519	75 p.	25 p.	30 - 40	Express
x0520	75 p.	25 p.	10 - 20	Long
x0521	75 p.	25 p.	10 - 20	Express
x0522	100 p.	100 p.	30 - 40	Long

Figure 2: Measurements of the sphere instrument show nearly no differences in lightness of these matt panels. Differences are obvious with 45°/0°.



Gloss measurements were conducted with devices made by Rhopoint and TQC at 20°, 60° and 85°, as well as the above devices with spherical and 45°/0° (illumination/observation) geometry at 60°. We determined that the results were comparable and consistent among the devices. A detailed comparison of the measuring instruments was not necessary.

TESTS WITH HARDENER AND THINNER

The matt clear coat, as well as a current gloss clear coat, were selected from the Axalta Coating System "Standox" paint programme, The two clear coats were used in different matt/glossy mixing ratios: 70:30, 75:25 and 80:20. A so-called short and normal hardener and a short (Express) and long thinner were also selected from the Standox programme. These mixtures were compared to a glossy 2K clear coat, which was provided with a normal hardener and a long thinner. All clear coats were applied to panels with the same waterborne base coat using pneumatic spraying. A paint formulation similar to a blue OEM colour was chosen as base coat (*Fig. 1)*.
Measurements with spherical geometry gave almost identical values for brightness on the high matt coatings. It increased on the other hand with directional geometry. (*Figure 2*) Varying hardeners and thinners only had a slight effect on brightness with directional geometry 45°/0°. But it influences gloss: the short hardener reduces gloss (sample x0520 in comparison to sample x0517), while the short thinner increases gloss (sample x0519 and x0521 in comparison to sample x0517). (*Figure 3)*.

GLOSS MEASUREMENT

It is normal to determine 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 70 GU the 20° and below 10 GU the 85° measuring angle. With the blue sample panels, the results of the gloss measurements at 60° and 85° clearly reflect the above statements concerning gloss level.
When using a multi-angle instrument and measuring at 45° illumination with the specified gloss angles, the matt samples showed angle-dependent behaviour. Higher brightness was obtained close to the gloss angle, so matt samples appeared white and had higher reflection than the glossy reference. In all examined matt samples, the chroma values increased from as-15° (aspecular) via as15° to as25° and then decreased again. The glossy sample typically showed the highest chroma value at an aspecular angle of -15°, i.e. close to the gloss angle.

DIFFUSE REFLEXTIONS INTERFERE

The chroma values decreased in the glossy samples if measuring far from the gloss angle. Matt samples appeared 'milky and white', i.e. their brightness was similar to white, and their chroma was correspondingly low. This effect is caused by diffuse reflections in the matt clear coat (*Figure 4*).
Corresponding behaviour is reflected in the a*b* diagram: effect pigments exhibited a unique progression of the aspecular line (connecting line of the a*b* values of the geometries of the gloss) if the base coat was sealed with a glossy clear coat. Colourful interference pigments turned this 'arm' anticlockwise. This was due to the shift in the reflection maxima to shorter wavelengths if the interference pigment was illuminated more flatly. White interference pigments and alu-

minium pigments did not exhibit this 'turning'. The aspecular line here continued straight from 45°/as25° via 45°/as15° to 45°/as-15°. In the matt samples, the 'arm' turned from 45°/as15° to 45°/as-15° clockwise towards the achromatic point with the blue values. This inverse behaviour originated in the scatter in the matt clear coat, where the above 'arm' turned towards the white. This also lead to a shift of the reflection maxima by increasing the low reflection areas of the spectrum.

TESTS WITH DIFFERENT DEGREES OF MATT

PPG offered a system for a second set of tests. There are two differently matt (semi-gloss and full matt) as well as a glossy clear coat. A fitting water borne base coat was also available and could be outfitted with differetn effect pigments, similar to the PPG Nexa system. "Kuncai XillaMaya Stellar Green" and "XillaMaya Galaxy Blue" and a medium-sized Silverdollar pigment were selected. They were at about 2% in the mixtures. The first two pigments represented new interference pigments whose flakes are coated with titanium dioxide. They exhibit typical colour shifts in relation to incident light.

Application was again on dark gray filled test panels with a manufacutere specified spray gun and method. All panels received the glossy clear coat to rule out any intererence of the matt coat with the base coat layer. One of those was the reference panel to understand the interference effect of the pigments when coated with differently matted systems.

The supplied two matt clear coats are very compatible and can be mixed with one another. 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 intermediate levels can also be created between these two clear coats 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 for the matt clear coat was carried out with the utmost care, as preliminary tests had showed that the matt degree depended on the application conditions. Therefore, painting took place within a short time period. The ventilation and drying times were also oriented to the paint manufacturer's specifications *(Figure 5)*.

