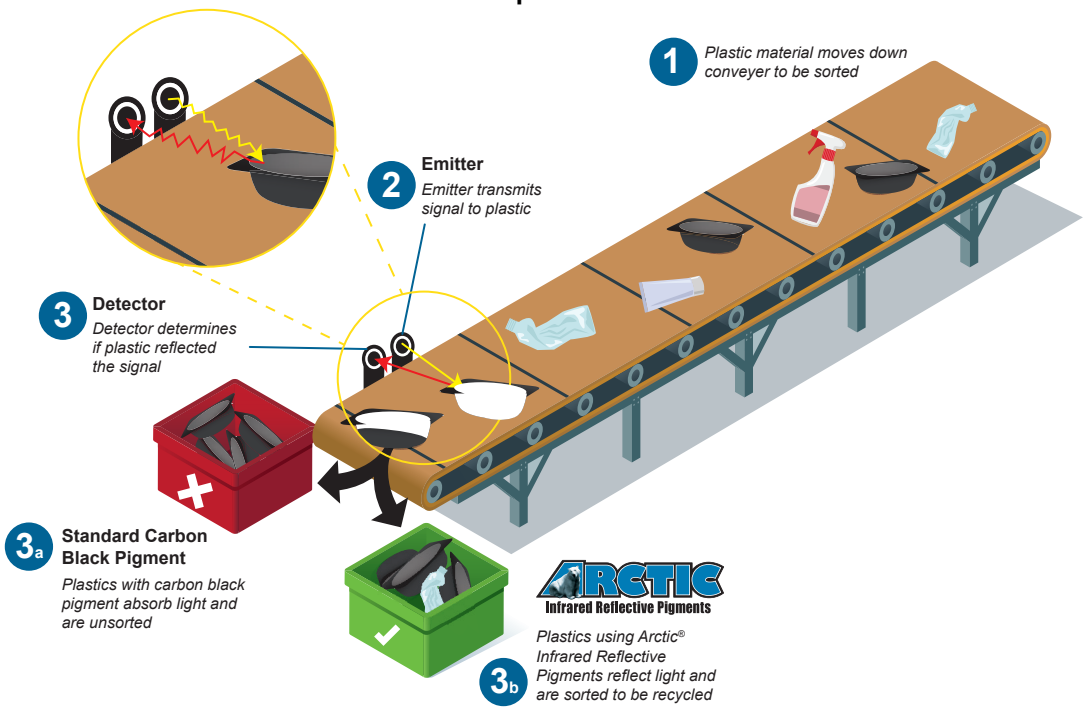
Removing the Black Hole in Plastics Recycling

Arctic® Infrared Reflective Pigments allow for a more sustainable solution to black plastic recycling

THE PROBLEM

One of the major benefits of plastics and a big part of its sustainability is that they can be recycled. This benefit is optimized when the recycle stream can be sorted by polymer type as seen in Graphic 1. A common sorting method uses near-infrared (NIR) light from 700 to around 2000 nanometers (nm) to scan the plastic. The reflected NIR light can be used to identify the polymer. Carbon black is the most commonly used black pigment for many applications, including the coloration of plastics. It is economical, has high coloring and visual opacity properties and acts as a UV absorber. The problem is that the carbon black pigment interferes with the reflectance by absorbing the NIR light which makes identifying the polymer impossible. This impedes the recycling of up to 10% of plastics at some facilities[1]. If the material can't be recycled it will often end up in a landfill. Since black is a very popular color for packaging, especially food tray packaging, a black pigment is needed that doesn't interfere with the NIR scanning and has regulatory acceptance for food packaging.

