

# DYNAMIX<sup>®</sup>

DRY DISPERSION TECHNOLOGY

**Blue 30C591**

CI Pigment Blue 28

**Blue 30C588**

CI Pigment Blue 28

**Blue 30C527**

CI Pigment Blue 36

**Yellow 30C236**

CI Pigment Brown 24

**Green 30C678**

CI Pigment Green 26

**Yellow 30C119**

CI Pigment Yellow 53

**Green 30C612**

CI Pigment Green 50

**Black 30C940**

CI Pigment Green 17

**Black 30C933**

CI Pigment Black 26

**Black 30C965**

CI Pigment Black 28

**Shepherd**

The Shepherd Color Company  
We Brighten Lives

2-08 1016

[www.shepherdcolor.com](http://www.shepherdcolor.com)



## Formulating Guide

### General Description

This innovative new Dynamix® “stir-in” pigment technology developed by Shepherd Color is specifically designed to be used in almost all types of coatings applications. They are as equally applicable to the various different segments of the Building & Construction market, such as Metal Roofing and Siding, Window and Door extrusion, Architectural wall cladding and facades, to diverse Industrial segments such as Appliances, Traffic and Protective coatings to high performance Automotive and even Architectural Decorative systems.

Dynamix® is also referred as a dry dispersion technology because it is the closest one that can arrive to the ease of incorporation of a liquid colorant, whilst still being a dry powder and 100% pure color.

### Formulating Approach

The principles of pigment dispersion are to separate the pigment particles that have agglomerated and aggregated during the various stages of finishing, packing, storage and transport using one or more high energy dispersion processes. Once dispersed, the particles are then required to be stabilized using binders and/or additives to prevent re-agglomeration or re-aggregation.

### Components

Dispersion in solventborne systems generally requires a resin and solvent. A typical starting point formulation might look like:-

Dynamix®	60
Resin	25
Solvent	<u>15</u>
	100

This assumes typical resin solids of 60%, achieving a pigment to resin solids ratio of 4:1.

A dispersing agent is not necessary to achieve complete dispersion. It might be required to enhance or reinforce the compatibility between a dispersion of Dynamix® and other pigments. Many additives typically used in the coatings industry that are designed for use with inorganic pigments, including those designed for titanium dioxide (TiO<sub>2</sub>) can be used.



The minimum level recommended by the supplier should be chosen. Dynamix® pigments typically have a low surface area and are lower than their corresponding dry pigment type homologues.

Other additives such as anti-settling agents may be required to prevent hard-settling of the high density inorganic pigments.

Dispersion in waterborne systems may or may not contain a resin. Where the system does not contain a resin, the use of a surfactant or dispersing agent must be used.

A typical formulation might look like: -

Dynamix®	60
Dispersing Agent	12
Water	<u>28</u>
	100

The choice of dispersing agent will depend upon the nature of the pigment and the interaction with the resin and final coating properties. The levels will also depend upon the type of dispersant. Manufacturer’s recommendations should be followed. As with solventborne dispersions, dispersing agents that are typically used for titanium dioxide (TiO<sub>2</sub>) can be used for Dynamix®. The recommended levels can be similar but should be adjusted for optimum performance, both in dispersion and in the final coating.

Other additives such as defoamers and anti-settling agents may be required to obtain the optimum properties from the dispersion.

### Order of Addition

In most cases, the liquid portion of the dispersion should be prepared first. The pigment should then be added to the liquid portion during stirring or mixing.



### Dispersion process

Dynamix® pigments can be dispersed under a variety of shear conditions.

Using a typical high speed dispersion (HSD) impeller or disc process where tip speeds in excess of 2000 ft/min (10 m/s) are common, full dispersion can be achieved within 5-10 minutes. Full dispersion is typically measured using grind gauges. A dispersion level of <5 microns (7.5 Hegman) is generally achieved under these conditions.

Where lower shear mixing is being used, more time may be required to achieve complete dispersion.

Typical times are:

HSD	5 – 15 minutes
Shaker	5 – 20 minutes
Paddle mixer	45 – 90 minutes

Dispersion of Dynamix® under high shear conditions is usually faster than that of titanium dioxide (TiO<sub>2</sub>).

Dispersing Dynamix® for longer periods of time will reduce the number of “specks” or “oversized” particles. In many cases, an additional 5-15 minutes may be sufficient to ensure that the number of “specks” is reduced to a minimum.

When dispersing high concentrations of Dynamix®, there is a possibility of a reduction in viscosity relative to normal pigments. This could be beneficial to the complete system or higher pigment loadings may be achieved for the same final viscosity.

### Compatibility

Dynamix® has been found to be compatible with a wide range of resins and coatings systems.

- Solventborne
- Waterborne
- High solids
- Low solids
- 100% solids (UV cure)

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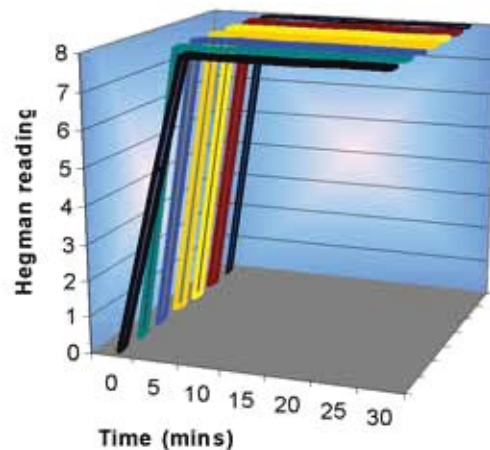
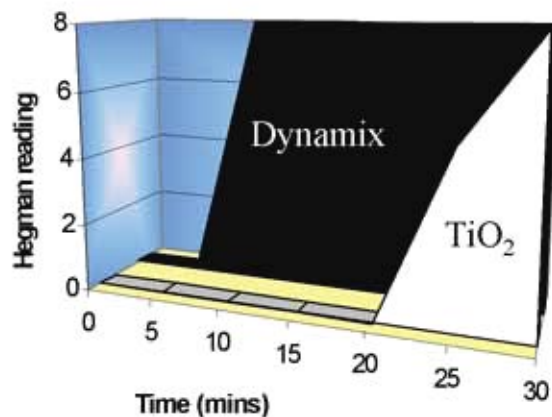
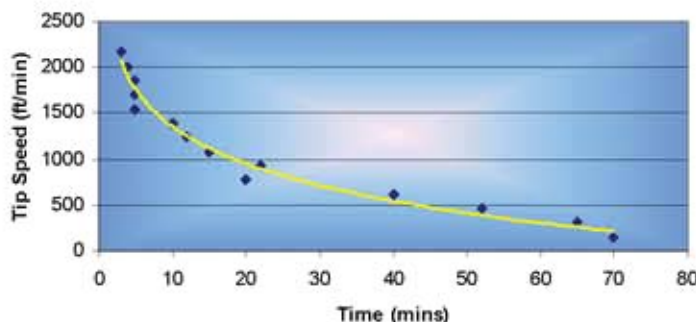
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Time to achieve dispersion



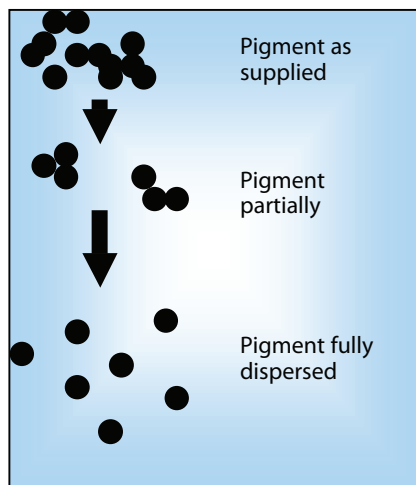
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# Novel, Easy-Dispersing Pigment Technology Breaks Conventional Barriers

**W**ith the exception of clearcoats, in the manufacture of many liquid coatings there is a colored pigment dispersion step. This step is necessary to bring the appropriate colored pigments to their full functional properties and to impart the desired color. Depending on the chemistry of the pigment and a few other factors, the dispersion step is one of the most critical steps in the whole paint-making process. It is a step that, if done well, provides the coating with its ideal properties. If not done well, the color will be different and other characteristics of the coating may also be impaired and less than desirable.



**Figure 1** | Pigment supply and dispersion illustration.



## Pigment Dispersion

Most pigments in their delivered form are composed of aggregates and agglomerates that form from the primary pigment particles during the process of drying, packing, storage and transportation (Figure 1). The extent to which these aggregates and agglomerates exist is variable from pigment to pigment. The pigment dispersion process only serves to de-aggregate and de-agglomerate the

pigment particles and enable them to be stabilized in some way to prevent recombination.

In most cases, the pigments should be dispersed to as close to their primary particle size as possible to gain the maximum effect of color, gloss and flow properties. In the event that aggregates or agglomerates still remain, there is still the potential for color development to occur upon paint application. Dispersing agents and other polymeric species are often added to facilitate the dispersion process and also serve to enrobe the pigments and prevent pigment particles from recombining.

The energy required to achieve this dispersed state is considerable and requires the use of high-energy equipment such as ball mills, bead mills, triple roll mills etc. This process is also subject to a great deal of variability due to many factors such

as residence time, temperature, flow rate, media charge, media size, millbase viscosity, batch size, equipment type, etc. This process can also take a considerable amount of time, ranging from many hours to days, depending on the dispersion equipment and the pigment in question.

### New Technology Advances

In the quest for a pigment technology that will not only bring out the maximum properties of the pigment, but also make the process of dispersion simple, quick and repeatable, many routes have been investigated, and various manufacturers have launched several to the market. Indeed, The Shepherd Color Company launched its first generation of surface-modified, easy-dispersing pigments back in 2002. These first-generation pigments worked extremely well. However, a couple of critical factors such as shelf life and multi-system compatibility led to the development of a new second-generation product, that today is known as Dynamix™.

By combining the effects of nanotechnology and creating a very thin surface modification of the pigment surface and a unique, well-controlled manufacturing process, the consequent products have outstanding characteristics that not only exceed initial expectations of dispersion capabilities but also provide compatibility across many paint systems, including both solventborne and waterborne.

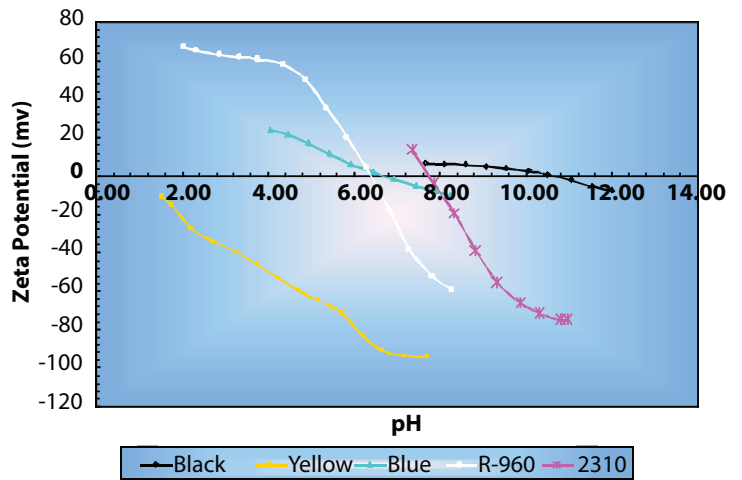
By looking at the Zeta potentials of the untreated pigments (Figure 2) and comparing them to the surface-modified ones (Figure 3) in aqueous environments, a dramatic change is noted. Comparing two titanium dioxide grades as reference pigments with typically good and excellent dispersion characteristics, it can be seen that the Dynamix pigments show similar characteristics and behavior.

### Dispersion Characteristics

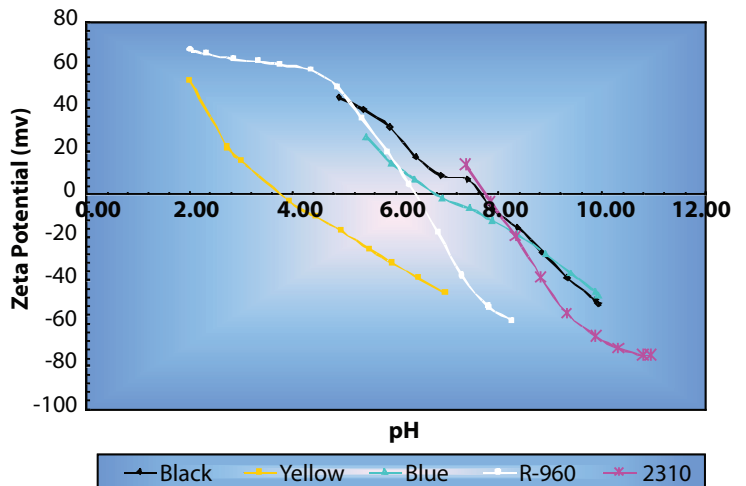
As can be seen in Figure 4, the dispersion characteristics of the Dynamix Yellow 30C236, a chrome titanate C.I. Pigment Brown 24 composition, are compared to those of Kronos 2310 TiO<sub>2</sub> (Kronos Inc.). This particular titanium dioxide pigment has been found to have wide compatibility with many coatings systems and be relatively easily dispersible.

