Specialty carbon blacks for industrial coatings

Technical Information 1458

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Contents

1 Introduction

Carbon blacks are used in a wide range of applications, mainly in the rubber and tire industry. Approx 10 % of the worldwide production of carbon black is used for printing inks, polymers or coatings. This technical information is focused on the usage of specialty carbon blacks in industrial coatings, especially in mass tone applications. Additionally, the technical information TI 1459, focuses on the tinting behaviour of specialty carbon blacks.

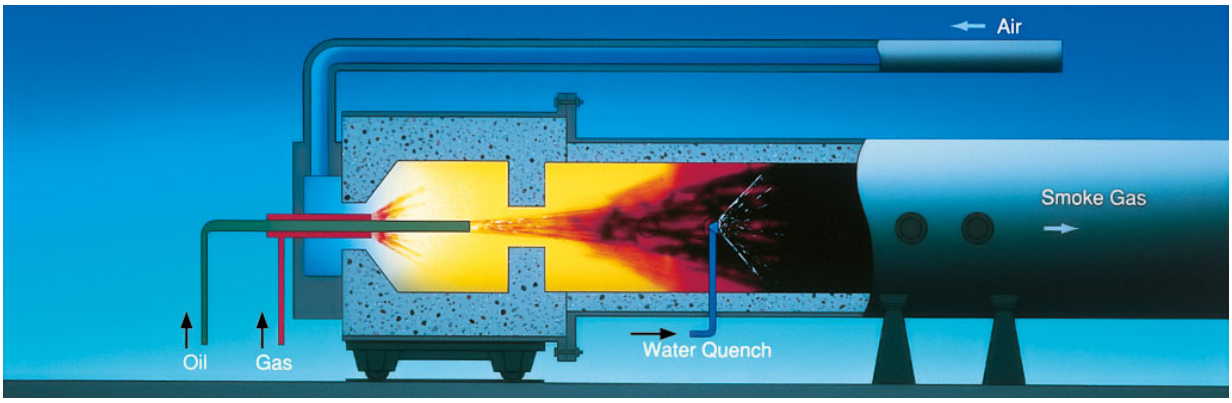
2 Manufacture and delivery

2.1 Manufacture processes

The furnace black process (fig. 1) is the most common pro duction method (95 % worldwide). In this technique specialty carbon black is produced in a closed reactor (furnace) under a defined atmosphere. The temperature necessary for pyrolysis is achieved by combustion of appropriate gases; the raw material is injected into the combustion chamber through a lance. After the formation of specialty carbon black, the process mixture is quenched by injection of water; this prevents any secondary reactions. The furnace process allows the particle sizes and structural properties of the product to be varied within wide limits.

