Paint it cool!

Pigments for solar heat management in paints

BASF
The Chemical Company

Reflection instead of absorption keeps the coated surface cool

Of 100 % solar radiation,
50 % are absorbed at the earth's surface.

Absorption 25 % ≙
TSR (Total Solar Reflectance) 75 %

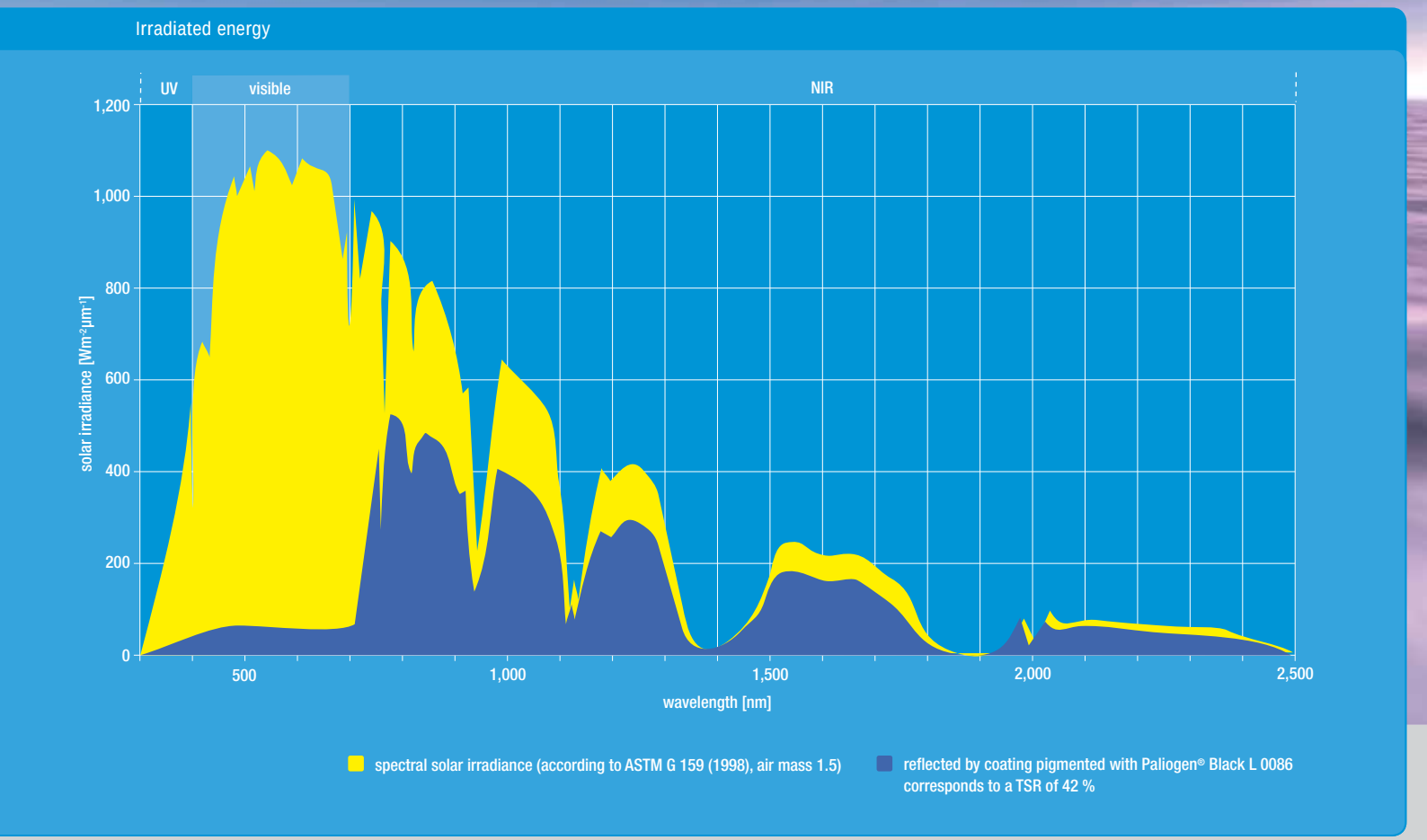
Rising energy costs, pronounced urban heat-island effect and global warming increase the need for intelligent solar heat management solutions like cool paints.
Roughly 50 % of solar radiation are absorbed at the earth's surface. Black surfaces usually absorb up to 90 % of this energy and therefore get hot. White surfaces, on the other hand, absorb only up to 25 % and tend to stay much cooler.

