*Mark Ryan*, Marketing Manager, The Shepherd Color Co, discusses CICPs, a class of pigments, which provide specialised properties for the most demanding applications

# High-performance colour pigments for powder coatings: durable, functional and colourful

We surround ourselves with colour. In fact, our use of colour predates even modern humans. Scientists have discovered that our ancestors, *Homo helmei*, dispersed pigments with an abalone shell and quartz rock into natural resins to produce paints for body adornment[1]. Those earliest pigments were natural ochres. In the intervening eons we have expanded our palette of pigments to include synthetic pigments and organic chemistry based pigments. Still a stalwart of performance are the inorganic pigments and a specific class of these pigments called Complex Inorganic Colour Pigments (CICPs).

CICPs provide interesting options for demanding applications for powder coatings. CICPs provide durable colour that can stand up to the most challenging and aggressive processing and applications. They also have excellent dispersion properties so that colour formulas are predictable and stable during production. Recent advances have found that besides colour, these pigments have properties that give them the ability to address regulatory requirements and give not only colour, but functional properties.

## BACKGROUND

CICPs are a specialised sub-section of pigments as can be seen in **Figure 1**. They are often made from a blend of simple oxides that are then calcined in a kiln from about 600ºC and higher. At these elevated temperatures the metal ions transfer back and forth so that they are no longer simple oxides, but a matrix of one or more metals and oxygen. In this new chemical form they have new properties and are stable up to their firing temperature. After calcining various milling techniques, such as jet mills, ball mills, impingement mills and screening devices are used to reduce the particle size to about one micron.

CICPs, due to their high index of refraction, are inherently good at scattering light. Particle size control and optimisation improves upon these properties. As the particle size decreases the surface area increases, which leads to higher tint strength. With most CICP pigments there is a trade-off between masstone colour and tint strength. For most pigments there is an optimum particle size that balances masstone colour and tint strength. To break the pigment particles into smaller parts takes a large amount of energy. Once that particle size is achieved, the CICP particles disperse fairly easily in common extruding equipment and do not break down further easily. In contrast, organic pigments often will continue to disperse during extrusion, especially if the extrusion step isn't optimised or curtailed by time as it is in powder coating manufacturing. CICPs have the advantage of greater colour control and predictability over organic pigments due to these dispersion and particle differences.

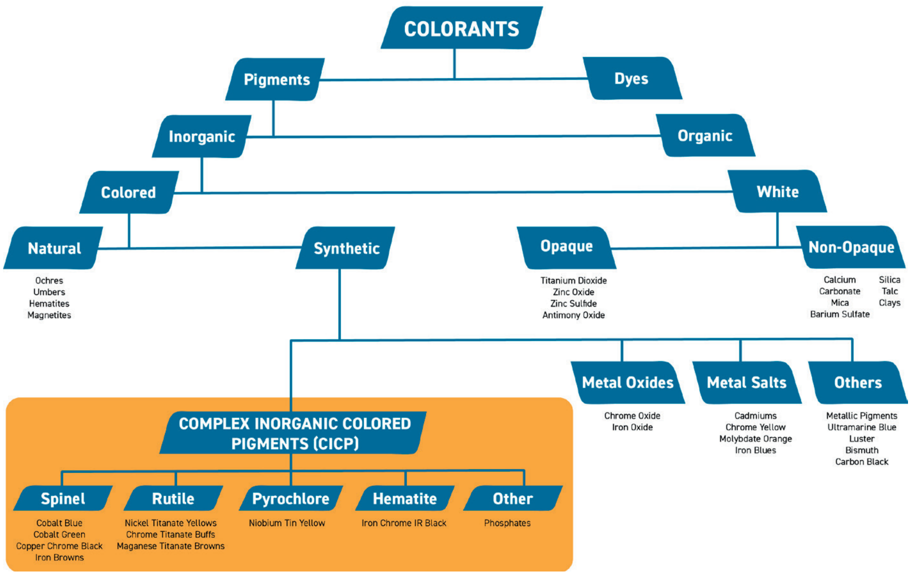

**Figure 1. Diagram of pigment and colourant groups**

CICPs are inert with robust base properties that are inherent because of their inorganic nature and high processing temperatures. CICPs are stable in a wide range of acids, bases and resistant to solublisation and migration in powder coating resin systems. This inherent stability means that the CICPs gain widespread regulatory approval – especially when the inherent insolubility of the pigments means that they are able to pass leaching and extractable testing. This, along with their non-migratory behaviour, means that many of the CICP pigments meet FDA direct food contact materials regulations and some are even approved for use in medical devices.