Using a Cowles-type high-speed dispersing setup, a high-molecular-weight solventborne acrylic resin and a pigment concentration of over 50%, the dispersion time (as measured with a Hegman gauge) can be as low as 10 minutes for complete dispersion. Under the same conditions, the titanium dioxide just about achieves the same level of dispersion around 30 minutes. Using a lower energy input, the DynamixYellow

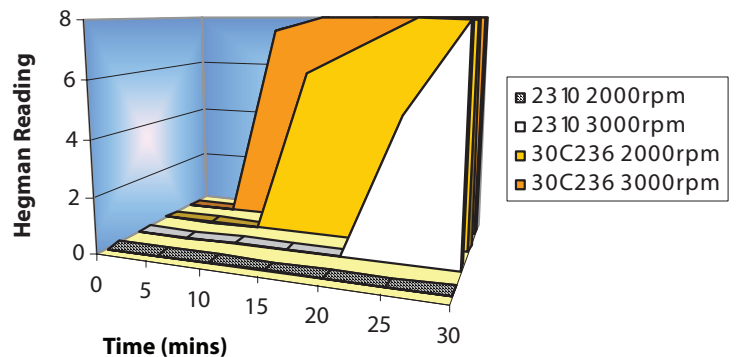
**Figure 2** | Zeta potential of untreated pigments in an aqueous environment.



**Figure 3** | Zeta potential of surface-modified treated pigments in an aqueous environment.



**Figure 4** | Pigment dispersion characteristics.



**Figure 5** | Ease of dispersion of Dynamix pigments.



can still achieve dispersion in less than 30 minutes, whereas the titanium dioxide has not even begun to show any tendency to disperse at all.

Visually, the impact of the ease of dispersion for the Dynamix pigments is even more striking. The images in Figure 5 were generated using Dynamix Blue 30C588, a cobalt aluminate C.I. Pigment Blue 28 composition and titanium dioxide, also using a high-molecular-weight solventborne acrylic resin with a pigment concentration of over 50%; all measurements were made with the same Hegman gauge.

This new advanced technology surface treatment is remarkably efficient and provides complete

dispersion characteristics, even under relatively low shear conditions.

In Figure 6, the relative amount of time required for complete dispersion as a function of the tip speed of the stirring blade is shown. Using a high-speed dispersion system, the time can be reduced to as little as 5 minutes. Using lower speed paddle mixers, this time is extended to a little over one hour.

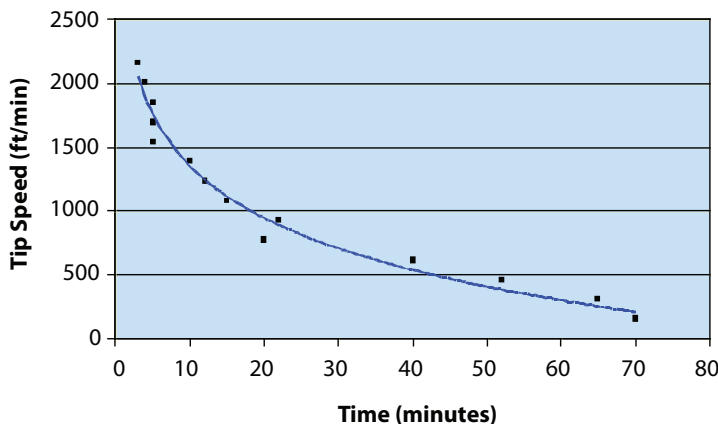
The Dynamix pigments show excellent dispersion behavior in solvents and in aqueous systems. In fact, using very simple formulas, dispersion in solventborne systems can be achieved without the additional use of dispersing agents. However, depending on the particular coating system being used, the appropriate choice of a dispersing agent will improve the compatibility of the dispersed pigment with other colored pigments in the final paint composition. In a similar fashion, in aqueous systems, the use of an appropriate surfactant will achieve similar compatibility. The choice of dispersing agent or surfactant will be wide and varied, but the coatings chemist can begin with one that is typically used for inorganic pigments and titanium dioxide.

One other feature of Dynamix pigments that is particularly interesting is that the surface area (and hence oil absorption characteristics) is lower than the corresponding pigment without the treatment. This fact, coupled with the easy dispersing nature of the surface, has a consequence on lowering the demand for the dispersing agent or surfactant significantly, sometimes by more than 50%.

**Table 1** | Dynamix compatibility.

Curing Type	Medium	Coating Type
Air -dried	Solventborne	Acrylic
Oven or heat cured	Waterborne	Polyester
Radiation cured	100% solids	Urethane
		Fluorocarbon
		Phthalate
		Acrylate
		Silicone
		Silicate
		Epoxy

**Figure 6** | Time to achieve dispersion.



### Paint Properties

During the development of each Dynamix pigment, the appropriate color characteristic is chosen. For example, the brilliant masstone of the cobalt blue pigments (C.I. Pigment Blue 28) can be maintained by choice or the tint strength can be maximized, e.g., chrome titanate pigments (C.I. Pigment Brown 24).

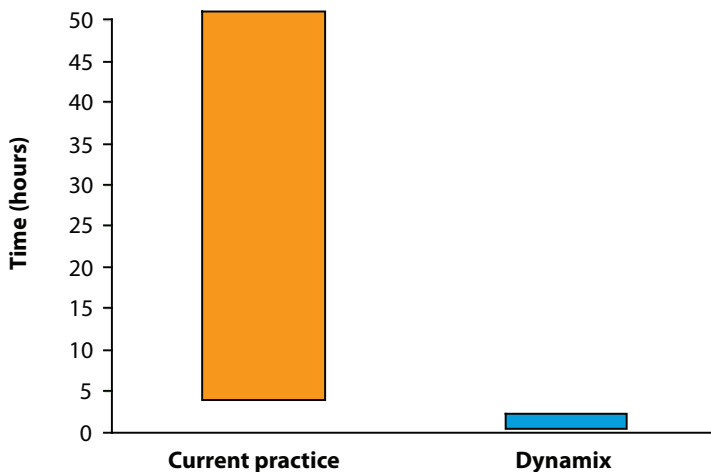
These features are controlled during the processing and then the surface modification fixes it in place.

By choosing to maximize tint strength, for example, considerable increases can be seen when compared to unmodified pigments dispersed using conventional means. Increases of between 25 and 50% are not uncommon, providing significant economies in pigment usage and enabling the coatings chemist to reduce his pigment demand in a formulation.

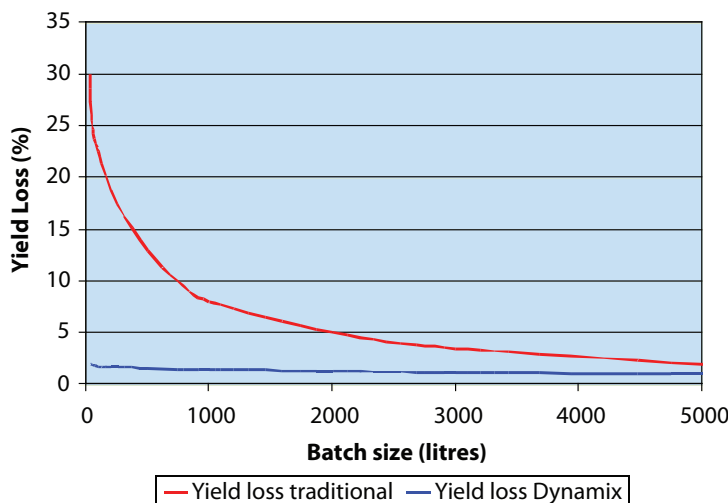
**Table 2** | Dynamix products in the marketplace.

Product	Chemistry	C.I. Classification
Dynamix Black 30C965	CuCr	CI Black 28
Dynamix Yellow 30C236	CrSbTi	CI Brown 24
Dynamix Blue 30C527	CoCrAl	CI Blue 36
Dynamix Blue 30C588	CoAl	CI Blue 28
Dynamix Blue 30C591	CoAl	CI Blue 28
Dynamix Yellow 30C119	NiSbTi	CI Yellow 53
Dynamix Black 30C940	FeCr	CI Green 17

**Figure 7** | Range of dispersion times.



**Figure 8** | Yield loss comparisons.



By achieving complete dispersion of the pigment, the color development is maximized in the sense of making the most of the coloristic properties of the pigment. No further energy will provide more. This means that the color stays constant and is repeatable time after time, leading to very consistent colored pigment dispersions.

Since the surface of the pigment has similar characteristics to titanium dioxide, similar dispersing agents can be used to stabilize both pigments. Under these conditions, no color development can be seen under typical application and shear testing conditions.

Having complete pigment dispersion through the use of Dynamix gives rise to paint films that show higher levels of gloss, display improved image clarity and can even show better paint flow properties. In some cases, pigment opacity is improved. In the case of cobalt blue pigments, an increase of over 25% in UV opacity has been achieved, a feature not insignificant in the world of thin film applications.

In certain paint systems, a lower viscosity has been achieved, leading to either better application characteristics or an increased pigment loading level. This is particularly advantageous for highly concentrated pigment bases and colorants.

Dynamix pigments have a wide range of compatibilities across many typical paint systems. Examples of such systems can be seen in Table 1.

### Operational Improvements

By eliminating the need for energy-intensive pigment dispersion steps, Dynamix pigment technology provides for significant cycle time savings. Reducing typical cycle times of 40 to 50 hours to as little as 2 to 3 hours can easily be achieved using Dynamix pigment technology (Figure 7). This is simply achieved by removing the lengthy bead mill or triple roll dispersion step of the process.

In addition to significantly reducing cycle times through the elimination of the traditional pigment dispersion techniques, yield losses of expensive pigments can also be reduced. Yield losses come from the clean down of dispersion equipment. Typically, the smaller the batch size, the greater the yield loss that can be expected. By exploiting the simple mixing dispersion capability of Dynamix pigment technology, these losses can be cut considerably (Figure 8).

In addition to these easily quantifiable operational advantages and savings, there will be other savings that could be seen throughout the production process, such as minimized clean-down operations, reduced quality control operations, improved first-run capabilities, etc.

**Potential Applications**

Dynamix pigments have been successfully trialed in a wide range and number of different applications. Typical examples are noted here.

Building and construction	Architectural
General industrial	Coil coating
Automotive	Liquid spray
ACE	Roller/curtain coating
High heat	Powder coating
Traffic paint	Inks
Maintenance coatings	UV curing

Whatever the application, pigment dispersion has never been easier than that provided by this novel technology.

**Pigment Range**

The surface modification works well in a number of different pigment chemistries. Seven products have been launched to the market initially (Table 2). More launches are planned in subsequent phases.

The Dynamix Black 30C940 is an Arctic® infrared reflective pigment. By controlling the masstone color, along



with the Total Solar Reflection, higher reflectances can be achieved than with typical pigment dispersion techniques. This is a significant advantage for the infrared reflecting pigments where the choice of pigment and the quality of the subsequent dispersion play a very large role in the final performance. Over- or under-dispersion leads to diminished reflectance properties. Using this new Dynamix technology, these worries and concerns can be eliminated.

**Conclusions**

By simply stirring in the new Dynamix pigments under relatively low to high shear conditions, complete pigment dispersion can be achieved in a matter of minutes. Significantly increased tint strengths, resistance to color, improved gloss and image clarity are some of the benefits to be achieved using this new technology.

In these days of careful cost control, consistent product quality and reduced manufacturing lead times, Dynamix represents a breakthrough in pigment technology, similar to that achieved by the use of predispersed colorants in the paint manufacturing process.

Manufacturing processes can be significantly simplified by the reduction of a process step and dispersion times are reduced from days to hours. No longer are the yield losses incurred with conventional dispersion techniques such as bead mills, and batch sizes are no longer controlled by the size of mills available.

Pigment dispersion can be made more frequently, in smaller batch sizes, to just-in-time requirements, and the color and strength will still remain the same. A small laboratory batch will yield the same color as the one out in production.

Finally, product development becomes a faster and more efficient process because the pigment dispersion, compatibility, stabilization becomes as easy as that needed to make a white. The time to make the colored versions and tint bases will just be a matter of simple mixing! ■

This paper was presented at the Nürnberg Congress held during the European Coatings Show, Nürnberg, Germany, May, 2007 and organized by the Vincentz Network. See [events@coatings.de](mailto:events@coatings.de).