But white is not always an option, much more often color and especially dark shades are desired or even required. For cool paints, the starting point is always to look at the absorbing components in a formulation.
BASF offers a solution with Paliogen® Black L 0086 and Sicopal® Black K 0095 to formulate any dark shade with less absorption than the conventional black pigments.
A Sicopal® Black L 0095 grade is under development.

Absorption 90 % ≙
TSR (Total Solar Reflectance) 10 %

Cool pigments for cool paints

Paliogen® Black L 0086 / Sicopal® Black K 0095



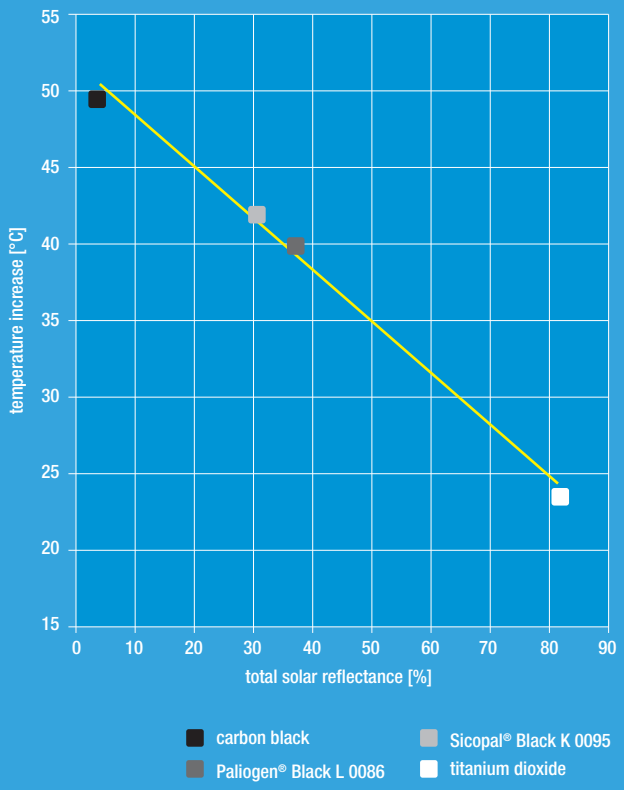
Total Solar Reflectance (TSR) is the percentage of irradiated energy that is reflected by an object. If this is coated with a film based on Paliogen® Black L 0086, the TSR is 42 %.

Usually an object like a roof, a facade or the interior of a car, needs to have a certain color and therefore the pigment choice for the visible wavelength range is not free. To ensure the right color for the cool paint, the pigment or pigment combination with the right NIR properties has to be chosen. BASF can predict the most suitable pigmentation for any given color and substrate to create coolness.

The sun emits energy from 300 to 2,500 nm

This wavelength range can be divided into three ranges:	
ultraviolet (UV)	300 - 400 nm
visible (VIS)	400 - 700 nm
near infrared (NIR)	700 - 2,500 nm
which contribute to the total irradiated energy like:	
ultraviolet (UV)	3 %
visible (VIS)	39 %
near infrared (NIR)	58 %