NIR Sorting of Plastics
Graphic 1

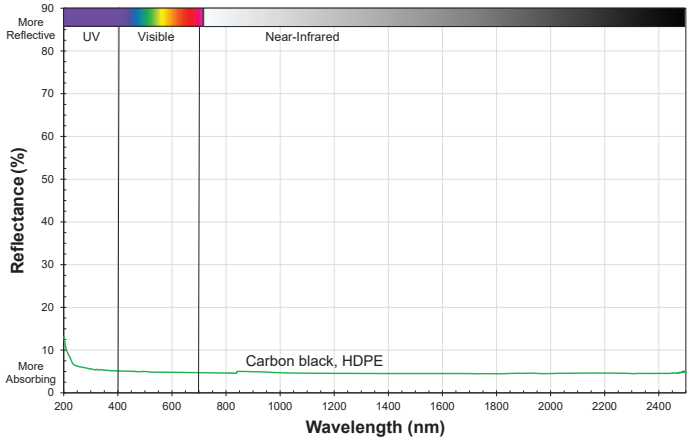


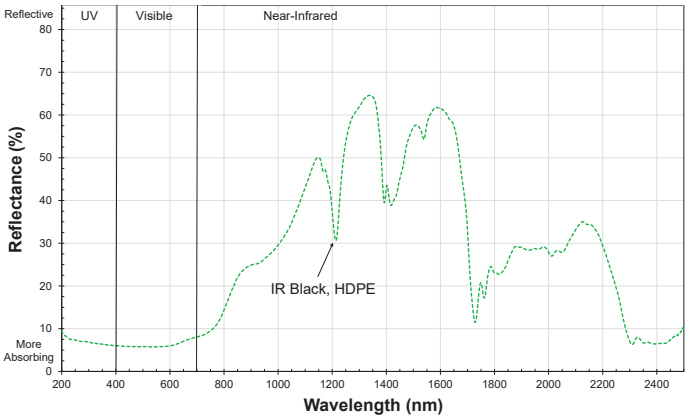
THE TECHNOLOGY

Light can be divided into three areas. There are the visible wavelengths from 400-700nm that we use to perceive color. On either side of the visible wavelengths are the areas invisible to the naked eye. Ultraviolet light (UV) has wavelengths less than 400nm, and the NIR whose wavelengths extend from 700 to about 2500nm.

Standard carbon black pigments absorb all wavelengths and their reflectance curves are flat across the UV-VIS-NIR range masking the identity of the colored plastic. Special black pigments stop absorbing around the 700nm boundary between the visible and NIR regions and instead reflect NIR energy. The difference in reflectance curves can be seen in Chart A that shows the flat reflectance curve of carbon black pigment that absorbs over the visible and NIR wavelengths and Chart B with the IR Black pigment that absorbs in the visible for dark color and reflects in the NIR wavelengths.

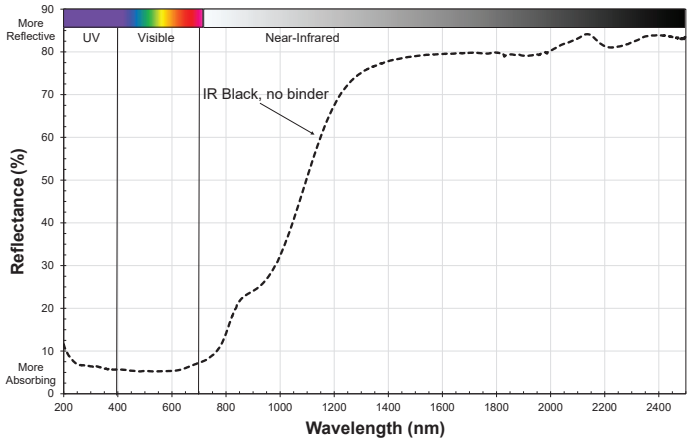
Reflectance Curves Black vs IR Black Pigment
Chart A & B