DEPENDENCE ON GEOMETRY

When illuminating at a constant angle and measuring at various angles from the gloss angle, the interference colour was only recorded to a limited extent. These angles were sufficient to attain results in these tests. As for the samples described previously, there were no differences among the samples for the spherical geometry. However, when measuring directionally with the geometry 45°/0°, the brightness of the sample with the highest matt property decreased compared to the other sample and to the glossy sample.

The gloss measurements were not surprising: for three gloss geometries 20°, 60° and 85°, the gloss values increased as the matt level decreased. The results at 60° angle appeared most plausible, because in the 85° angle the gloss and the silk gloss panel had almost identical numbers. And they were too far apart when measuring with 20° angle (*Figure 6)*.

When comparing brightness in relation to gloss angle, the measured values close to the gloss for the matt samples were significantly higher than for the glossy reference. The reflection curves also explained this: the low reflection spectral ranges were compensated and thus giving the whitish effect of the matt clear coat (*Figure 7)*.

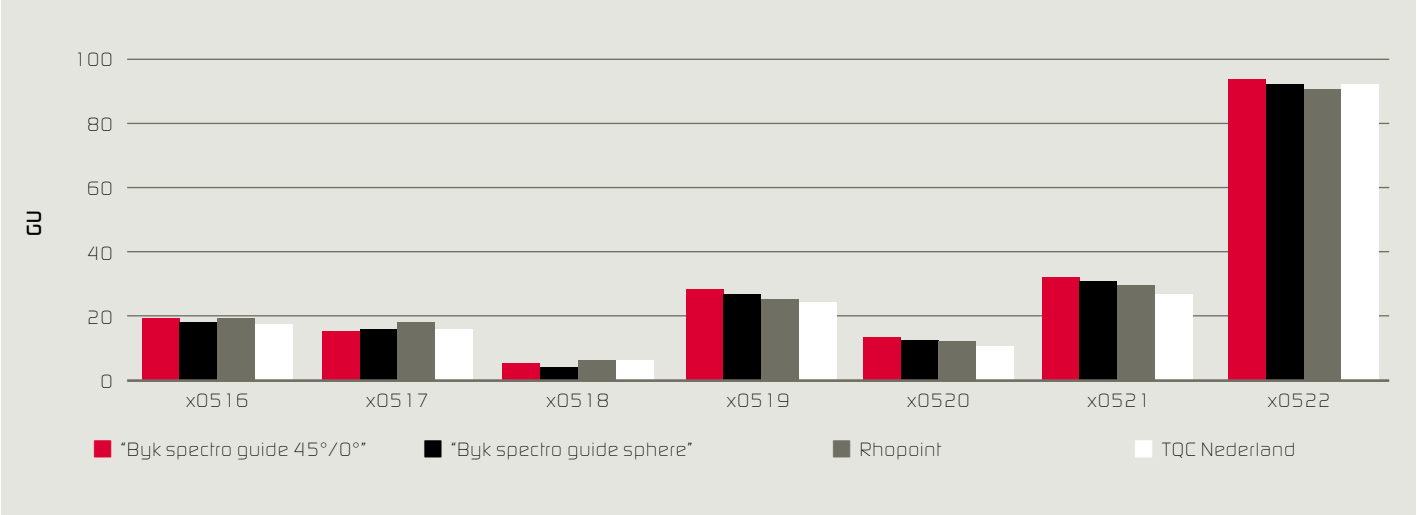
For chroma, values from the geometries close to the gloss increased to 25° from the gloss and then decreased to angles far from the gloss. The 'whitening' close to the gloss angle caused the chroma to decrease. Farther away from the gloss angle, with less compensation for the low reflection spectral ranges, the samples appeared more 'colourful'.

Although the extended 'arm' of the aspecular measurement values bent from 45°/as25° via 45°/as15° to 45°/as-15° anticlockwise among the interference pigments, clear 'twisting' was also apparent with these lines clockwise to the achromatic point. Owing to the 'whitening' close to the gloss – greater here than with angles far from the gloss – the colour of the base coat changed. The corresponding behaviour occurred among the blue base coat samples for chroma and gloss values. They contained a mixture of blue-coloured pigments with "Kuncai XillaMaya Galaxy Blue". The procedure and application matched those for the green effect pigment. Therefore, the basic statements can be applied to all colourful effect pigments. The special behaviour of effect pigments in conjugation with matt clear coats is not due to the colour shift, but can be attributed to the reflections within the matt coating. A colour shift to the shorter wave spectrum also occurred when the sample was illuminated more flatly, but this reaction is much less noticeable visually.