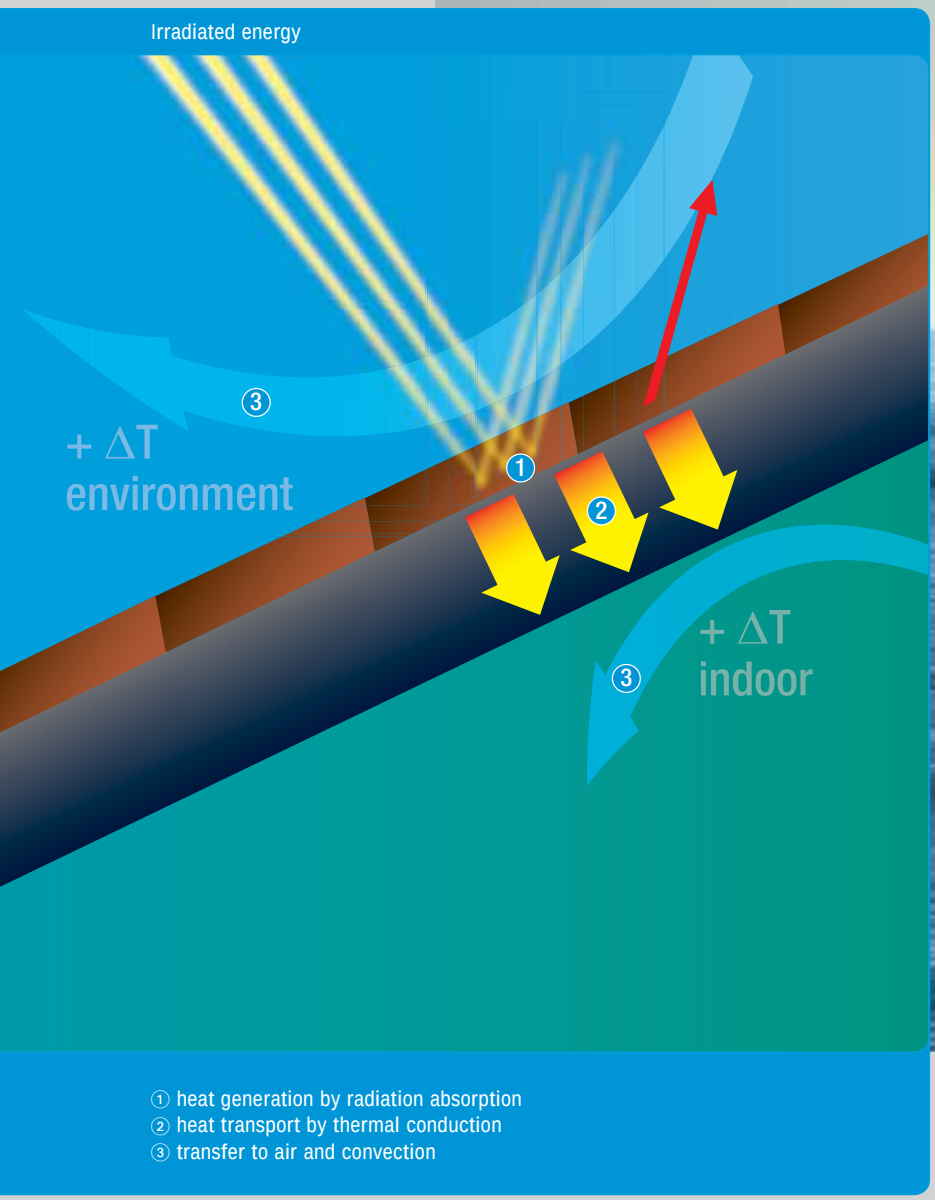
Experimental correlation between TRS value and heat build-up



The assessment of suitable pigmentations is based on Total Solar Reflectance (TSR). The above graph shows the correlation between TSR and the temperature increase of titanium dioxide, carbon black and alternative black pigments suitable for cool paints. Carbon black shows the highest temperature increase and lowest TSR value, the alternatives offer both reduced temperature increase and higher TSR. Titanium dioxide gives the lowest temperature increase and the highest TSR. This clearly shows the relationship between Total Solar Reflectance and heat build-up.

Cool pigments for cool surfaces

Paliogen® Black L 0086 / Sicopal® Black K 0095



① heat generation by radiation absorption
② heat transport by thermal conduction
③ transfer to air and convection

The energy radiated by the sun hits the colored surface. When the radiation is absorbed, this generates heat, which is then transported by thermal conduction into the material and by convection into the surrounding air. Less absorption automatically means less heat build-up.

The reflection from the color-coated surface contributes to lower temperatures in the coating and also lower temperature strain in coating layers and for the substrates. This results in longer lifetime of the coated material.