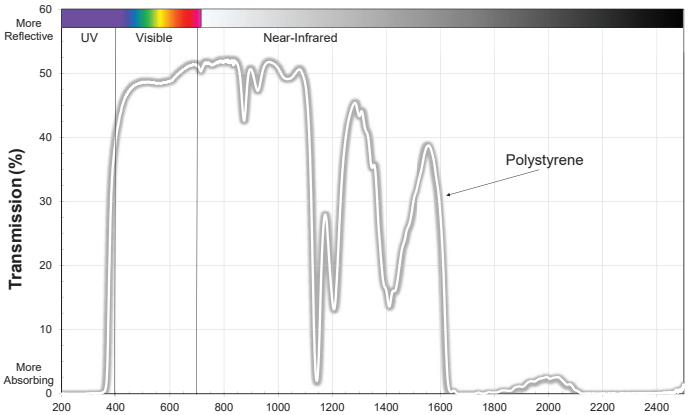




In Charts A&B, the pigments are tested in HDPE. You can actually see the reflectance curve of the IR reflecting black by itself, formed into a round chip by extreme pressure without any plastic binder (Chart C). This removes the influence of the plastic on the binder. The reflectance curve of the pigment by itself is smooth and relatively free of peaks and valleys that would denote areas of absorbance. In Chart D, we see a curve for polystyrene (PS) plastic without any pigment in it. We look at the transmission instead of the reflectance because the resin is clear. In the visible wavelengths, the high and consistent level of transmission shows that the plastic is clear and neutral in tone. In the NIR wavelengths you can see the peaks and valleys that denote areas where the PS absorbs certain wavelengths. These areas of absorbance vary from polymer to polymer, while the consistent and high reflectance of the IR black allows these differentiated areas of absorbance for each resin to be seen.In Chart E, the you can see that the dips in the reflectance curve of the pigmented plastic correspond to valleys in the NIR section of the curve of the PS by itself. These areas of absorbance vary from polymer to polymer while the consistent and high reflectance of the IR black allows these differentiated areas of absorbance to be seen.

Reflectance Curves of IR Black Pigment vs Unpigmented Resin
Chart C & D

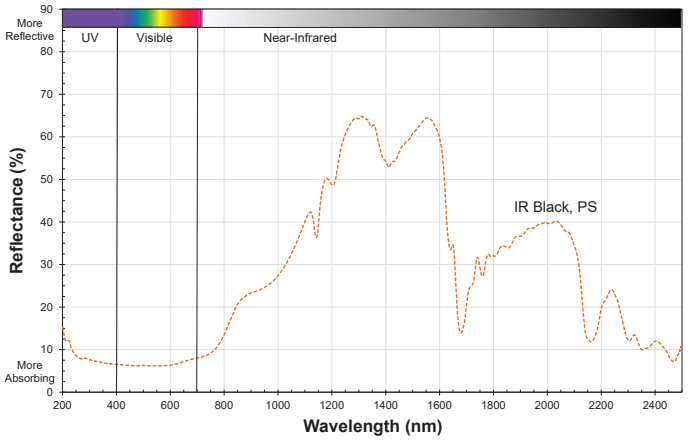




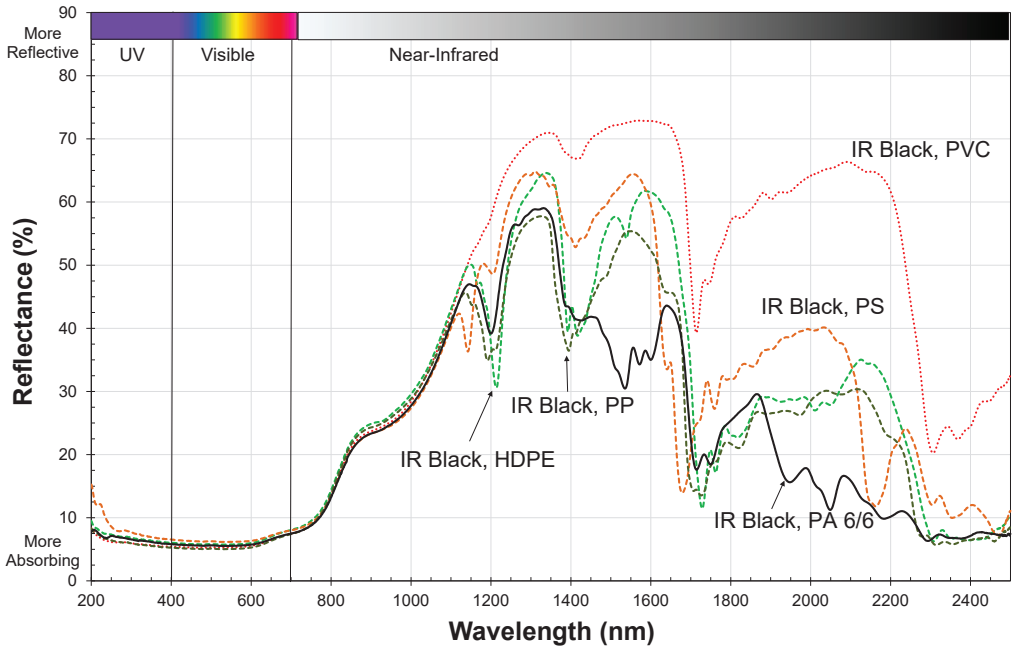
In Chart E, you can see that the dips in the reflectance curve of the pigmented plastic correspond to valleys in the NIR section of the curve of the PS by itself. These areas of absorbance vary from polymer to polymer while the consistent and high reflectance of the IR black allows these differentiated areas of absorbance to be seen.