FOCUS ON ALUMNIUM PIGMENTS

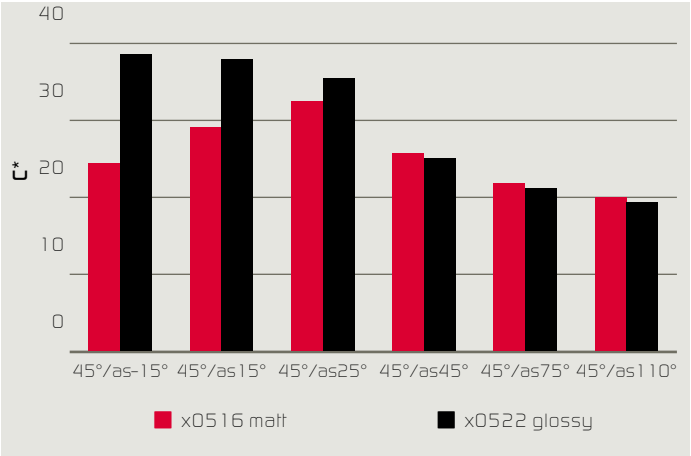
The third test series showed that the statements can be applied to different colour systems. In this series, the blue interference pigment

Figure 3: Hardener and thinner influence the degree of gloss (GU): The short hardener reduces the gloss (sample x0520 in comparison to sample x0517).



was replaced with a Silverdollar aluminium pigment of medium size. Aluminium pigments do not exhibit any colour shift in different angles. The emphasis here was on the change in brightness if the pigment was measured at different angles from the gloss at fixed illumination. High brightness numbers were found in the matt samples compared to glossy ones when measured in angles close to the gloss angle. The same effect on chroma was also repeated among the samples with the aluminium pigment. Chroma is lower with matt clear coats measured close to the gloss angle when compared to the glossy sample. When measured with a 45°/as25° geometry in angles far from the gloss angle, matt and glossy clear coats gave the same number - the farther way from the gloss angle the closer it gets. The behaviour in respect to the 'matt property' does not differ from that of the above tests with interference pigments.

Figure 4: Comparing chroma of the glossy and matt panels: Decreasing chroma of the glossy panel. Chroma of the matt panel increases to 45°/25°, but drops afterwards.



SUMMARY

The matt level can be easily set by combining various matt clear coats. This is the optimal solution for the repair of vehicles or matt painted

Figure 5: 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.

Panels	Basecoat	Clearcoat
x0595	Green + Stellar Green	glossy
x0596	Green + Stellar Green	FC01
x0597	Green + Stellar Green	FC02
x0598	Green + Stellar Green	FC03
x0599	Green + Stellar Green	FC04
x0600	Green + Stellar Green	FC05
x0601	Blue + Galaxy Blue	glossy
x0602	Blue + Galaxy Blue	FC01
x0603	Blue + Galaxy Blue	FC02
x0604	Blue + Galaxy Blue	FC03
x0605	Blue + Galaxy Blue	FC04
x0606	Blue + Galaxy Blue	FC05
x0607	Blue + Silverdollar	glossy
x0608	Blue + Silverdollar	FC01
x0609	Blue + Silverdollar	FC02
x0610	Blue + Silverdollar	FC03
x0611	Blue + Silverdollar	FC04
x0612	Blue + Silverdollar	FC05

Figure 6: The gloss measurements at 60° appear most plausible. In case of measuring geometry 85°, the results for the glossy and silk glossy samples are almost identical.