Shade examples

RAL 5013 cobalt blue

Standard formulation		Optimized formulation	
12.8 parts	Lamp black 101	11.8 parts	Paliogen® Black L 0086
36.2 parts	Heliogen® Blue L 6700 F	33.3 parts	Heliogen® Blue L 6700 F
6.0 parts	Hostaperm®1 Violet RL	8.8 parts	Hostaperm®1 Violet RL
45.0 parts	Kronos®2 2310	46.1 parts	Kronos®2 2310
7 %	TSR (on white substrate)	33.8 %	TSR (on white substrate)
7 %	TSR (on black substrate)	19.6 %	TSR (on black substrate)
40 µm	film thickness		
20 %	pigment weight concentration		

RAL 8017 chocolate brown

Standard formulation		Optimized formulation	
29.3 parts	Lamp black 101	76.9 parts	Sicopal® Black K 0095
20.0 parts	Sicotan® Yellow L 1910	10.1 parts	Sicotan® Yellow L 1910
46.7 parts	Bayferrox®3 Red 130	12.3 parts	Bayferrox®3 Red 130
4.0 parts	Kronos®2 2310	0.7 parts	Kronos®2 2310
6.4 %	TSR (on white substrate)	30.7 %	TSR (on white substrate)
6.4 %	TSR (on black substrate)	24.7 %	TSR (on black substrate)
40 µm	film thickness		
20 %	pigment weight concentration		

RAL 9005 jet black

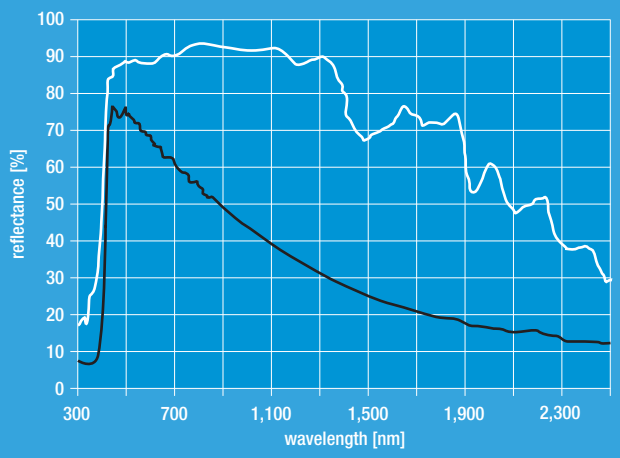
Standard formulation		Optimized formulation	
60.7 parts	Carbon Black FW 200	22.8 parts	Paliogen® Black L 0086
39.3 parts	Bayferrox®3 Yellow 3920	8.5 parts	Heliogen® Green L 8735
		50.0 parts	Sicopal® Black K 0095
		18.7 parts	Hostaperm®1 Violet RL
4.1 %	TSR (on white substrate)	28.4 %	TSR (on white substrate)
4.1 %	TSR (on black substrate)	18.7 %	TSR (on black substrate)
40 µm	film thickness		
20 %	pigment weight concentration		

The shade examples show the impact of the black pigment used to formulate the respective shade. Of course it is not only applicable to blue, brown and black shades, but BASF offers the service to predict the TSR for any given pigment combination over a given substrate with defined film thickness and pigment content.

Cool pigments for cool applications

Paliogen® Black L 0086 / Sicopal® Black K 0095

P.W. 6 titanium dioxide – reflectance curves and TSR values

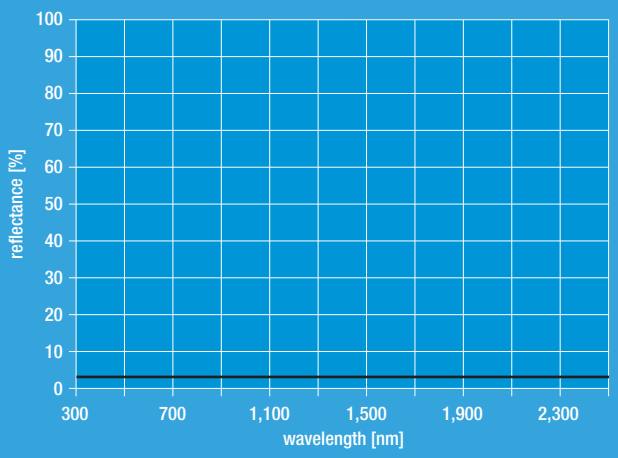


P.W. 6 titanium dioxide on white substrate

P.W. 6 titanium dioxide on black substrate

- TSR over white: 84.8 %
- TSR over black: 50.6 %
- calculated with BASF software „CoolSim“
  - 10 % PWC
  - 40 µm dry film thickness
  - substrate: LENETA opacity chart FORM 2A black and white