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# PIGMENTS FOR COATINGS

Masstone	4:1 Tint	Shepherd Product	Pigment Color Index		Total Solar Reflectance	Oil Absorption	FDA Approved	CONEG	RoHS/WEEE Approved	EN 71.3	AP (89)1	French Positive List	Heat Stability	Light Fastness (1-8)	Mean Particle Size (microns)	Specific Gravity
		Black 430	CI Black 28 CuCr		6%	11	✓ <sup>1</sup>		✓	✓	✓		>800°C	8	1.2	5.4
		Black 20C920	CI Black 28 CuMnCr		5%	15	Not available in Europe.						>800°C	8	1.0	5.1
		Black 444	CI Black 26 CuFeMn		5%	26		✓	✓	✓	✓		600°C	N/A	0.5	5.3
		Black 10C909A	CI Green 17 FeCr	✓	24%	11			✓		✓		>800°C	8	1.4	5.3
		Black 411A	CI Brown 29 FeCr	✓	25%	14			✓	✓	✓		>800°C	8	1.0	5.2
		Blue 385	CI Blue 28 CoAl	✓	28%	31	✓ <sup>1</sup>	✓	✓	✓	✓	✓	>1000°C	8	0.8	4.2
		Blue 424	CI Blue 28 CoAl	✓	37%	17	✓ <sup>1</sup>	✓	✓	✓	✓	✓	>800°C	8	2.0	3.7
		Blue 211	CI Blue 36 CoCrAl	✓	29%	17		✓	✓		✓	✓	>1000°C	8	0.8	4.6
		Green 260	CI Green 50 CoNiZnTi	✓	21%	11	✓ <sup>2</sup>	✓	✓	✓	✓	✓	>1000°C	8	1.2	5.2
		Green 223	CI Green 50 CoNiZnTi	✓	25%	13	✓ <sup>2</sup>	✓	✓	✓	✓	✓	>1000°C	8	1.0	5.1
		Green 187B	CI Blue-36 CoCrMgZnAl	✓	29%	11		✓	✓	✓*	✓	✓	>1000°C	8	1.2	4.8
		Green 410	CI Green 26 CoCrZnTiAl	✓	25%	10		✓	✓	✓*	✓		>1000°C	8	2.0	5.1
		Yellow10C112	CI Yellow 53 NiSbTi	✓	71%	11	✓ <sup>1</sup>	✓	✓	✓	✓	✓	>800°C	8	1.5	4.6
		Yellow10C242	CI Brown 24 CrSbTi	✓	66%	14	✓ <sup>1</sup>	✓	✓	✓	✓	✓	>800°C	8	0.7	4.4
		Yellow10C272	CI Brown 24 CrSbTi	✓	62%	18	✓ <sup>1</sup>	✓	✓	✓	✓	✓	>800°C	8	1.8	4.6
		Brown 20C819	CI Black 12 FeAlTi	✓	44%	18		✓	✓	✓	✓		>800°C	8	0.9	4.2
		Brown 157	CI Brown 33 FeCrZnTi	✓	38%	14		✓	✓	✓	✓		>800°C	8	2.7	4.9
		Brown 10C873	CI Yellow 164 FeAlTi	✓	33%	12			✓		✓		>800°C	8	0.9	4.7
		Violet 11	CI Violet 16 Mn		15%	20	✓ <sup>1</sup>	✓	✓	✓			290°C	5 <sup>3</sup>	1.7	2.8
		Violet 92	CI Violet 14 Co		17%	15		✓	✓	✓	✓		>600°C	6	2.7	3.8

All values represent typical values and are not to be construed as specifications.

SCTM 340      Calculated      1- FDA 21CFR 178.3297  
2- FDA 21CFR 170.39  
3-Tint Only  
\* Not for modeling clay or finger paints

Observed      ASTM D1366      ASTM D153



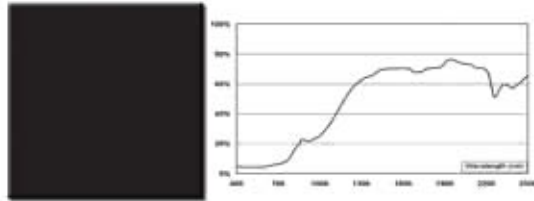
*Just stir them in!*

**100% PURE HIGH PERFORMANCE PIGMENTS**  
**WORKS IN SOLVENTBORNE & WATERBORNE**

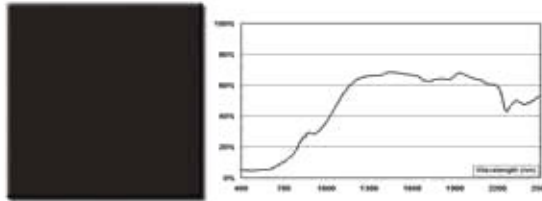
# Pigments for Coatings



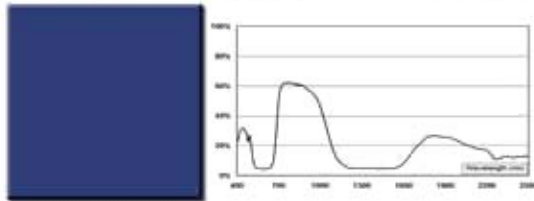
**Black 10C909** FeCr **TSR 24%**



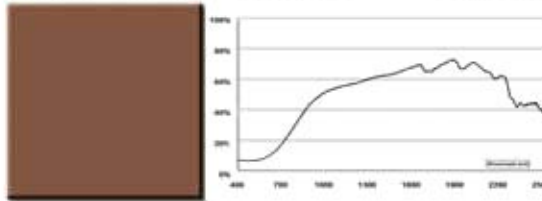
**Black 411** FeCr **TSR 28%**



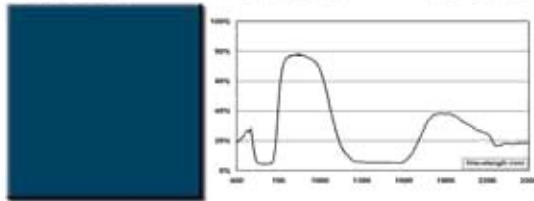
**Blue 385** CoAl **TSR 28%**



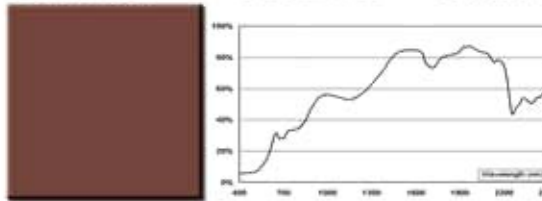
**Brown 10C873** MnSbTi **TSR 33%**



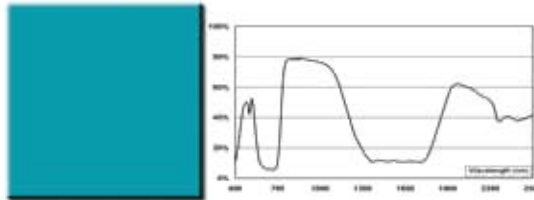
**Blue 211** CoCrAl **TSR 31%**



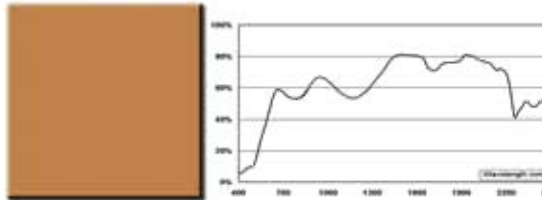
**Brown 157** FeCrZnTi **TSR 38%**



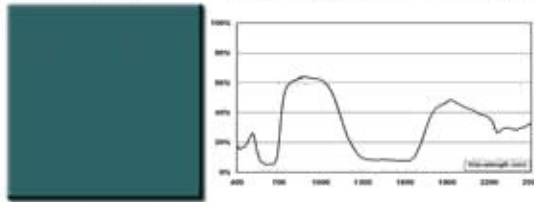
**Blue 424** CoAl **TSR 37%**



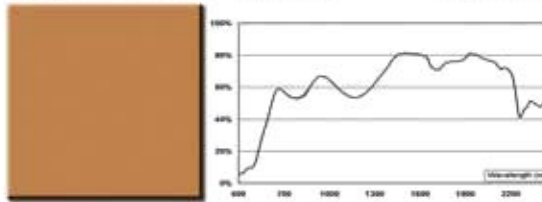
**Brown 156** FeZnTi **TSR 47%**



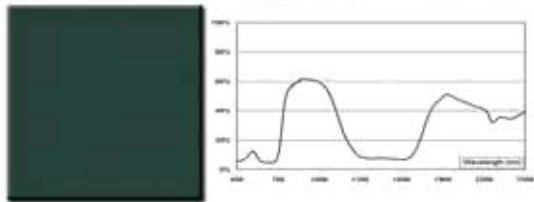
**Green 187B** CoCrMgZnAl **TSR 29%**



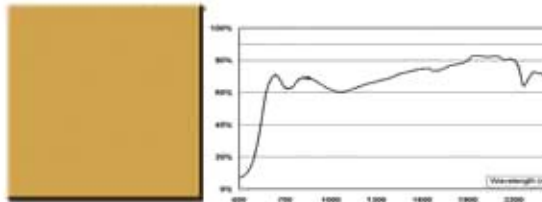
**Brown 20C819** FeAlTi **TSR 44%**



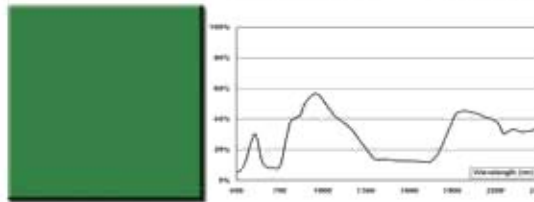
**Green 410** CoCrZnTi **TSR 25%**



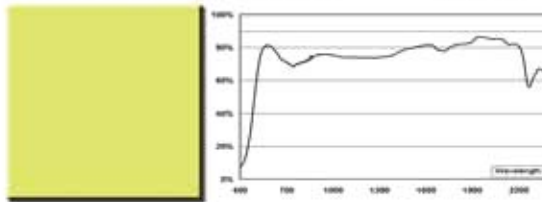
**Yellow 10C242** CrSbTi **TSR 66%**



**Green 223** CoNiZnTi **TSR 25%**



**Yellow 10C112** NiSbTi **TSR 71%**










TSR = "Total Solar Reflectance" (uv, visible, IR, according to ASTM E903-96, with opaque PVDF films).  
Colors swatches are approximate and for representation only.

The Shepherd Color Company specializes in high-performance ceramic colorants. These highly engineered pigments enhance the value of materials by imparting maximum colorfastness in extreme environments.



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### Arctic® Infrared Reflective Pigments:

-  Withstand the toughest conditions by reflecting the sun's energy away from an object to keep it cool.
-  Are perfectly suitable for all types of architectural finishes including coil coatings, acrylic and silicate paints, among others.
-  Can be used in a vast array of materials such as cement, concrete, pavers, vinyl windows and siding, roof tiles, automotive interior/exterior applications and military applications. Specific products for non-coating applications are available.
-  Mitigate solar-induced heat build-up and the destructive events associated with it. Cool products last longer!
-  Increase heat reflectivity to keep the object or material cooler - which translates into energy savings.
-  Allow products to meet Energy Star™, CEC Title 24, US Greenbuild LEED and ASHRAE requirements as well as other government and local building codes and regulations- without sacrificing the color!
-  Are Shepherd Color engineered ceramic colors. Architects and builders can be confident in the pigment's ability to endure in harsh environments as they have over the past 30 years.



## Infrared Reflective Pigments

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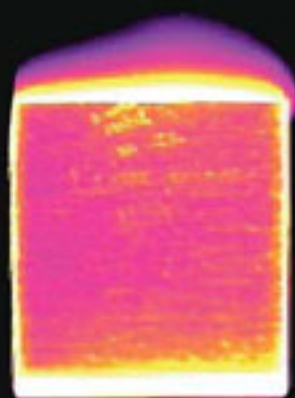
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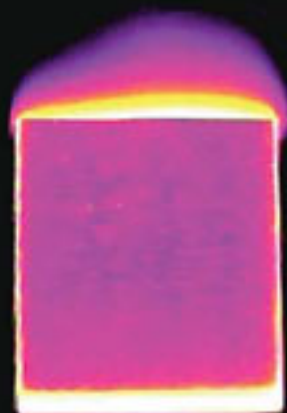
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# The Future is Lookin' Cool...



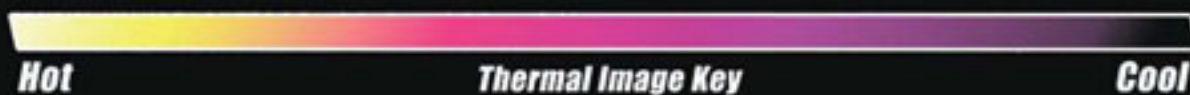
**Conventional**



**First  
generation**



**Black  
10C909**



*The above thermal images indicate the temperature of painted metal panels illuminated under identical conditions. Each panel is the same visible color (dark brown). Shepherd has improved the resistance to heat build up over successive generations of Arctic technology.*

**With today's innovations, who knows  
what tomorrow holds...**

**Arctic Infrared-Reflecting Pigments are cooler than ever.**

**These highly-engineered ceramic colorants are the pigments of choice for countering solar-induced heat buildup. Black 10C909 is the latest example of this energy-efficient, cost-effective technology.**



**Shepherd**

# Black 10C909 : Arctic Innovation

The search for energy-efficient and environmentally-friendly products has driven recent advances in infrared-reflecting technology. Enabling this trend are **infrared-reflective pigments** – colored powders that turn back the sun's **heat**. EnergyStar™ compliant roofing, vinyl siding that doesn't warp, automotive compounds and paints for cool car interiors – these applications and many more benefit from the use of these pigments.