The three regions (UV, VIS, and NIR) can be seen in CHART F along with the reflectance curves of five plastics (PP, HDPE, PS, PVC and PA) all pigmented with NIR black pigments. The higher the curve, the more reflective the plastic at that wavelength. All the plastics absorb in the UV region, providing protection to the plastic and any materials in the packaging. All the curves show low reflectance (high absorbance) in the visible (400-700) wavelengths. By absorbing the visible wavelengths, the plastic appears black. Once past the visible wavelengths, the NIR wavelengths (700nm+) are invisible to our eyes. Whether the pigment absorbs or reflects in the NIR has no effect on our perception of color, but these are the critical wavelengths needed to identify the plastic.

Reflectance Curve of Pigmented Plastic
Chart E



Reflectance Curves of IR Black with Various Resins
Chart F



The reflectance curves of the five different plastics with the IR black pigments have differences in reflectance at various wavelengths. By analyzing the relative reflectance values at key NIR wavelengths, the polymer type can be identified.

This means that plastic pigmented with these special NIR black pigments can have the visual color desired *and* the NIR properties to allow the 'fingerprint' of resins in the NIR to be seen. If the plastic can be identified and sorted, it can be recycled properly and not sent to a landfill.

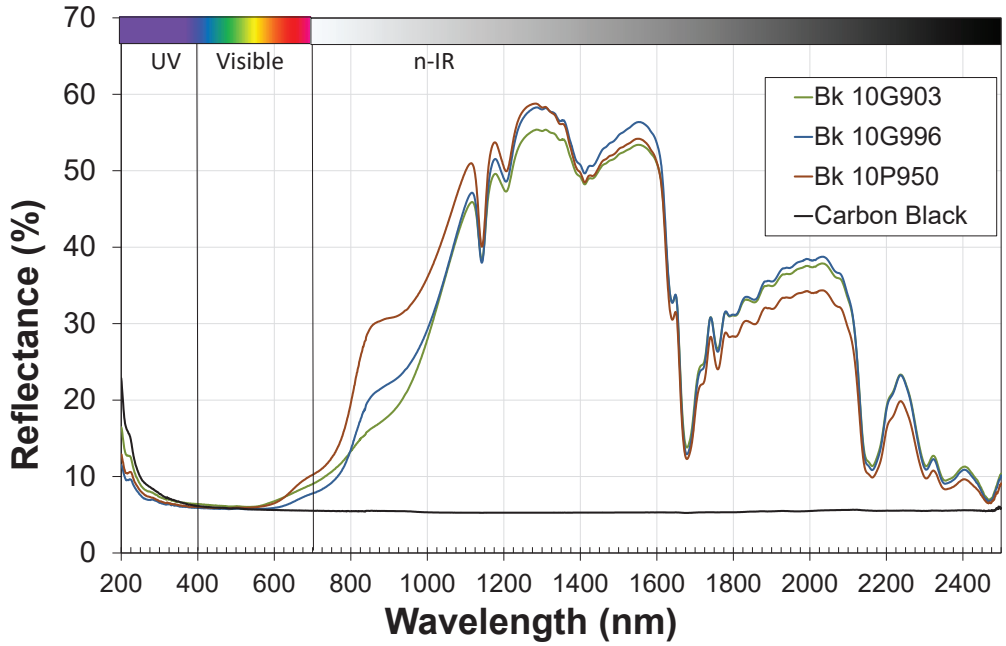
YOUR SOLUTION

These pigments with the specific visible absorbance for dark color and NIR reflectivity are known as 'IR pigments". The Shepherd Color Company has spent the last 40 years developing, optimizing, and manufacturing IR black pigments for the plastics industry. We call this technology Arctic® Infrared Reflective Pigments, because they were first used in plastics to reflect the sun's IR energy and keep materials cooler. Based on this depth of knowledge and expertise, we are able to offer pigments that have the right IR properties for this new application.