P.Bk. 7 lamp black 101 – reflectance curves and TSR values



P.Bk. 7 lamp black 101 on white substrate

P.Bk. 7 lamp black 101 on black substrate

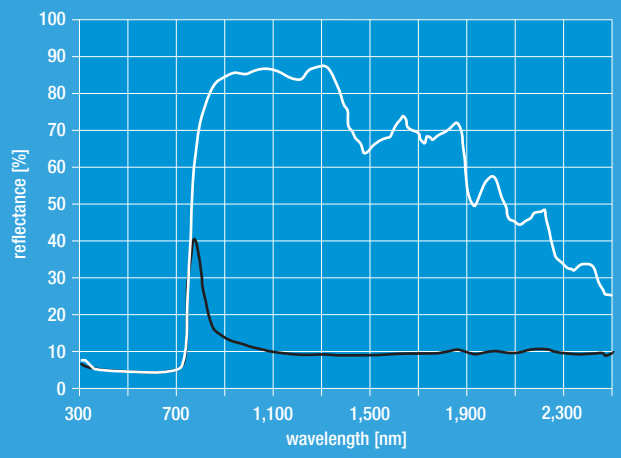
- TSR over white: 4.0 %
- TSR over black: 4.0 %
- calculated with BASF software „CoolSim“
  - 10 % PWC
  - 40 µm dry film thickness
  - substrate: LENETA opacity chart FORM 2A black and white

The first graph shows the reflectance curves of a coating pigmented with titanium dioxide over a white-and-black substrate. There is only little difference between the two curves, which indicates the good hiding and reflectance properties of titanium dioxide.

The second graph shows the respective reflectance curves of carbon black, which is the standard black for most applications. There is no significant influence of the substrate.

The coating pigmented with carbon black absorbs the energy irradiated by the sun throughout the whole spectral range.

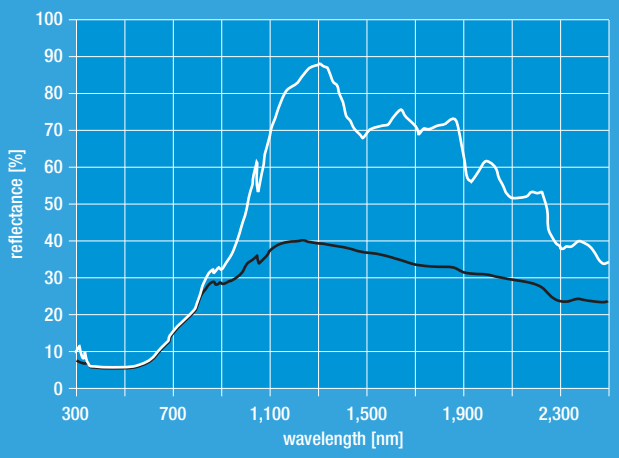
Paliogen® Black L 0086 – reflectance curves and TSR values



- Paliogen® Black L 0086 on white substrate
- Paliogen® Black L 0086 on black substrate

- TSR over white: 42.0 %
- TSR over black: 10.4 %
- calculated with BASF Software „CoolSim“
  - 10 % PWC
  - 40 µm dry film thickness
  - substrate: LENETA opacity chart FORM 2A black and white

Sicopal® Black K 0095 – reflectance curves and TSR values



- Sicopal® Black K 0095 on white substrate
- Sicopal® Black K 0095 on black substrate

- TSR over white: 30.9 %
- TSR over black: 20.3 %
- calculated with BASF software „CoolSim“
  - 10 % PWC
  - 40 µm dry film thickness
  - substrate: LENETA opacity chart FORM 2A black and white