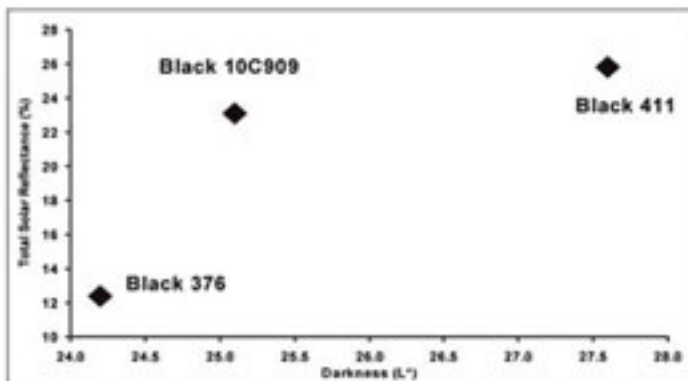
Recent options in IR-reflecting pigments left a gaping hole. There were no cost-effective pigments that exhibited true deep black color and still delivered a high level of solar reflectivity. Shepherd scientists went to work...

The Shepherd Color Company introduces Black 10C909, the newest addition to our Arctic™ line of Infrared-reflective pigments. Other blacks make you choose between high reflectivity, true black color, or cost-effectiveness. Black 10C909 offers a **'no-compromise'** solution!

## Black 10C909 Masstone

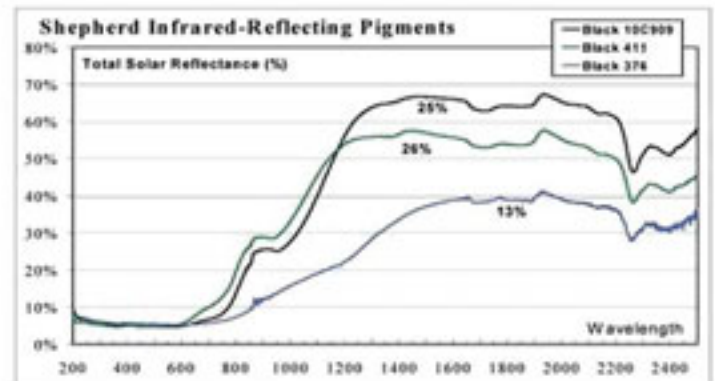
### True deep black : More color options

Until now, the blacks that exhibited the greatest reflectivity were the least 'black'. That is, their brown undertones made them unsuitable for producing the deepest colors. Or, they were expensive and utilized new and unproven chemistries. Black 10C909 is truly **BLACK**, allowing for formulation of jet blacks and deep colors, without sacrificing reflectivity!



### High IR-reflectance : Low heat build up

Making a true black that meets the U.S. EPA's EnergyStar™ threshold of 25% Total Solar Reflectance for steep slope roofs has been a real challenge for formulators. One had to use expensive, unproven chemistries or settle for a 'brownish' shade black. With Black 10C909, the task has never been easier.



## Black 10C909 Tint

### Well-known chemistry : Reliable durability

Don't take a chance on your warranted products! Shepherd's Black 10C909 is a conventional chemistry, one with years of proven performance. Its structure is a ceramic hybrid of  $Fe_2O_3$  and  $Cr_2O_3$  hematite, oxides that have been used since decades in the most durable exterior systems.

### Affordable : Cost effective solution

Unlike other solutions that contain exotic elements or elaborate organic structures, Black 10C909 is a ceramic pigment, composed of some of the most common elements found on Earth. This ensures a stable and cost-effective pigment, allowing for affordable solutions to your cool product requirements.

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# Introduction to IR-

While the human eye is sensitive to only a small part of the electromagnetic spectrum, pigment interactions with wavelengths outside the visible can have interesting effects on coating properties. One key area of the spectrum is the infrared (IR), specifically the near infrared. While not visible to the human eye, a pigment's, and thus a coating's IR properties can affect usability and durability.

The primary purpose of IR-reflective coatings is to keep objects cooler than they would be using standard pigments. This IR-reflective feature is the basis for

their use in markets like Cool Roofing for the EPA's Energy Star Program<sup>1</sup> and the California Energy Commission<sup>2</sup> Title 24 2008 version. This technology is also finding use in transportation and other areas where the ability to stay cool is a valuable benefit.

The easiest way to increase IR reflectivity is to use white pigments like titanium dioxide. TiO<sub>2</sub> reflects in the visible and in the infrared. The key to fight this "White Blight" and produce innovative, colored IR-reflective coatings is to use pigments that absorb in the visible to produce color and reflect in the IR for coolness. From these demands, Shepherd Color has developed a line of highly engineered products called Arctic® IR-reflective pigments. The Arctic line of pigments provides a palette of colors that allows the formulation of coatings and the design of materials to meet infrared reflectivity and long-term durability requirements, and provide deep and rich colors.

Articles have been written about the pigments used to make infrared reflecting coatings. This article is meant to inform chemists and formulators about some specific issues and phenomena pertinent to formulating and optimizing IR-reflective coatings. Some variables and factors that can affect a coating's IR reflectivity are individual pigment selection, milling and dispersing, mixing IR-reflective pigments, opacity, and contamination.

## Solar Spectrum

Any discussion of IR coatings requires a short review of basic physics. The sun's energy that reaches the Earth's surface is divided into three parts.

Figure 1/Solar spectrum.

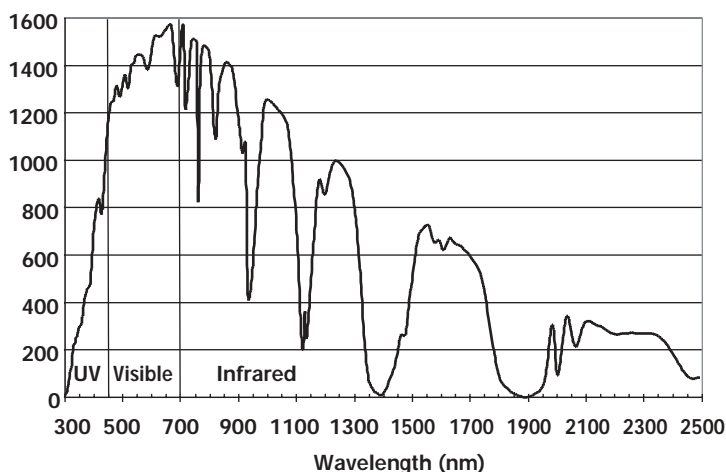
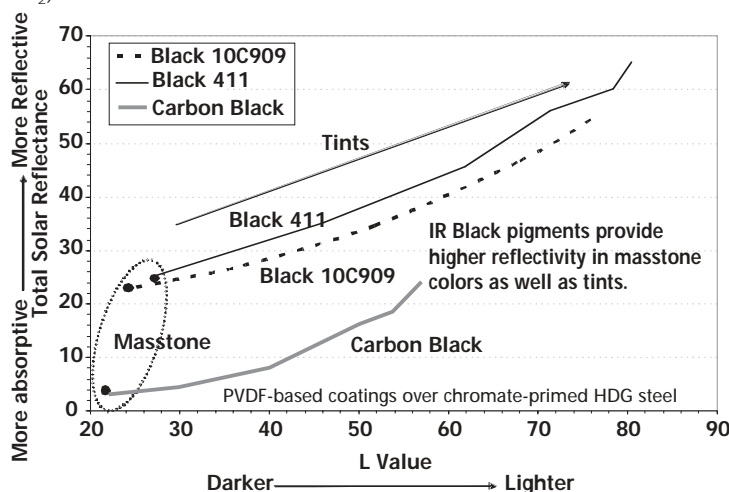


Figure 2/Total Solar Reflectance versus L value (black pigments mixed with TiO<sub>2</sub>).



By Mark Ryan, Technical Sales Representative/Shepherd Color, Cincinnati, OH

# Reflective Pigments

- **Ultraviolet (295-400 nm):** The UV region starts at 295 nm where the atmospheric cut-off occurs. While UV only accounts for roughly 5% of the sun's energy that reaches the Earth's surface, it is a major contributor to the degradation of coatings.
- **Visible (400-700 nm):** Roughly 50% of the sun's energy makes up the wavelengths that give us the perception of color.
- **Infrared (700-2,500 nm):** Forty-five percent of the total solar energy is in the infrared region. As can be seen in Figure 1, the majority of the energy in the infrared range is found in the 700-1,200 nm range. Beyond 2,500 nm there is little solar energy. The solar infrared region is different from the infrared energy given off by objects as heat. For most everyday objects, the heat emitted is found at much longer wavelengths and is dependant on an object's black body properties.

For an object in an outdoor environment, the four main mechanisms of reflectivity, emissivity, convection and conduction determine its temperature. Convection is largely dependant on air flow, and conduction depends on how well an object is insulated to prevent heat flows. Reflectivity and emissivity are the factors that can be manipulated.

## Cool Mechanisms

Objects reflect or absorb solar energy from these three regions: UV, visible and infrared. Total Solar Reflectance (TSR) describes how much of the sun's energy an object reflects. The common instrument for determining TSR is the Devices and Services<sup>3</sup> Solar Spectrum Reflectometer Model SSR, more commonly known as the "D&S". The D&S returns a single number for the TSR, while a spectrophotometer reads individual wavelengths that can be used to make the spectral reflectance curves seen in this article. Reflectivity can be manipulated by the careful selection of high-IR-reflective Arctic pigments. The key is to reflect infrared and absorb and reflect in the visible region to produce the needed color.

## Cool Coatings System

Shepherd Color Company supplies pigment to the high-performance coatings market. These products, including the Arctic line, are highly engineered ceramic pigments. These pigments, also called mixed metal oxides (MMO) or complex inorganic colored pigments (CICP), provide lasting color for demanding applications. The inorganic ceramic nature of the pigments provides resistance to high tempera-

tures, chemicals, acids, bases, weathering and environmental pollutants.

## Colormatching Blindfolded

### Pigment Selection

The highest reflective pigments should be chosen for cool coatings. Carbon black, iron oxide black or copper chromite black are standard black pigments for most formulations, but they have very low infrared reflectivity and a TSR of about 6%. One key to formulating cool coatings is the use of an infrared-reflecting black pigment. In general, IR-reflective formulations incorporate Arctic Black 10C909 to lower the L value in colors made with the other Arctic colors. Black 411 provides a higher TSR, but with a redder undertone. A complete listing of Arctic pigments (Table 1) provides a nearly full color gamut to use to help formulate high-IR-reflective coatings.

## IR-Reflective Coatings Benefits

### General Benefits

- Longer potential life-cycle due to less polymer degradation and thermal expansion due to lower temperature.
- Aesthetically pleasing colors.
- Cooler to the touch for better ergonomics.
- Improved system durability and less thermal degradation

### Roofing Benefits

- Less heat to transfer into buildings.
- Reduced heat island effect.
- Lower peak energy demand.
- Reductions in air pollution due to lower energy usage, power plant emissions, and a reduction in urban air temperatures.
- Installation crews can work longer into the day before roof gets too hot to work on.

Table 1/Arctic pigments.

Pigment	Color Index	Color Shade	Total Solar Reflectance (TSR%)
Black 10C909	Pigment Green 17	Blue Shade Black	24
Black 411	Pigment Brown 29	Red Shade Black	30
Blue 385	Pigment Blue 28	Red Shade Blue	28
Blue 211	Pigment Blue 36	Green Shade Blue	30
Blue 424	Pigment Blue 28	Turquoise	39
Green 187B	Pigment Blue 36	Teal	29
Green 179	Pigment Green 26	Camouflage Green	24
Green 223	Pigment Green 50	Yellow Shade Green	25
Brown 12	Pigment Brown 33	Red Shade Brown	30
Brown 157	Pigment Brown 33	Medium Shade Brown	38
Brown 8	Pigment Black 12	Blue Shade Brown	38
Brown 156	Pigment Black 12	Yellow Shade Brown	51
Yellow 10C112	Pigment Yellow 53	Green Shade Yellow	66
Yellow 10C272	Pigment Brown 24	Red Shade Yellow	71

This advantage in TSR for the masstones also continues when the pigments are added with TiO<sub>2</sub> to make tints. Figure 2 portrays TSR on the vertical axis and the lightness L value on the horizontal axis. Each line represents a different pigment with the dot on the left-hand side (low-L-value) as the masstone. Adding white increases the L value and increases the TSR. What you can see from the graph is that low-L-value masstone colors with around 25% TSR can be achieved with IR-reflective blacks, while standard blacks need to be mixed to a light to medium gray before they can achieve 25% TSR.

Figure 3/Grind study of Black 10C909 (Masstone L value and Total Solar Reflectance).