These Arctic pigments:

- Are incredibly inert and stable
  - Heat stability (>1500F/800C)
  - UV stable
- The IR properties are inherent in pigment chemistry
  - IR reflectivity will not degrade over time
  - IR properties and pigment will not migrate out of plastic
- Wide resin compatibility
  - Non-warping in polyolefins
  - Compatible with wide range of resins

Reflectance Curves of IR Blacks vs Carbon Black
Chart G



Improving the recyclability of plastics, the key is to not absorb in the IR wavelengths (see Chart G), but rather reflect (scatter) or transmit the IR energy. Shepherd Color pigments have both properties which allow IR systems that are based on reflective or transmitting sensors to properly identify polymers. Shepherd Color has a range of Arctic black pigments with different coloring properties for specific applications.

- Our Arctic Black 10G996 has a jet masstone color and excellent IR reflective properties to color OEM black plastic.
- The Arctic Black 10P950 is a warmer toned black, with excellent coloring strength for addition to previously recycled colored material to darken and standardize the color while preserving the IR properties for the next time the plastic is recycled.
- Arctic Black 10G903 is a balance between the other two pigments in both masstone color and tinting strength, with slightly lower IR reflectance.

REGULATORY COMPLIANCE

Shepherd Color Arctic IR pigments inherent inertness leads to a wide range of regulatory approvals. The Arctic pigments are globally available in almost all chemical registries. They have a wide range of food packaging approvals based on their stability and non-migratory nature.

Regulatory approvals include:

- BfR (German food contact materials)
- AP(89)1 (Council of Europe Resolution on use of colorants in plastics)
- AS 2070-1999 (Australian Standard for plastics in food contact)

Not listed, but meets purity requirements:

- French Positive List
- GB9685-2016 (Chinese food contact regulations)
- US FDA testing underway

TECHNICAL ASSISTANCE

The invisible NIR wavelengths are critical to the performance of the materials, but they cannot be directly observed and has been likened to having to match colors while being blindfolded. Furthermore, when pigments are blended together to adjust visible color, the NIR wavelength reflectivity also changes. Shepherd Color has decades of experience in the use of IR reflecting pigments in a wide range of polymer systems. We have the resources and capability to read the critical NIR wavelengths and help formulate pigmentation strategies to balance the visible color and NIR properties. This assistance can help you develop and commercialize NIR compliant products quickly.

Besides the spectral properties in the visible and NIR, this application often involves regulatory issues around food packaging requirements. Navigating these requirements on a global scale is made easier through Shepherd Color's expertise and knowledge of the regulations and how our pigments can be incorporated into compliant solutions. Direct access to our subject matter experts reduces development time and increases confidence in the applicability of the pigment for the application.

CONCLUSION

Increasing the recycling of plastics depends on a wide range of variables. One key technological hurdle is the sorting of black materials in the recycling stream. While standard black pigments impede the sorting of these plastics, IR reflective pigments like Shepherd Color's Arctic pigments allow the identification and sorting of dark colored plastics. Shepherd Color also has technical and regulatory expertise to help plastics companies develop and commercialize this new sustainable technology.

ABOUT THE SHEPHERD COLOR COMPANY

Founded in 1981, The Shepherd Color Company produces a wide range of high-performance Complex Inorganic Color Pigments (CICPs) used in a variety of industries. These pigments are an extraordinary class of inorganic pigments that offer stable, long-lasting color for many applications. They have unbeatable weatherability, heat and chemical resistance, are non-warping and easy to disperse. *More Expertise. Better Performance. Best Value.* ***That's Shepherd Color.***

[1]September 2011; *"Development of NIR Detectable Black Plastic Packaging"*; page 31; www.wrap.org.uk

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