



# The new carbon black and its role in the United States manufacturing renaissance

FEATURE

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**From the dawn of civilization, carbon black has been a component of humankind's tool chest. Carbon black production methods and morphology have changed over the eons to become more efficient, less polluting, and higher performing in the markets that carbon black serves.**

Carbon black is the oldest man-made nanoparticle. A rough description compares carbon black to an aciniform-type morphology, which resembles a bunch of grapes. The individual "grapes" are the primary particles and the entire bunch is referred to as the aggregate. The dimensions of the "grapes" are less than 10–300 nm and the dimension of the aggregate is 100–800 nm. The interstitial volume created by the grapes that are covalently bound to each other creates the advantageous interaction with polymer systems that can penetrate these void volumes.

If you take a second to look around the room you will notice that carbon black is everywhere. Anything that is black and plastic, anything that is printed in black color, and anything that is black

and made out of rubber will have carbon black present. In plastic, carbon black imparts not only black color, but also provides electrical conductivity and some minor improvements in strength and toughness. The current amount of carbon black that is compounded into plastics is 800,000 tons per annum.

Carbon black is no new comer to the industrial work sector. Roman text from Vitruvius described the process in detail to produce an incomplete combustion product from the resin of pine trees. The resulting black powder would be mixed into gum Arabic for writing inks and also mixed with glue for mural paintings to be on display throughout the Roman cities of antiquity. Over the years, the processes to produce carbon black evolved to make a



FIGURE 1

Samples of Monolith carbon black prior to shipment to customer.

variety of other types of carbon black, including lampblack, thermal black, and a variety of other blacks from the carbon black family. From the days of the ancients to the mid-19th century, the common feedstock was aromatic oils, such as pine resin.

During the mid-19th century, a new process was developed that utilized natural gas impingement on iron channels to produce carbon black. This process was coined the channel process and it quickly became the most prominent carbon black production method. The black was blacker, a term referred to as jetness in the industry. This increased jetness is due to smaller primary particle size that is enabled by the channel process and is a very attractive property when carbon black is used as a pigment. Up until 1912, the main use of carbon black was as a pigment in plastics, paints, and other media. In 1912, an English rubber compounder named S.C. Mote discovered that carbon black imbued the filled rubber compound with better tensile strength, better crack resistance and a variety of other improvements over the rubber compound that did not contain carbon black.

The date of this discovery is quite ominous as this occurred on the eve of the start of World War I. Zinc oxide had been used as a reinforcing agent in tires, however, zinc is a component of brass and was needed for bullets, munition, and armament components. This set the stage for carbon black to move from a small black pigment business to a global industrial specialty chemical business. The volume of carbon black supplied to the market sextupled from 1915 to 1924 as a result of this new innovation, and the volume would continue to grow over time as carbon black piggy-backed onto the automobile revolution.

A few years later, in the early 1940s, a new process would be developed that would again revolutionize the carbon black industry. The furnace process utilizes the heaviest components of the oil distillation process known as Pyrolysis Fuel Oil (or PFO), and burns or combusts this oil at high temperature utilizing a methane pilot flame. At the time, PFO was a waste product that had no other uses. As the heaviest component of the oil distillation process there were catalyst fines, sulfur, minerals and other impurities with the heavy hydrocarbon as well. These impurity components wind up in the product carbon black and result in a carbon black that is close to 96–97 percent carbon.

The advantages of the furnace black process over the channel process were manifold. The furnace process was cleaner, collecting more than 40–50 percent of the input carbon compared to 10 percent for the channel process. The process was more economic; natural gas was much more expensive than PFO and the process cost was very similar. The product was better; furnace black was blacker and reinforced rubber better than channel black. The entire industry was overhauled; within 30 years only 10 percent of the product carbon black would be made by the channel process.

Today, Monolith Materials has developed a plasma based process to make carbon black from natural gas. The process is cleaner; Monolith emits 70 percent less CO<sub>2</sub> and around 100 times less of NO<sub>x</sub> and SO<sub>x</sub> compared to the furnace process. The process is more economical; natural gas is plentiful and abundant, and over the years, chemists and petroleum engineers have devised other uses for PFO. It can now be further cracked or used as is to create other products. A former waste product, PFO now tracks the price of commodity oil in lock step.

The new carbon black is 99.5 percent or greater carbon compared to around 96 percent carbon for the furnace process. There is less sulfur, ash, oxygen, and hydrogen in the new carbon black produced by Monolith. This enables Monolith's new material to satisfy both commodity and specialty markets in a way that furnace black simply cannot.

Monolith is part of the reinvigoration story of the American manufacturing industry with the 200,000 ton per year plant in Hallam, Nebraska. A portion of this plant will come online in 2018 and full capacity will be reached in late 2019. Just outside of Lincoln, Hallam is the ideal location with the capability to supply carbon black from America's heartland, centered at the confluence of railway and natural gas hubs.

The carbon black industry used to be predominantly stationed in North America; however, in the last 30 years the geographic manufacturing shift to Asia has reduced United States production to less than 20 percent of the global output. With plentiful natural gas located in the United States and the newly developed environmentally friendly plasma process to produce carbon black, the United States appears to be a prime candidate to retake its mantle as the global leader of carbon black production in the 21st century.

Additionally, tire manufacturers and rubber compounders are building capacity in the United States. For the first time in 30 years, a carbon black plant has been built in the United States at Monolith's Redwood City pilot plant location. The furnace process, while cleaner than the channel process, still produces enough pollution that the EPA will not allow a permit to build a new furnace process plant on American soil. Increased rubber and plastic compounding capability in the United States and Monolith's development of the new carbon black could not have occurred at a better time. While American tire manufacturers and plastics compounders have been concerned about importing carbon black from dubious Russian and Chinese suppliers, Monolith has been finalizing the plasma based technology and beginning the buildout of one of the largest global carbon black plants here in the heart of the USA.

Since the 1940s, the carbon particle market has exploded with new morphologies, including nanotubes, buckyballs, carbon fibers, graphene and pyrolysis black. Carbon fibers have been the most successful of the new entrants in the field of functional reinforcement, while nanotubes and buckyballs have had difficulty due to toxicology uncertainty and high manufacturing prices. Pyrolysis black is a recycled product made through the tearing apart and pyrolysis of rubber tires. It is a mixture of grades of carbon black and the interstitial rubber cannot be removed, which eliminates one of the prime advantages of traditional carbon black in polymer composites. Pyrolysis black claims the title of green carbon black, however, the energy input into the system to pyrolyze the oil and purify the ingredients puts the process in the gray zone of whether or not it is environmentally friendly. Graphene is new and holds great promise; however, it is unclear if graphene will ever be cost competitive with carbon black.

Monolith's carbon black is different from these alternative carbons and is in fact very similar to furnace black. Monolith has the capability to make the majority of the different grades of carbon black in the same way that furnace black can make the

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