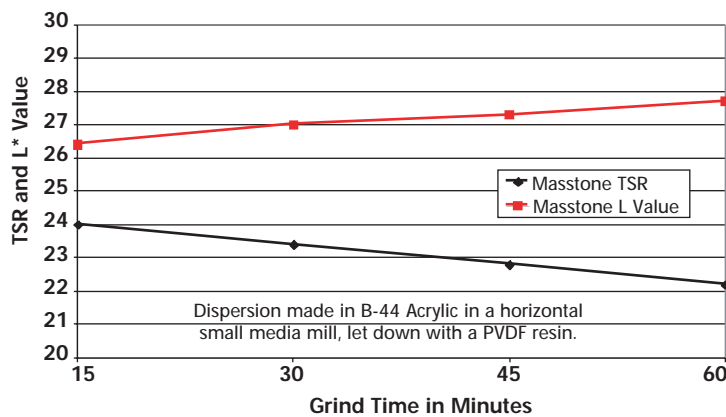
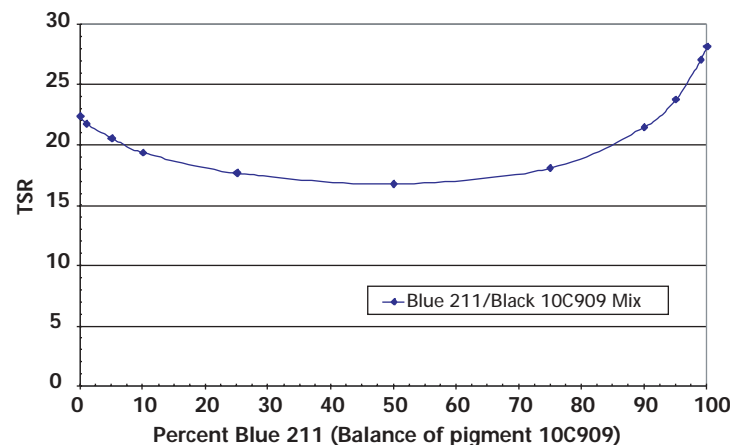


Figure 4/Effect of blending pigments on TSR (mixes of Black 10C909 and Blue 211).



### Dispersion

Arctic pigments are compatible in almost all solvent and aqueous coatings systems, including polyesters, acrylics and fluoropolymer systems. To achieve full dispersion and optimum properties, the pigments should be dispersed in a small media mill to at least a 7 Hegman. Care must be taken not to over grind the pigment. Additional grinding will break the pigment into smaller particles, causing color shifts, which usually increase tint strength but lightens masstones. Consistent grinding past the dispersion step needs to be carefully controlled to maximize color and IR properties. Figure 3 shows that with increased grinding, Arctic IR Black 10C909 moves lighter in the masstone and lower in TSR, both of which are undesirable.

Many additives can be used to produce stable dispersions. In some systems no additives are needed due to the inherent dispersion properties of the pigments. Due to their high specific gravity, careful screening of finished paints for pigment settling should be conducted.

### Blending Pigments

Very few colors are single-pigment dispersions. In order to match a color, care must be taken when more than one pigment is mixed together to make a color. As seen above, any Arctic pigment mixed with white will provide a higher total solar reflectance than the Arctic pigment by itself. Two Arctic pigments with different absorption areas, when mixed together, will have a lower reflectance than the pigments have individually. A good example of this is a mixture of Arctic Blue 211 and Black 10C909. While both have about 25-30% TSR, when combined they will have a lower TSR than a weighted average of the individual pigments, as seen in Figure 4.

An examination of the spectral curves in the infrared (Figures 5 and 6) shows that the black's reflectance comes just as the cobalt absorption band of the blue starts. This is to be expected since pigmented films don't really reflect; they either absorb, scatter or transmit. The absorbance of the pigment over-powers the scattering. This battle between absorbance and scattering is predominate over transmittance in thick objects. But in the relatively thin world of paint films, transmittance can also play a factor.

### Opacity

CICPs, such as Arctic pigments, are known for their high visible opacity. What is harder to see is that since they don't absorb in the IR region, the only two mechanisms left are scattering and transmission. Thin films

Figure 5/Effect of mixing pigments on reflectance curves (ratios of Black 10C909/Blue 211).

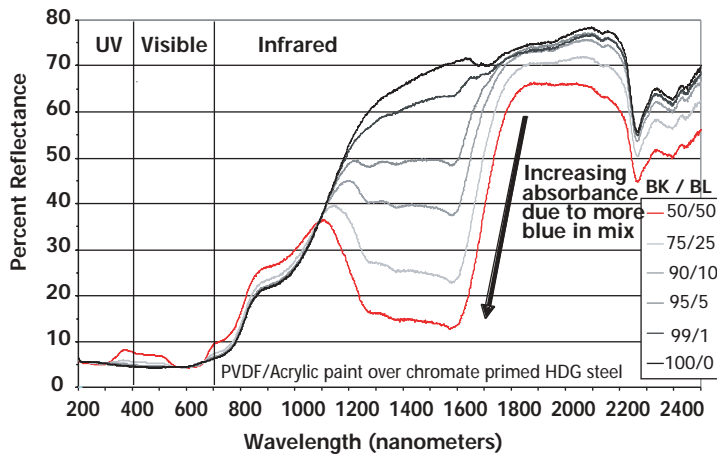


Figure 6/Effect of mixing pigments on reflectance curves (ratios of Black 10C909/Blue 211).

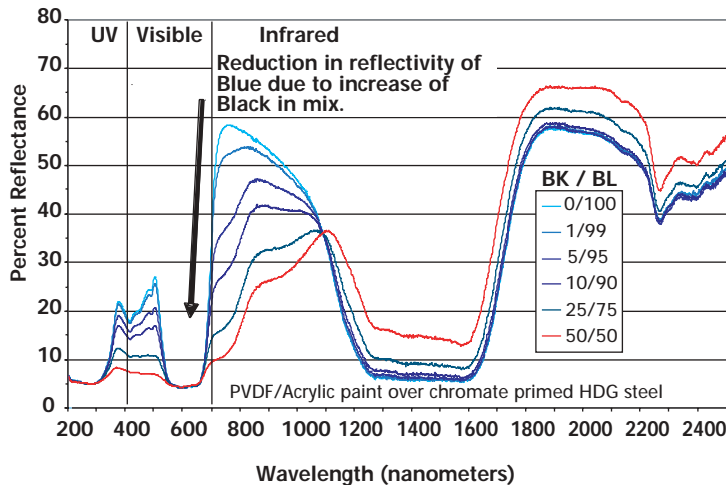
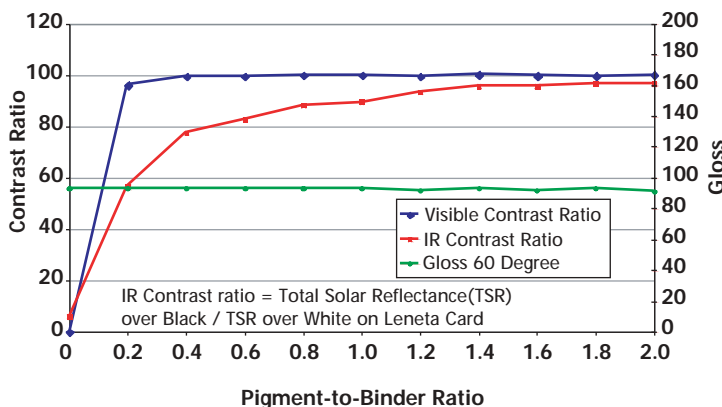


Figure 7/Visual versus IR opacity [Black 10C909 in 1.1 to 1.3 mil DFT (acrylic system)].



may not completely scatter and reflect the sun's energy back out of the coating, so the IR energy may continue through to the substrate.

Figure 7 shows how a paint film can be visually opaque, while still semi-transparent in the IR. A solventborne air-dry acrylic was used to make coatings with varied pigment-to-binder ratios. The paints were then drawn down over the black and white portion of Leneta cards. The visible contrast ratio was read, and a "TSR contrast ratio" was determined by dividing the TSR reading over the black part of the card by the TSR over the white portion of the card. For each pigment-to-binder ratio, P/B, the respective contrast ratio was plotted, along with the 60 degree gloss of the coating. As can be seen, the films obtained visual opacity much sooner than IR opacity. Along with P/B ratios, a similar behavior can be seen if the P/B were held constant and the film thickness increased.

This difference in visual and IR opacity leads to many issues. A pigment's and a coating's TSR can depend on the substrate and film thickness. This makes it difficult to predict TSR for a pigment or coating without knowing particulars about its application and use. A gray primer with carbon black in it will cause a greater loss in TSR than if a similar color primer is made with IR black, other non IR absorbing pigments, or left white.

Along with these negatives, the positive is that an IR-reflective substrate can help to keep a coating's TSR higher. A different take on the graph in Figure 7 is the graph that is shown in Figure 8, which illustrates the visible contrast ratio along with the TSR readings of the coating containing the Black 10C909. The red and blue lines represent the TSR over white and over black respectively. Not surprisingly, the TSRs differ while the film is not visually opaque, but the TSR is also higher over the white when visual opacity is reached. As the P/B increases and hides the black and white portions of the Leneta card, the TSR numbers start to converge. In the range of about 0.4 to 0.8, the Black 10C909 film shows good visual opacity and the ability to maximize the coating's TSR over reflective substrates.

### Contamination

One last area of concern is contamination. Figure 9 shows the curve previously shown that demonstrates the decline in TSR when Black 10C909 and Blue 211 are mixed together. Even more damaging to TSR is the inclusion by design or contamination of a non-IR-reflecting black, like carbon black. The carbon black

Figure 8/Total Solar Reflectance and contrast ratio vs pigment-to-binder ratio. [Arctic Black 10C909 (1.1 to 1.3 mil DFT- Acrylic System)]

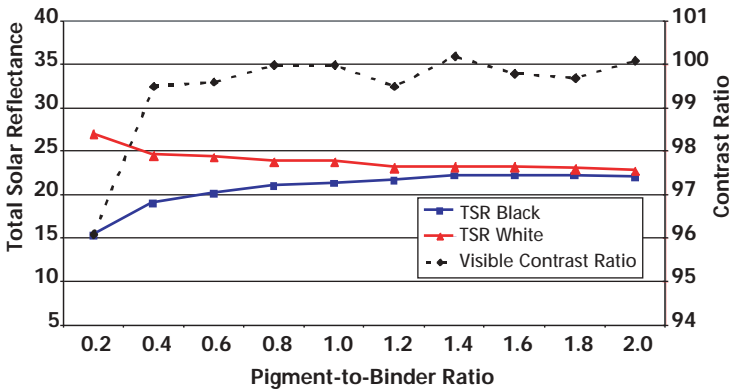
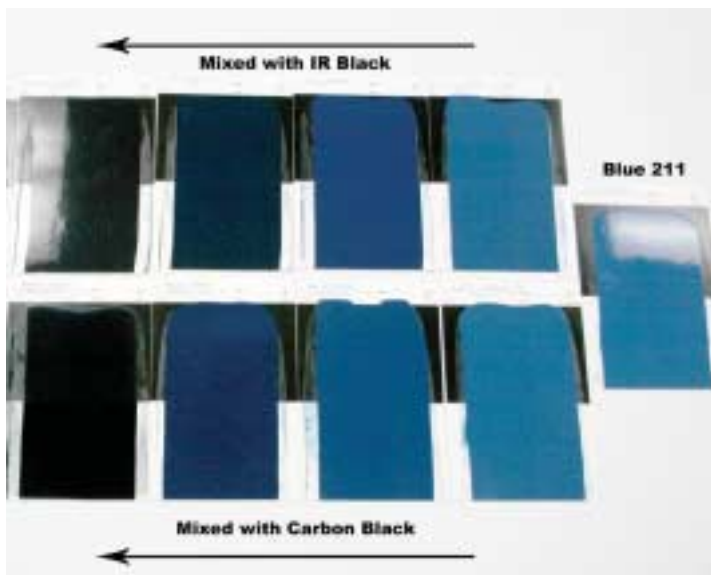
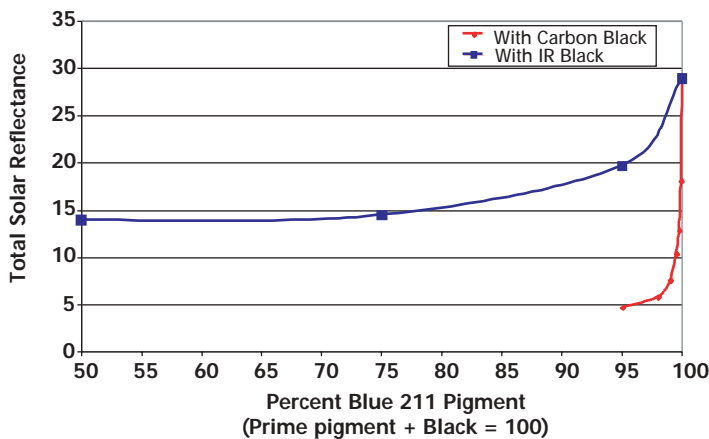


Figure 9/Cobalt Blue with Carbon and IR Black.



greatly affects the TSR of the mix when as little as 0.10% is included, and before the color starts to change dramatically, as seen in the picture. The two lessons that this shows is that mills and handling equipment must be clean to make sure that cross-contamination doesn't occur and that using even small amounts of non-IR colors to shade a batch can have drastic effects on TSR.