This inert nature also makes the CICPs the standard pigments for high-durability, long term building products, especially coatings based in high-performance resins like fluoropolymers. While simple oxides are also stable, the CICPs have greater colour range and chromaticity.

Because of their more complex manufacturing and their high-temperature processing, CICPs are higher priced than simple oxides. CICPs are, therefore, used in largely special applications where other pigments fail due to heat, UV, chemical or weathering.

## RANGE OF PIGMENTS

Complex Inorganic pigments come in a wide range of colours, with the notable exception of a true red. They generally lack the ultimate chromaticity of organic pigments but due to higher scattering, they are more opaque. Due to weaker absorption bands, which leads to lower chromaticity, they also tend to have lower tint strengths than organic pigments.

## PROPERTIES BEYOND VISUAL COLOUR

The colour of a pigment is the prime attribute by which we judge the utility of a pigment. CICPs, by their inherent nature and properties can exhibit beneficial properties beyond selectively absorbing and scattering visible wavelengths of light to give the impression of colour. Two of these functional benefits are the inclusion of CICPs into a number of direct food contact approval lists around the world and the near IR reflectivity of visually absorbing pigments.

## FDA FOOD CONTACT APPROVED CICP PIGMENTS

CICP Pigments are excellent pigments for FDA food contact applications because of their high heat, acid and base stability along with their low migration and solubility. There is also increased interest in FDA status of colourants beyond typical food applications. Many entities in the marketplace are seeing the FDA status as a kind of 'safe' label.

Due to changes in the Food Drug and Cosmetic Act (FD&C Act), new approvals for food contact are specifically granted to a pigment chemistry produced by a specific pigment producer[2]. No longer are generic pigment classes, denoted by CI Pigment number, approved across all producers. A colourant producer now receives a Food Contact Notification (FCN) based on a CAS number subject to controlled production methods, with the same raw materials and meeting purity requirements laid out by the FDA. Title 21 CFR 178.3297 lays out definitions and provisions that the FCN is subject to.

There are two new useful and unique approvals to the palette of CICP pigments in the black and blue colour ranges.

The first is in the black colour space and is a very useful tool in colouring high temperature cookware. A PBk26 known in the market place as Shepherd Color Black 20F944 is a better alternative to the commonly used PBk28 (Copper Chromite) based pigments. With a small particle size and strong visible absorption the pigment produces deep masstone black colours that are also heat stable to around 600°C, depending on the system that it is used in.

The second pigment is a green-shade blue PBl36 (Cobalt Chrome

Aluminate). Red-shade blue PBl28 (Cobalt Aluminate) has been approved for food contact approvals for years, but PBl36 known in the market place as Shepherd Color Blue 10F545 opens up a new colour space for CICP pigments in food contact applications. With a deep, dark masstone and a strong, vibrant tint the new addition bridges the gap between the aforementioned red-shade blues and the PG50 (Cobalt Titanate) pigments.

CICPs make excellent colourants for powder coated cookware due to their regulatory approvals and inherent stability.

## ADVANCES AND SPECIALISATION IN IR REFLECTIVE BLACK CICPS

Infrared reflective pigments have been used for decades in various applications. The use of CICPs based on chromium-iron oxide type pigments really started with their use in the early 1980s to keep PVC substrates from being deformed and degraded when exposed to sunlight[3]. These chromium-iron oxide pigments have matured into a wide range of pigments for specialised applications not only in

building products like window profiles but also in a myriad of other applications where solar induced heating of materials can cause issues.

First, a brief summary of these chromium-iron oxide pigments, mainly the CI Pigment Brown 29, and why they are so useful. While our eyes are only sensitive to wavelengths of light from about 400-700nm, the sun's spectrum extends beyond this narrow range. Roughly half of the sun's energy is in the visible (400-700nm) while the other half is in the near-infrared (700-2500nm) with a few percent in the highly damaging 295-400nm UV range. A black pigment has to absorb in the visible range for colour, and most, like carbon black, continue this absorption into the near-infrared. Chromium-iron oxide (PBr29) based black pigments (IR Blacks) absorb in the visible so that they are dark in colour, but around 700nm they start to reflect. When we look at the total solar range of 295-2500nm, a standard black will only reflect about 5% of the sun's total energy, while an IR black will reflect in the mid-to-high 20%. We say that the standard black has a Total Solar Reflectance (TSR) of 5% (or 0.05) while the IR Black pigments would have around a TSR of 28% (or 0.28). This TSR can be read by a spectrophotometer. The effectiveness of the pigments can also be tested by using a device that will show the difference in heating a test panel that contains different pigments.