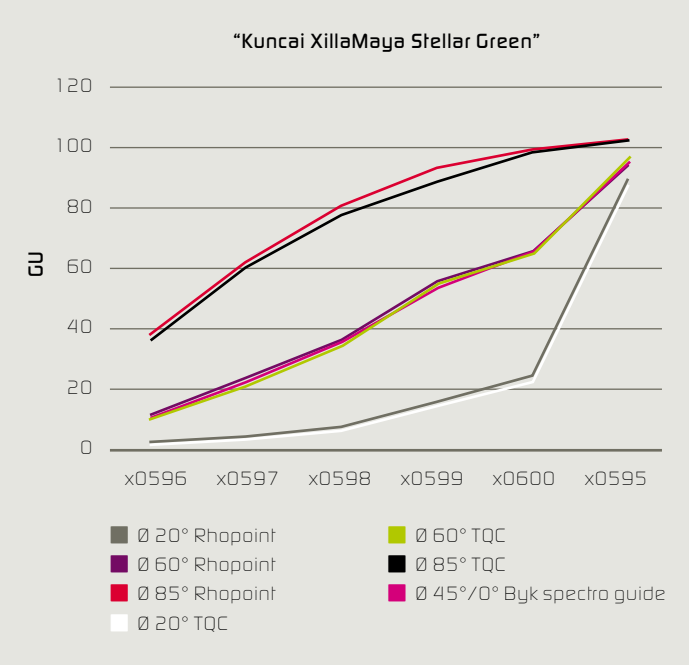
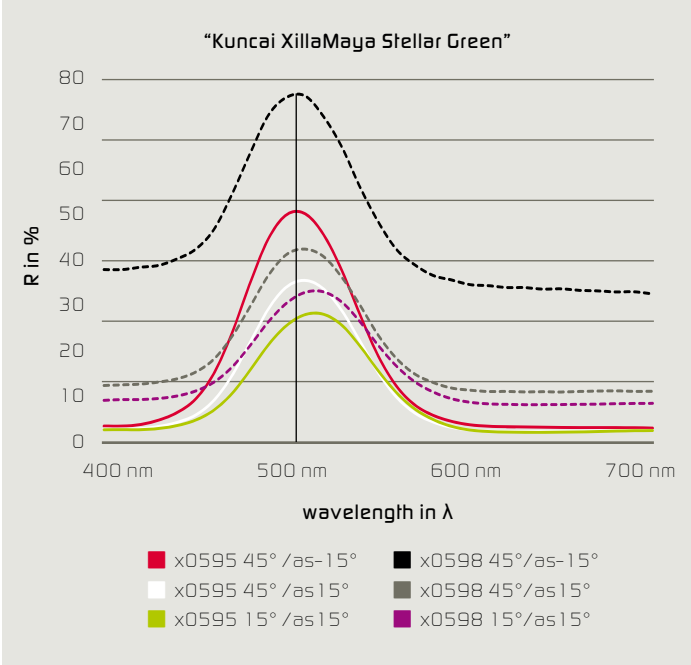


Figure 7: The low reflection spectral ranges of Stellar Green are increased by the matt clear coat. But still there is a colour shift to shorter wavelengths when illuminated flatter.



“Accept a compromise“

3 questions to Werner Rudolf Cramer

What are suitable measuring geometries for interference pigments? *Since the resulting colour of the interference depends on the angle of illumination, measurements close to the gloss angle at different illumination angles are optimal. However, the measuring devices have only one or two illuminations, so you have to accept a compromise.*

What must a paint shop pay attention to during repair? *The best way to improve an effect is the method of blending. Here, the base coat is sprayed running in the adjacent plarts. Since the eye does not recognise flowing transitions, a perfect repair is achieved in this way.*

With which visual technique is the interference best observed? *Hold a panel flat at about eye level and then move it parallel down. So only the observation angle is changed. The difference angle (aspecular) remains constant. If you would tilt the pattern sheet up and down, you change the illumination and observation angle simultaneously.*

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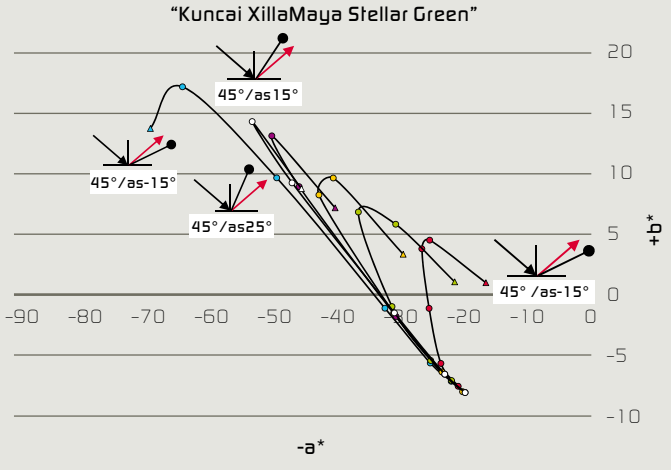
vehicle parts. However, systems with matt pastes are also available, which are added to adjust the desired matt level. The colour ‘whitens’ in all systems, this effect appears strongest close to the gloss angle.

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



panel	BC	CC
x0595	green	glossy
x0596	green	FC01
x0597	green	FC02
x0598	green	FC03
x0599	green	FC04
x0600	green	FC05

Low reflection spectral ranges are increased in their reflection here. The chroma decreases, while the brightness increases. Scatter effects within matt clear coat are the reason for this. In case of base coats with interference pigments, their optical properties – a shift in the reflection maxima to the short-wave spectrum – were retained if these were sealed with matt clear coat. The same also applied 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 decreased in base coats with interference pigments. It increased up to geometry 45°/as25° and then decreased again towards the angles far from the gloss.