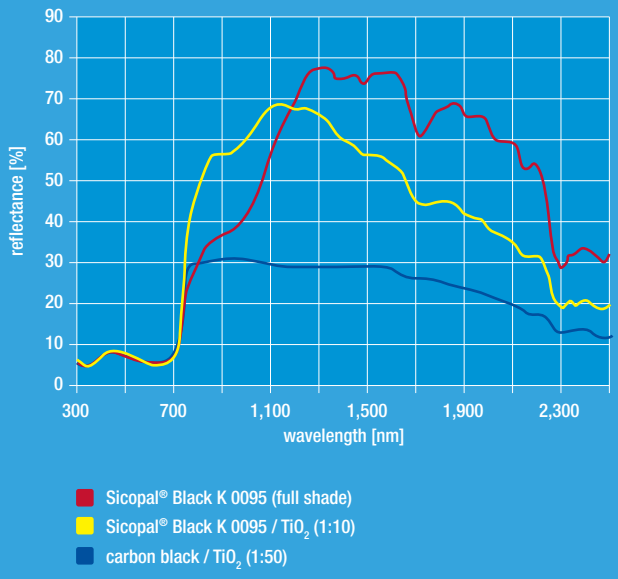
The graph shows the performance of Paliogen® Black L 0086, an organic black pigment, which shows hiding in the visible (VIS) range. For the near-infrared range, the substrate impacts the reflectance performance. Paliogen® Black L 0086 is suitable for cool paints on reflective substrates or in combination with reflective pigments. For black shades it yields up to 42 % Total Solar Reflectance (TSR).

The second alternative offered by BASF is Sicopal® Black K 0095, an inorganic pigment. The reflectance curves clearly show that it is a near-infrared-reflective pigment and is therefore partially hiding in the NIR-range. The TSR yield for black shades is up to 30 %.

Cool pigments for cool compositions

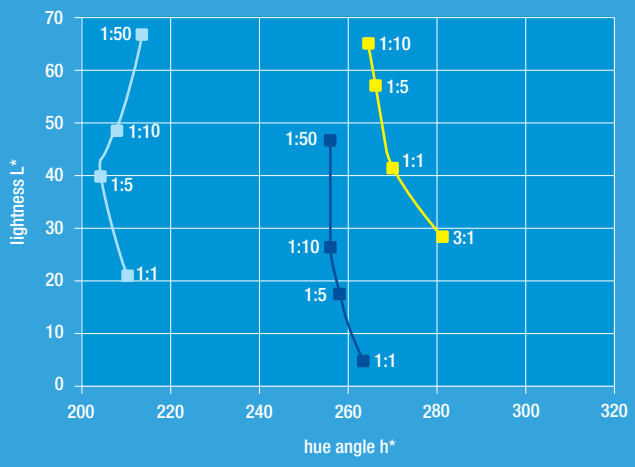
Paliogen® Black L 0086 / Sicopal® Black K 0095

Influence of pigment composition in primer on TSR values
Top coat based on Paliogen® Black L 0086



- Sicopal® Black K 0095 in full shade; TSR: 29.5 %
- Sicopal® Black K 0095 / TiO_2 (1:10); TSR: 32.4 %
- Carbon black / TiO_2 (1:50); TSR: 18.3%
- top coat contains Paliogen® Black L 0086.

Cool “black” pigments in alkyd melamine paint and coloristical characteristic in white reduction



Normally paint films are applied as top coats to a thickness, where a good visible hiding (e.g., of a black and white contrast) is obtained. Often, there is still a transparency in the infra red range. For best cut of heat build-up this needs to be compensated by:

- higher pigment concentration in the top coat
  - not always possible from the technological point of view
- higher film build in the top coat
  - risk of delamination and others
- special pigmentation in the lower paint layer(s) or in the plastic substrate
  - replace IR-absorbing components by IR-reflecting or IR-transparent pigments

The coloristical profile of cool pigments

Pigments with good IR-transparency or IR-reflecting properties show a different coloristical profile, compared to P.Bk. 7. To obtain a neutral gray shade, the greenish Paliogen® Black L 0086 can be mixed with Sicopal® Black K 0095 (ratio: ~ 7:1). Please note the differences in tinting strength as shown in the graph.

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