By the late 1990s, programmes like the EPA Energy Star and later USGBC LEED programme and California Energy Commission's Title 24 building code, among others, added reflectivity requirements for steep-slope roofing. At this point the market for these IR blacks is divided into masstone optimised blue-shade blacks and warmer tone products with higher tint strength.

The IR Reflective blacks continue to be one of the 'hottest' topics in pigments today. The CICP IR Black pigments are the workhorses that provide high IR reflectance, durability, economical use and a broad range of properties that can be tailored to specific applications.

## CONCLUSIONS

CICPs provide specialised properties for the most demanding applications. Their heat stability, inertness, weather-stability and ease of dispersion make them the best option when other colouring pigments fail. Besides these colouristic properties, the CICP family of pigments, because of their inert nature, finds wide regulatory approval as seen in the FDA direct food contact listings. The CICPs also have interesting near-IR properties that make them useful in building products and signal management for military camouflage.

While inorganic pigments have been used since the caveman era, advances continue as seen in the new NTP Yellow (PY227) and improved RTZ Orange (PY216). New pigment chemistries and applications continue to be found.

PPCJ


**References**

1. "If this is Man" *The Economist*, Dec 20, 2005, http://www.economist.com/node/5299185
2. FDA Website: https://www.fda.gov/food/packaging-food-contact-substances-fcs/inventory-effective-food-contact-substance-fcs-notifications
3. United States Patent No. 4,424,292. "Infrared reflecting vinyl polymer compositions". Ravinovitch *et al.* 1984.



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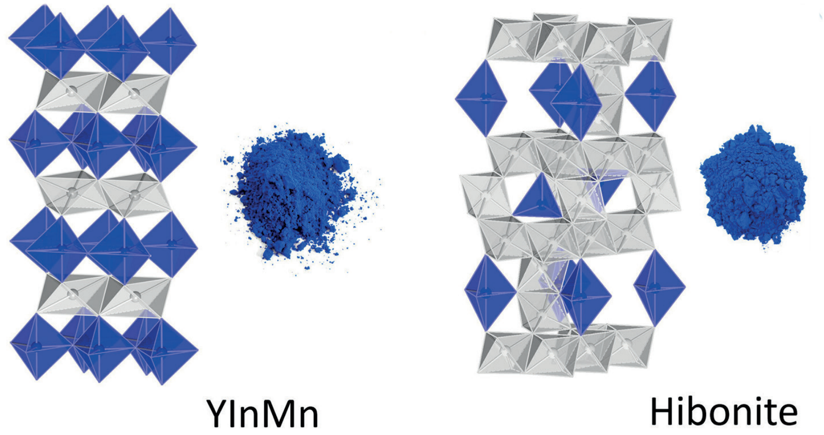
# Blue pigment discoverer makes key design advance for future durable, vivid pigments

An Oregon State University chemistry researcher who made history a decade ago with the accidental discovery of the first new blue inorganic pigment in more than two centuries is again pushing forward the science of colour.

Analysing the crystal structure of pigments based on hibonite, a mineral found in meteorites, Mas Subramanian of the OSU College of Science has paved the way toward designing more pigments that are stable, durable and non-toxic with vivid hues. Findings from the study, supported by the National Science Foundation, were published in the American Chemical Society journal, *ACS Omega*.




Subramanian and his team discovered YInMn blue in 2009 when they were experimenting with new materials that could be used in electronics applications.

"We got lucky the first time with YInMn blue and now we have come up with some design principles," Subramanian said.

Through much of recorded human history, people around the world have sought inorganic compounds that could be used to paint things blue, often with limited success. Most had environmental or durability issues.

"Most pigments are discovered by chance," Subramanian said. "The reason is because the origin of the colour of a material depends not only on the chemical composition, but also on the intricate arrangement of atoms in the crystal structure. So someone has to make the material first, then study its crystal structure thoroughly to explain the colour."

Before YInMn blue, the last blue discovery was cobalt aluminium oxide-based blue, synthesised by a French Chemist in 1802. Cobalt blue remains a dominant commercial pigment because of its intensity of colour, ease of synthesis and wide applicability.

Its production, however, requires a significant amount of a cobalt ion, $Co^{2+}$, that's hazardous to both humans and the environment.

By analysing the structure of hibonite-based blue pigments, Subramanian has developed a way to match or surpass cobalt blue's vividness, while using much less of the harmful carcinogenic cobalt ion, or replacing it entirely.

The hibonite-based pigments are more thermally stable than cobalt blue due to their higher preparation temperature and remain unaltered structurally and optically upon exposure to strong acid and alkali.

The researchers report that an oxide containing calcium, aluminium, titanium along with cobalt or nickel can crystallse into a structure similar to hibonite that allows for a series of blue colours.