### Conclusion

The formulation of IR-reflective coatings for various applications depends on many factors, some of which cannot be seen with the naked eye. There are two main keys to formulating these coatings. The first has to do with the physical characteristics laid out in this article.

- **Individual pigment selection:** Select IR-reflective pigments.
- **Milling and dispersing:** Do not over grind and degrade IR properties.
- **Mixing IR-reflective pigments:** Be aware of the invisible interactions of different pigment types in the IR region.
- **Opacity:** Use an IR-reflective substrate/primer if possible, or manage the pigment-to-binder and film thickness to minimize effect of absorptive substrates.
- **Contamination:** Inclusion of even small amounts of IR-absorbing pigments can greatly reduce TSR.

The second key is to work with a partner with the products, research, and most importantly, technical support to allow you to formulate, test and validate your IR-reflective coatings. The IR range is invisible to the human eye, not covered by standard spectrophotometers, and measurable only by expensive and specialized equipment. A partner who can shepherd you in pigment selection, color matching and testing, along with guidance in the different regulations and programs can be an invaluable aid in formulating, marketing and supporting differentiated IR-reflective coatings. ☺

### References

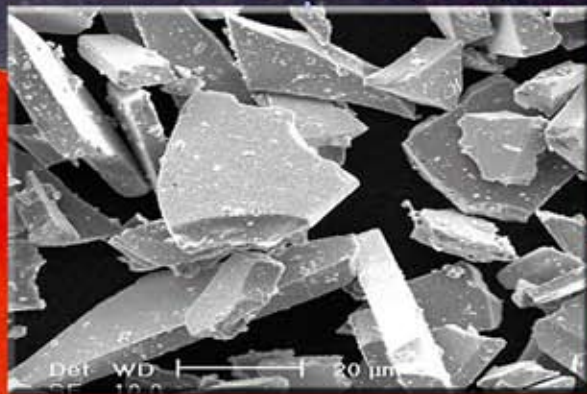
- 1 EPA Energy Star Roofing: [www.energystar.gov/index.cfm?c=roof\\_prods.pr\\_roof\\_products](http://www.energystar.gov/index.cfm?c=roof_prods.pr_roof_products).
- 2 California Energy Commission: [www.energy.ca.gov/](http://www.energy.ca.gov/).
- 3 Devices and Services: 10290 Monroe Dr., Ste. 202, Dallas, TX 75229; 214/902.8337; [www.devicesand-services.com](http://www.devicesand-services.com).

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- Food contact approval
- Europe AP(89), all grades
- Australia AS 2070, all grades
- US FDA FL105 only

- Unsurpassed brilliance
- Maximum reflectivity
- Effective at low loadings



StarLight® FL500	$D_{50} = 238 \mu$
StarLight® FL105	$D_{50} = 90 \mu$
StarLight® FL37	$D_{50} = 28 \mu$

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MicroMirror® pigment technology is based upon a silver coating on a glass substrate, using a novel manufacturing process. StarLight® will sparkle and surpass the brilliance and luster of other effect pigments currently available. Colors can be created with these pigments to impress and enhance every possible application. The perfectly flat, uniform glass flake substrate maximizes reflection and provides a solid base for optimum metallic appearance and the MicroMirror® effect.

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**Industrial liquid coatings**  
**Powder coatings**

**Plastics**

**Inks**

**Dispersions**

**Packaging**

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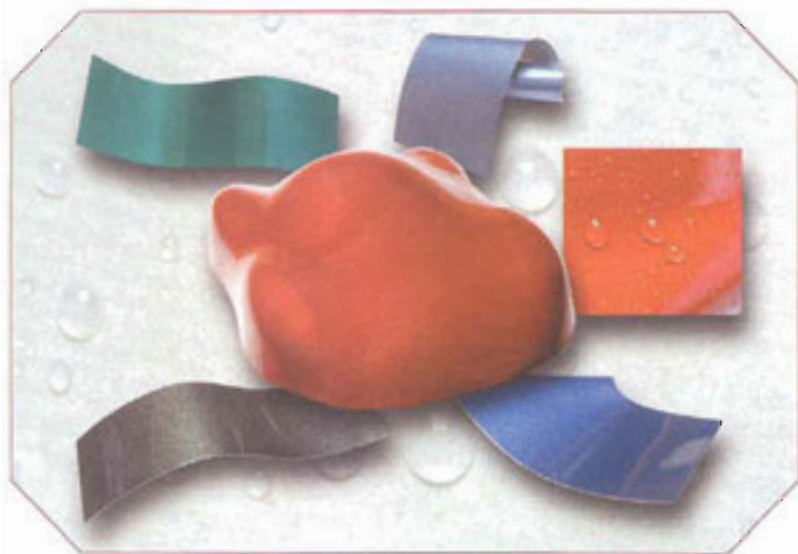
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# Twinkle, twinkle, little star



The coatings industry is always looking for new ways to differentiate their paints and enhance visual effects to promote product marketing. Jeff Nixon unveils the latest effect pigment, which uses silver to create very bright effects.

Correct or no, the general consensus is that colour and special effect trends originate from the fashion industry. In the world of apparel and cosmetics, colours and effects are relatively short-lived and evolve or are replaced within about two years. Fast following sectors include sporting equipment and apparel, food, gift wrap, and interior design elements.

These colours then appear in appliances and consumer electronics, however at this point, they have often become somewhat more subdued – less bold, daring, and ‘trendy’. The design palette is more enduring, perhaps of three or four years’ lifespan. The automotive industry can undergo still longer colour and effect cycles, reflecting the life (or expected ownership period) of the product.

It can be difficult to extract a common theme from the fashion world, so the automotive industry is looked to for leadership in colour trends for durable goods and elsewhere. Even in the narrowly-defined OEM topcoat segment, there is not unanimity, but some commonalities can be discerned. For example, according to several OEM paint manufacturers, blues will increase in popularity during model years 2004-2006, and colours will be generally brighter and cleaner.

Several years ago, silver surpassed white as the most popular colour and today comprises over 20% of US OEM finishes and an even greater percentage in Europe and Asia. Silver imparts a futuristic and technological appearance and should continue to be a popular colour for the first decade of the new millennium. Warmer tones of silver and even a possible return of golden or champagne hues are predicted by industry insiders.

In keeping with the high-tech movement, effect pigments, especially those that are particularly brilliant and pronounced, are more and more in demand. The increasing desirability of metallic-effect finishes is one of the few trends upon which most everyone seems to agree. Consequently, newer, more brilliant metallic finishes that provide sharper flop or greater sparkle are in development.

With the possible exception of automotive finishes, nowhere is this trend clearer than in Asia. Perhaps in accordance with the high-tech conveniences found in their everyday life, consumers in these markets like metallic effects, especially effects that sparkle and shine.

## CONVENTIONAL METALLIC EFFECTS

Selection of pigments is the key to creating a metallic effect. There are several types of conventional metallic pigments from which to choose.

Aluminum flakes and powders are the most common of the metallic pigments and are used in many applications, including automotive topcoats.

They are relatively inexpensive and well understood. There are two types of products, leafing and non-leafing. Leafing grades float to the surface; non-leafing grades distribute themselves evenly within the coating film. For each type, different shapes and particle size distributions are available.

In general, the larger particle sizes give greater sparkle effects, whereas the smaller ones are more opaque and greyer in appearance.

All the grades are lamellar and thin and can be deformed by mechanical means, for example by vigorous dispersion, stirring, or even during paint circulation. The net result is a loss of brilliance.

Aluminum flakes produce the best results when used either alone or in combination with transparent pigments, so their applicability for opaque colours is limited. Despite innovations in the manufacturing process, a high degree of brilliance and sparkle remains difficult to obtain.

The mechanical forces incurred during the manufacture of powder coatings make the use of aluminum flakes exceedingly problematic. It is often necessary to use ‘bonded’ pigments that are more easily incorporated.

Bronze pigments find some use in coatings applications where golden or copper shades are required. The colour of these pigments varies from a golden yellow to reddish brown. They are denser than aluminum flakes, leading to greater concentrations being required to achieve similar levels of visual effect. More recent developments have yielded pigments with improved tarnish resistance.

To meet the trend towards brighter metallic pigments, Shepherd Color investigated the use of

*Figure 1: The uniform surface of the silver results in high brilliance and by coating the edges also ensures that incident light is not diffused, maintaining sparkle*



Left: The surface is extraordinarily uniform, maximizing brilliance. The edges are coated, generating extra sparkle.

Below: A very thin silver coating, as seen in this cross section, lowers cost effectiveness.



Figure 3: Sparkle effects are created when different pigment particles come into line (see note - 2)

† The effects in Figure 3 and Figure 4 are dependent on particle orientation, as described in Figure 5

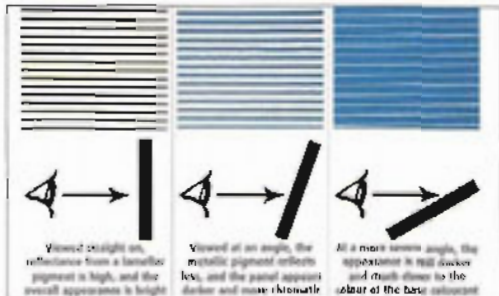


Figure 4: The Venetian blind effect describes the angle dependence of colour with lamellar pigments (see note - 2)

metallic silver, which is brighter than conventional aluminium, and developed a new pigment to address the limitations of conventional metallics.

StarLight pigments employ MicroMirror technology to achieve an high brilliance and sparkle. MicroMirror technology creates a highly reflective, uniform surface for maximum effect.

StarLight pigments are multi-layered materials. The substrate is a variety of borosilicate glass (C type), chosen for its high strength and exceptional chemical resistance. Because the glass is not malleable, it will not deform during processing or in circulation, and its high strength minimises breakage. The substrate thickness is controlled to within a few percent variation, providing an extremely consistent effect.

Deposited on the glass surface is a sub-micron layer of metallic silver, the most highly reflective metal known. The uniformity of the silver surface is of critical importance, both to ensure complete coverage of the glass substrate, including the edges, and also to minimise surface roughness that would otherwise diffuse incident light (Figure 1).

Decades ago, mirrors were made by depositing silver onto glass. The techniques used at the time led to imperfect adhesion, as can be seen in antiques where the silver layer has partially delaminated. MicroMirror technology has solved this problem through an exclusive bonding process that ensures excellent adhesion of the silver to the substrate. Oxidation of the silver layer, or tarnishing, has been overcome through a proprietary surface finishing process.

**DESIGN AND STYLING EFFECTS**

StarLight silver-coated glass pigments are manufactured in two basic shapes: spherical and lamellar.

The lamellar grades are based on a glass flake substrate that is an unvarying five microns thick. FL105 has a narrow particle distribution for maximum contrast. As for the spherical grades, SM36 is based on a solid glass substrate, whereas HM72 is a silver-coated hollow ceramic microspheres. The particle size distributions can be seen in Figure 2.

Figure 2: Size distributions of various pigment grades

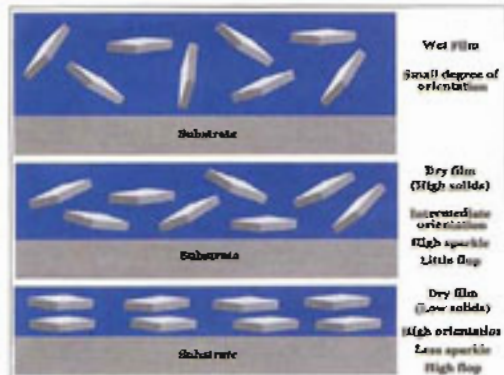
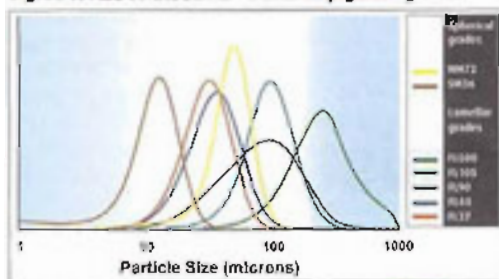


Figure 5: The orientation of the pigments affects the stylistic effect - increasing 'sparkle' results in decreasing 'flop' and vice versa

Metallic silver, with its unsurpassed reflectance properties, allows for the maximum brilliance to be achieved. Because of this, StarLight can be used at lower loadings than conventional metallics. An added advantage is that the particles will be spaced further apart and the contrast between the base colour and the effect is magnified.

To attain a desirable effect, conventional metallics are used in combination with transparent pigments. This can limit the overall performance of the system, as well as the colour range possible. Furthermore, transparent films must be applied at greater thicknesses, if the substrate/primer is to be hidden. Because of its increased brilliance, StarLight can be used to good effect in more opaque systems, allowing for maximum performance, colour range, and economy of application.