Compared to traditional cobalt blue, the new blue can be "tuned" by adjusting how much cobalt ($Co^{2+}$), nickel ($Ni^{2+}$) and titanium ($Ti^{4}$+) are placed into the hibonite structure's three possible "chromophore" environments; those are the parts of a molecule that determine colour by reflecting some wavelengths of light, while absorbing others.

This study shows the presence of chromophores in a "trigonal bipyramidal-shaped crystal environment" – essentially consisting of two triangular-base pyramids joined base-to-base – is critical for colour enhancement.

"This part of the crystal structure of hibonite, like YInMn blue, allows for vivid blue colours with a reddish hue," Subramanian said. "The hibonite blue exhibits better energy-saving, heat-reflecting properties than traditional cobalt blue due to the presence of titanium and less cobalt content.

"In nature, hibonite is only found in meteorites that have been subjected to thousands of degrees of temperature when they go through the Earth's atmosphere, so it makes sense that the structure is remarkably stable," he added. "These kinds of mineral structures are probably the future for designing durable and safe inorganic pigments."

Determining the key structural ingredients required for making vivid colours should allow for shorter times between pigment discoveries, Subramanian said, adding that science doesn't always follow a prescribed path.

"Research is like when you go on a journey to see something and maybe when you get there it wasn't as interesting you thought it would be, but what you saw along the way was more interesting than you could have imagined."

# Presenting: DCL Corporation

DCL™

*See The Difference We Make*

In April 2018, HIG Capital combined two leading pigment suppliers, Dominion Colour Corporation & LANSCO Colors, to create a global leader in the supply of colour pigments and dispersions for the coatings, plastics and ink industries. Now the company has a new name for this industry vanguard. Presenting DCL Corporation.

The new company name – DCL – combines letters that represent its strong legacy, while at the same time starting an exciting new chapter for the company. Its new logo visually demonstrates this by using a modern, geometric pattern made from a rainbow of colours representing its vibrant pigment and dispersion business. DCL will continue its heritage of innovation and will be a world class supplier to colour consuming industries around the globe. With its tagline it asks you to “See the Difference we Make”.

“With world-class manufacturing, research and technical service labs and sales offices around the globe, we are poised to rapidly respond to customer needs and make a positive impact,” said Chuck Herak, CEO of DCL Corporation. “DCL Corporation is large enough to compete on a global stage by servicing multi-national customers, while still being responsive to the needs of our small and medium sized customers all over the world,” he added.

Guided by commitments to quality, health and safety, and protection of the environment, DCL’s century of experience and agility to meet customers’ demands combined with an innate ability to create tailor-made solutions separate them from the competition. This capability along with a dedication to customer satisfaction, innovation and long-term sustainability is what DCL calls “the DCL difference.”

**www.pigments.com**

## C&G Pigment establishes European subsidiary

C&G Pigment, a leading marketing company for inorganic pigments, has registered a subsidiary in Leverkusen, Germany. The company establishes a European presence to market its product portfolio from well known Chinese pigment manufacturers throughout the continent.

C&G Pigment with its strategic portfolio of iron oxide, titanium dioxide and carbon black pigments, has announced the opening of a German subsidiary under the name of C&G Pigment Europe GmbH. The company serves as a platform to offer the product portfolio and logistics services to the customer base on the European continent. It is located in Leverkusen, Germany and will be managed by Mr Axel Schneider who has been appointed Managing Director.

“Even though the competitive landscape in Europe is very intensive, we are convinced of the potential this market holds for us,” says Jiming Cai, founder and owner of C&G Pigment. “Our partners are keen to develop their business into this market and support us in the best possible way. So we are pleased to move ahead with a full pigment focus in order to provide expertise and solid added value to the European users.”

**www.cg-pigment.com**

## Symic A for trendy matte effects and intense combination gold

Structureless matte effects are currently very much in vogue: Symic A 502 and A 522 synthetic pearlescent pigments from Eckart produce earthy bronze and copper shades with a velvety sheen.

The new Symic A 393 enriches the A range with its distinctive, brightly coloured combination gold.

With a particle size of 1-15μm, the A fraction represents the finest pigments from Eckart’s Symic  product family. Symic  A 502 and A 522 are a visually very attractive combination of the gentle sparkle of pearlescent pigments and strong earth tones.

Due to its synthetic mica base, Symic  is ideally suited for both pearlescent colour accents and intensive full tones. Symic pigments are characterised by their intense effects and colour purity.

Technically, they convince through their easy processing in all common aqueous and solvent-based systems, their ideal intercoat adhesion and their extremely long durability. Eckart recommends the pigments primarily for decorative interior applications.

**www.eckart.net**