Each grade produces a distinct effect. The spheres provide a steady, star-like shine. The lamellar flakes produce a brilliant sparkle as well as a colour flop, depending on how they are positioned in the film.

**SPARKLE AND FLOP**

Sparkle is the change in amplitude of light reflected from a particle with change in viewing angle. For an object incorporating StarLight pigments, at any given angle, certain of the particles will be strongly reflecting specular light. When the angle changes slightly, the particles that formerly reflected the specular light are no longer seen. Rather, new particles in line with the light source come into view. As the object continues to change position with respect to the incident light and the viewer, the effect is a 'twinkling' throughout the film (Figure 3).

Sparkle effects are strongest when very flat particles are randomly aligned and highly reflective. The sparkle effect and the overall brilliance is enhanced because even the edges of StarLight pigments are silver-coated. This can be seen easily under direct sunlight.

Flop is the change in colour with a change in viewing angle. Flop is due to the reflection of the incident light being very high when the reflecting particles are in alignment with the observer. When the object is rotated away from this alignment, there is little reflection from the metallic pigment particles, and the underlying colour is uncovered. This phenomenon is known as the Venetian blind effect (see Figure 4).

Flop is maximised when flat particles are both highly aligned and reflective. With both StarLight and conventional metallic pigments, orientation has a dramatic effect on sparkle, flop and brilliance. Highly oriented particle arrangements produce high flop and relatively less sparkle. Randomly oriented pigments produce a high degree of sparkle and little flop. Intermediate orientation produces intermediate levels of both flop and sparkle.

Orienting the particles within a film depends to a great extent on the composition and application of the paint system. The particles are virtually randomly distributed and oriented immediately after dispersion. Additional orientation will occur upon application, depending on the method employed (e.g. roll coating > curtain > spray). Orientation can also be enhanced through the addition of appropriate levelling agents or dispersion resins. However, the greatest contributor to orientation is the amount of film shrinkage that occurs upon curing (Figure 5). This is most heavily influenced by the percent solids of a paint system:

Various combinations of sparkle and flop can be achieved through appropriate formulation and application.

The particle size has a tremendous impact on the effect. The large particle size of FL500 produces a 'broken glass' effect in low loadings and a 'glistening wet' effect at higher loadings. Both effects are very pronounced, and perfectly suitable for skis or bicycle helmets, but perhaps too flashy for automotive topcoats. For this application, the finer grades produce lustre and brilliance at low loadings, and the effect is more subtle.

An interesting side effect of the optical nature of StarLight is the possibility to achieve golden hues with increased loading.

As with conventional metallic pigments, the use of transparent colourants will provide the maximum brilliance. However, more opaque colourants can also be used to create colours and effects that have been impossible until now. For example, a StarLight-containing opaque basecoat can provide added depth and lustre to a transparent topcoat.

Conductivity is important for many applications, and silver is one of the most highly conductive metals on earth. It is the metal of choice for the most demanding electronics applications, where shielding from electromagnetic interference is necessary for signal fidelity. StarLight pigments provide a scaffold for optimal arrangement of silver conduction pathways.

### PROCESSING

StarLight silver-coated glass pigments have the correct balance of physical properties and morphology that allow them to be easily dispersed under a variety of processing conditions.

Unlike conventional metallic and pearlescent pigments, StarLight is very resistant to stress and shear. There is no need for a soaking period for

pre-dispersion. The pigments can easily be incorporated using low-shear mixing equipment and are robust enough to survive a degree of vigorous mixing without changing the appearance or the brilliant effects.

The strength and robustness of StarLight is demonstrated by the fact that they can be easily incorporated into powder coatings by dry mixing. There is little damage to the StarLight pigments during the subsequent compounding and extrusion stage. With conventional metallic pigments, great care must be taken, and even so, the effect is diminished. StarLight retains its brilliance and sparkle even in the thicker films typical of powder coating.

### APPLICATIONS

New applications for silver-coated glass effect pigments are being discovered day by day. Most applications centre on the aesthetic properties of StarLight pigments. They are designed to capture and captivate the eye of the consumer. StarLight can attract notice for such objects as canned beverages, packaging for consumer goods, candles, picture frames, decorative ornaments, musical instruments, and even fishing lures.

The effect is especially prominent in direct sunlight, and many outdoor items are excellent candidates. Sunlight on StarLight produces dazzling effects on new

and custom automobiles, motorcycles, bicycles, boats, skis, spas, and swimming pools.

Trendy or fashionable items that are designed to 'make a statement' are natural applications. Cosmetics, apparel, cellphones and PDAs, sunglasses, and alloy wheels are all statements of fashion and status and can benefit from the distinctive appearance of StarLight.

### THE SILVER SOLUTION

Silver-coated glass flake pigments are used to achieve uniquely brilliant effects, without the limitations of conventional metallic pigments. They can be incorporated in any and all layers of basecoat, clearcoat, tricoat and other paint systems, in combination with opaque as well as transparent colourants. They are highly resistant to deformation during coating manufacture and application, including that of powder coatings.

The various grades can be used singly or together to create a multitude of effects: sparkle, flop, contrast and shine. Indeed, many design possibilities will continue to emerge from the laboratory into the sunlight. **APCI**



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**Shepherd**

*We Brighten Lives*

THE SHEPHERD COLOR COMPANY



## OUR PURPOSE

At Shepherd Color we don't just brighten the world with our pigments. As a company we strive to enhance the lives of everyone with whom we have contact. That means working to satisfy the needs and advance the goals of our employees, families, customers, suppliers, shareholders, and community. We know striving for excellence in every facet of our operations is good business. More importantly, the impact it has on people is what makes business worth doing.

## OUR CORE VALUES

Our core values don't just direct us:  
they define us.

We are people of exemplary character.

We strive for excellence in all we do.

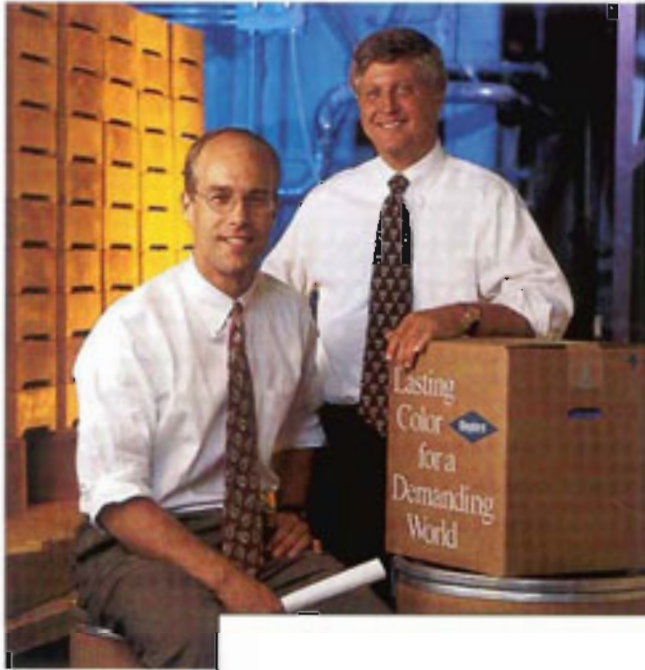
We work for long-term impact.

## OUR QUALITY PURPOSE

We understand that excellence and self-improvement must go hand in hand.

While providing superior products and service, we continually work to improve our operations for the mutual benefit of both our internal and external customers.

## OVER 70 YEARS OF EXPERIENCE



Shepherd Color is a fourth-generation family-owned and operated business dedicated to being a world-class producer of complex inorganic color pigments. Born in the late 1920s as the color department of The Shepherd Chemical Company, we originally made ceramic colors, primarily for the porcelain enamel industry. By the early 1960s, the color department's product line had expanded to a full range of complex inorganic color pigments used in the premium coatings and plastics markets. Thanks to increasing sales in those markets, the color operation outgrew its space at Shepherd Chemical. In 1980 The Shepherd Color Company was organized as a separate entity and relocated to a new facility north of Cincinnati.



Since our spin-off, we've broadened our global reach. Each year Shepherd Color supplies millions of pounds of high-quality pigments to customers around the world through sales offices in Cincinnati; Brussels, Belgium; and Melbourne, Australia.





## LASTING COLOR



Our complex inorganic color pigments, as a class, are the most stable and durable on the market. Available in blacks, browns, yellows, greens, blues, and violets, these pigments boast unsurpassed heat stability, chemical resistance, light-fastness, and weatherability. That outstanding durability makes them the colorants of choice when high performance matters.

Complex inorganic color pigments are synthetic minerals produced by heating mixtures of metal oxides at temperatures in excess of 1,800°F (1,000°C). The synthetic minerals formed under these conditions are extremely stable, typically crystalline structures of rutiles and spinels.







Lasting Color  
for a Demanding World

Lasting Color  
for a Demanding World

GREEN 260

Lasting Color  
for a Demanding World

Lasting Color  
for a Demanding World

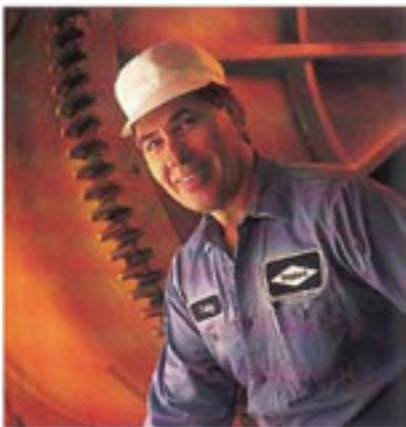
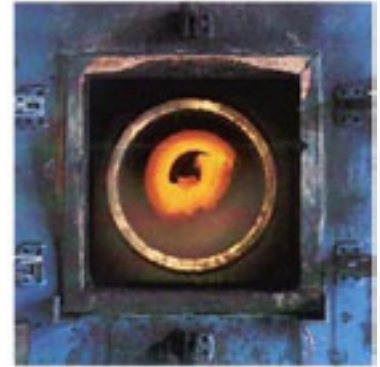
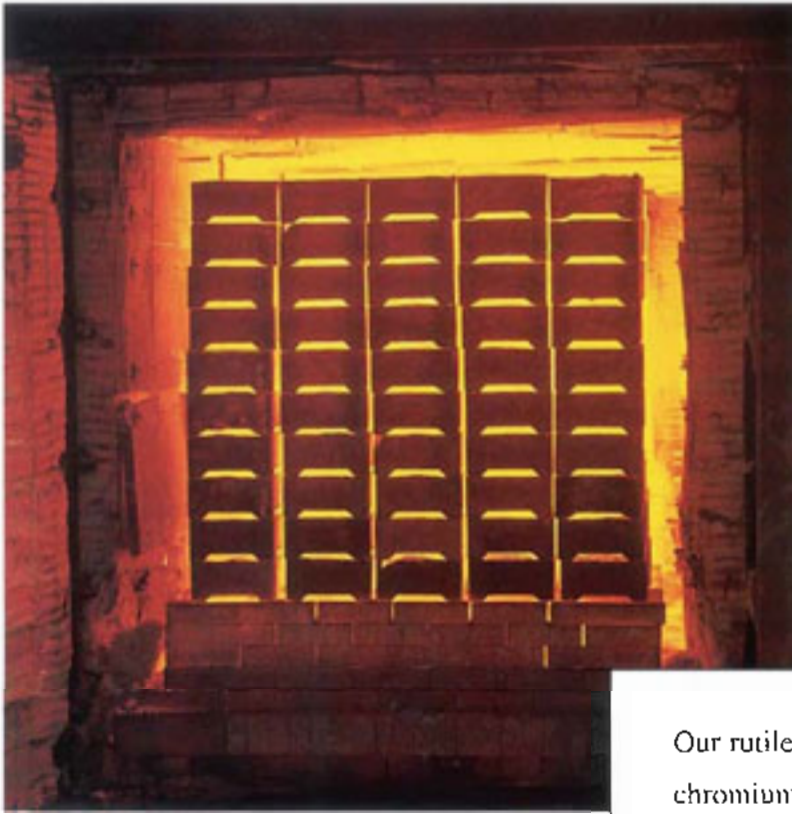
YELLOW 195

YELLOW 29

BLUE 214

BLACK 1 G

BLACK

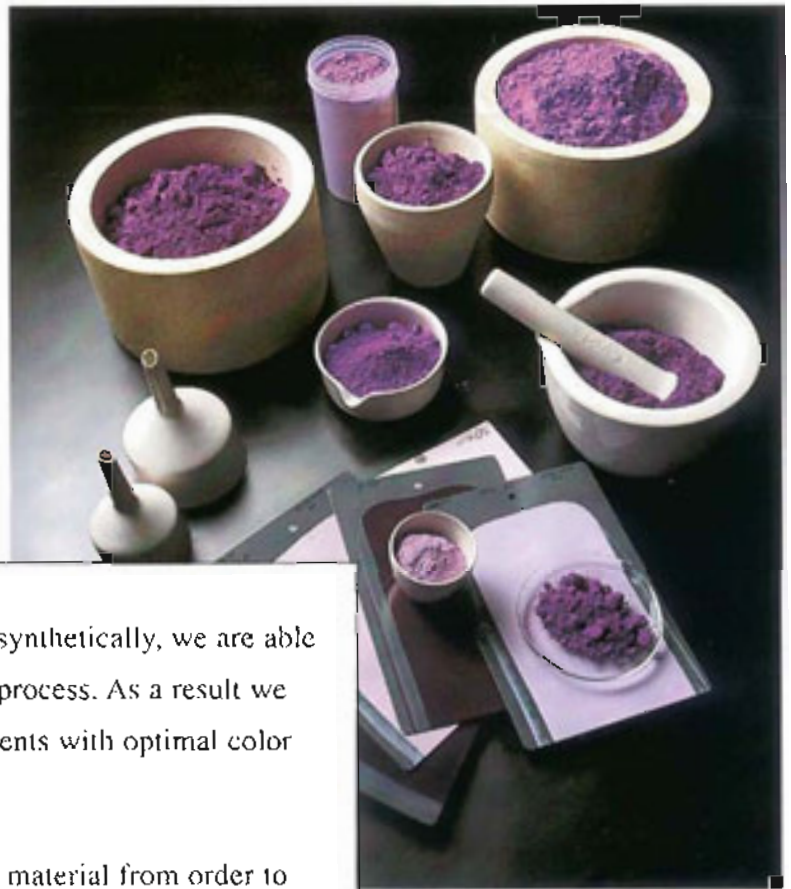


Our rutiles are nickel antimony titanate and chromium antimony titanate yellows and manganese antimony titanate browns, all of which are available in various shades. Our spinels include copper chromite blacks, IR reflective blacks, cobalt aluminate and cobalt chromium aluminate blues, cobalt chromite and cobalt titanate



greens, and numerous shades of iron titanate and iron chromite browns. In addition to spinels and rutiles, we make cobalt phosphate and manganese phosphate violets.

# CONTROL AND CONSISTENCY



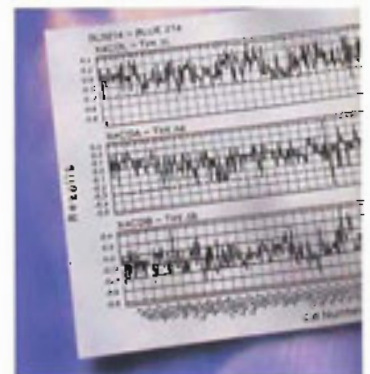
Because we prepare our mineral pigments synthetically, we are able to control every step of the manufacturing process. As a result we produce the brightest, highest quality pigments with optimal color control in a wide range of hues.

To ensure our customers receive consistent material from order to order we employ statistical process control methods throughout

production and testing. We screen raw materials, monitor manufacturing parameters and test methods, and assess the physical properties of our pigments to make sure our processes are under control. Finally, before shipping, we compare each lot of pigment to a control standard to make sure our customers get exactly what they expect.



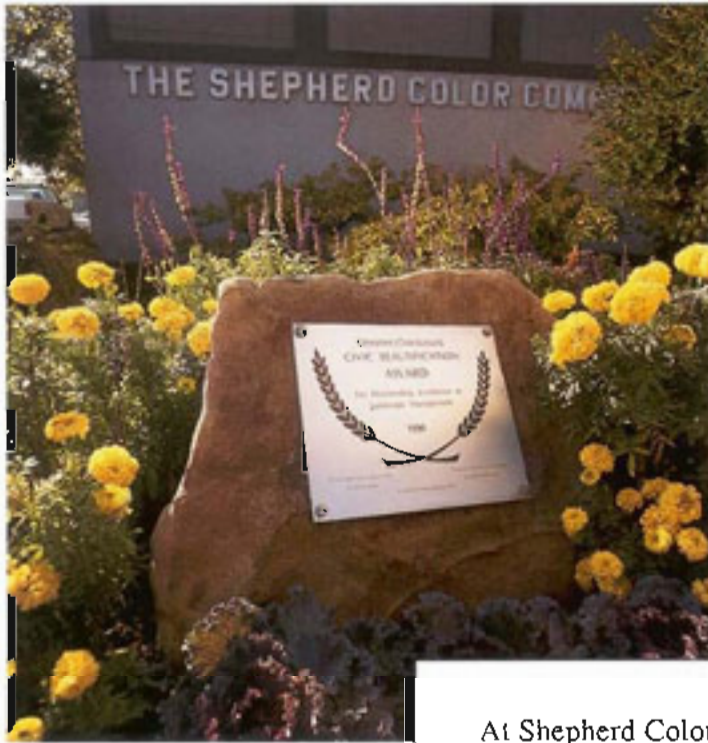
Thanks to such thorough attention to detail, we've been ISO 9000 certified since 1994. We maintain ISO certification through frequent internal audits, continuous training, and periodic reviews, all of which help guarantee that we deliver the best products possible, both now and in the future.







# SAFE AND ENVIRONMENTALLY FRIENDLY



Constant attention to our landscaping and grounds have resulted in Shepherd Color receiving the Greater Cincinnati Civic Beautification Award, for outstanding excellence in landscaping management.



At Shepherd Color we take health, safety, and environmental stewardship very seriously. Recognizing our responsibility to our customers, employees, community, and the environment, we've established an internal reclamation program and in-house safety audits that exceed industry guidelines and set a standard of excellence.

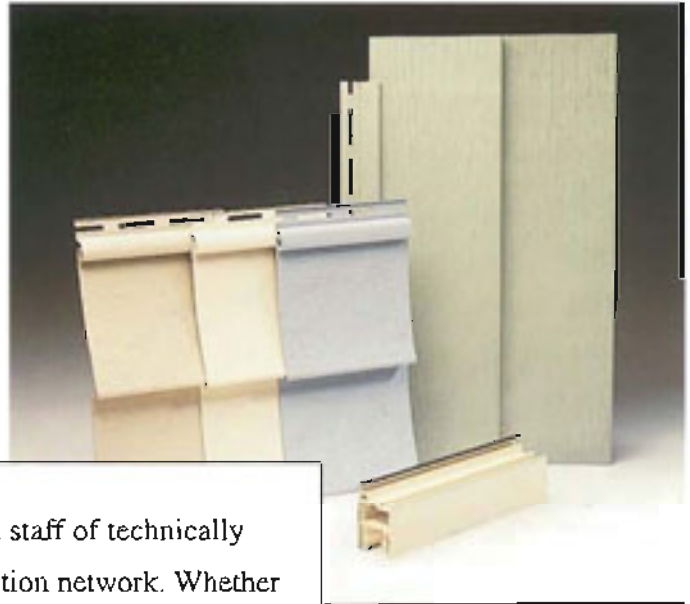
Complex inorganic color pigments are chemically inert in all but the most extreme chemical conditions. Their component metals are tightly bound and very difficult to extract. This results in environmentally friendly colors that have low toxicity. Consequently, some of our pigments have been used to color medical devices and cosmetics and many are approved for use in cookware, containers, and other food preparation and storage items.

We invite customers who have questions or need advice or documentation regarding regulatory compliance to call our environmental, health, and safety groups at 513-874-0714.



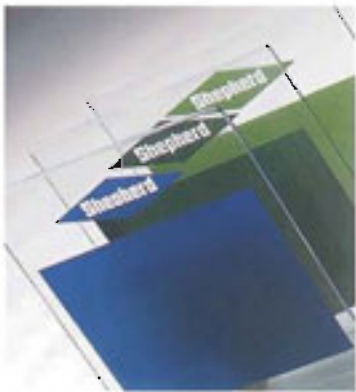


# WORLDWIDE MARKETS



We support our worldwide customer base with a staff of technically trained sales representatives and a global distribution network. Whether they have a single facility or are a multinational with affiliates and licensees around the world, Shepherd customers can expect consistent color, time after time.

Because our products are known for their stability and durability, they're used in a wide range of demanding applications including coil and extrusion coatings, high-temperature industrial coatings, powder coatings, engineering resins, vinyl siding, glass and porcelain enamels, ceramics, fibers, concrete, and artist colors, just to name a few.



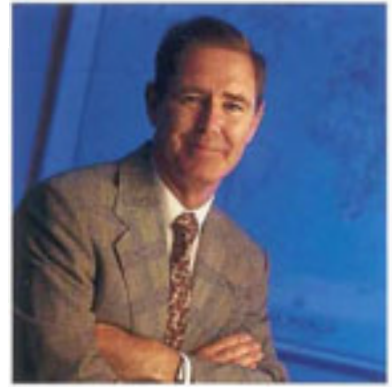
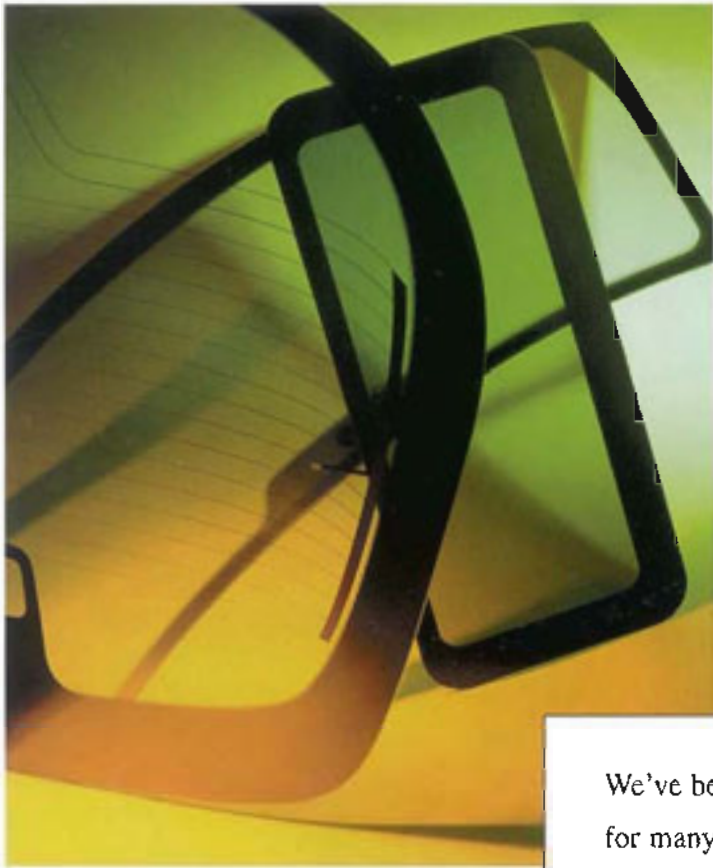
Shepherd Color has been a supplier to the premium coil coating industry from that industry's inception. Our pigments are most often used where coating systems are warranted for long-term color retention

and substrate protection. Such premium coating systems include those based on fluorocarbon, silicone polyester, acrylic, polyester, and vinyl plastisol resins. In powder coatings, our pigments offer the dual advantages of durability and better color control. Our pigments are widely used to make high-heat coatings for mufflers, barbecue grills, space heaters, and wood burning stoves.









We've been a supplier to the vinyl siding industry for many years as well. To prevent premature color fade, PVC manufacturers use Shepherd pigments when preparing long-lasting colored siding. Makers of vinyl window profiles have long used our pigments in their warranted products.

In engineering resins, Shepherd pigments offer heat-stable colors that minimize warpage in large parts molded at high temperatures.

They are widely used to color many types of plastics, including polyolefins, polyesters, polyamides, ABS, polycarbonates, and fluorocarbons.



# SERVICE AND SUPPORT



Outstanding service, customer support, and reliability are fundamental to our business philosophy. We work hard to deliver our products on time and to make sure they perform consistently on a lot-to-lot basis. What's more, we follow-up with technical assistance.

We're happy to custom blend pigments as well, for customers who can't find the hue they're looking for in our extensive product line

or for those who have a specific requirement for a unique application.

But our products are only the beginning. In addition to beautiful colors, Shepherd customers can expect extraordinary service. No matter what a customer's needs, we want to make doing business with Shepherd

Color a pleasure. We want every customer to remember us as polite, friendly, and efficient.

For information and questions about pigment suitability, weathering or other performance characteristics, custom color matching, or pigment applications, please contact us at 513-874-0714.





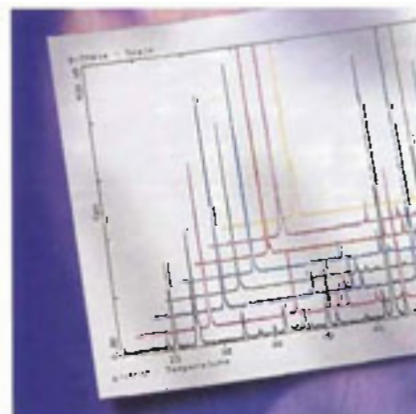


# THE FUTURE



Although we're proud of our pigments, our emphasis on improvement means our research and development team is continually working to develop new pigments for the future. That means creating brighter, purer and even more consistent pigments, as well as pigments with improved ultraviolet, infrared, or processing properties, and colorants with optimal particle sizes.

We recognize that each customer has specific and unique needs. Tell us what you need and we'll get to work on it.





*The Shepherd Color Company*

We Brighten Lives

513-874-0714

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