Figure 1

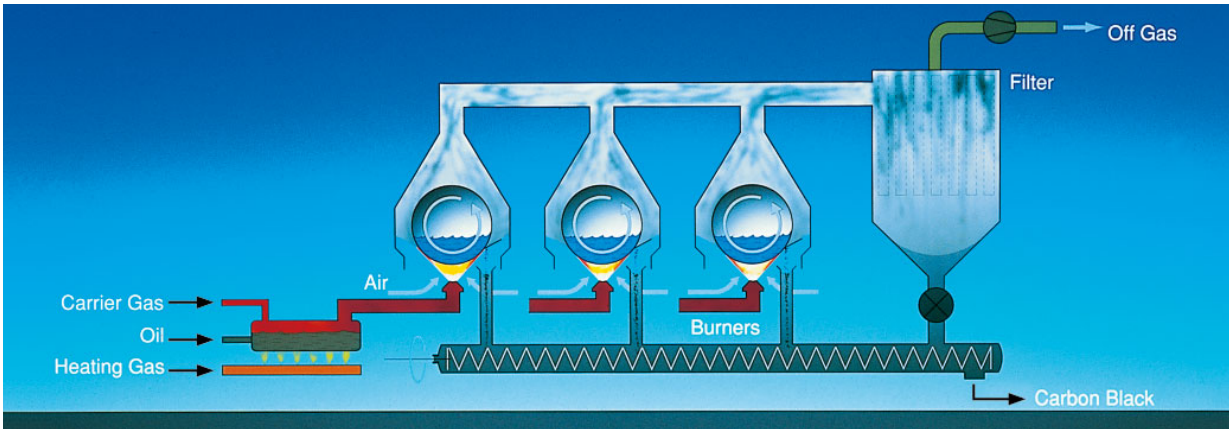
Furnace black process



In contrast to the furnace black process, during the Degussa gas black process pyrolysis occurs in the presence of atmospheric oxygen. This means that the gas black Process uses an open reactor (fig. 2), which is reflected in the volatile content of the resulting pigment surface. The process derives its name from the fact that the specialty carbon black feedstock is vaporized using heat and is then fed into the combustion chamber by means of a carrier gas. The specialty carbon blacks produced by this method have smaller particles. The particles' sizes can be varied in the production process, but the structure cannot be influenced.

Figure 2

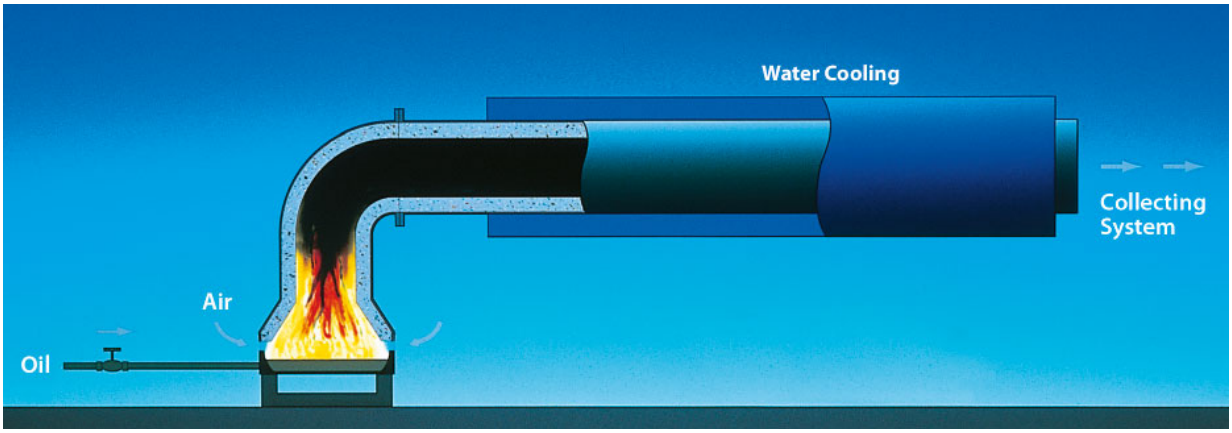
Degussa gas black process



The origin of specialty carbon black production is the lamp black process (fig. 3). In this case the raw material is placed in large pans and then vaporized using the heat that is radiated from the covering hood before pyrolysis. The lamp black process is also considered as an open process with access to atmospheric oxygen, to a certain extent through a gap between the combustion pan and the exhaust hood. The particle distribution in a relatively wide range is predominated by large specialty carbon black particles.

Figure 3

Lamp black process



The particle size determines the intensity of blackness, known as jetness or optical density. Specialty carbon blacks are classified according to an internationally recognized system, which signifies the manufacturing process and the jetness. The first two letters indicate the strength of the pigment: High color (HC), medium color (MC), regular color (RC) and low color (LC). The final letter describes the manufacturing process: Furnace (F) and the gas black (G) processes [1].

2.2 Delivery forms

Gas and furnace blacks are produced as loose powders. If in a production plant only low shear dispersers such as three roller-mills are installed, a powdered delivery form is recommended. Powdered specialty carbon blacks have very good dispersion properties. Additionally, dry beaded specialty carbon blacks are offered for the coatings industry. They are recommended for high energy equipment like pearl mills or ball mills. Advantages of dry beads are a lower dusting, higher density and improved economics.

A third process (wet granulation) produces large stable granulates which also offers almost dust-free handling. However, they are unsuitable for use in the coatings industry because of their high mechanical stability.

3 Properties of specialty carbon black

3.1 Primary particle size

The primary particle size has the main influence on color properties. A finer particle size leads to a higher jetness (blackness) and higher viscosity. Additionally, an increased dispersion energy is required. Furthermore, the undertone is influenced by the primary particle size. The smaller the particles, the deeper the bluish undertone. Moreover, the tinting strength increases when using finer particle sized specialty carbon blacks.

Figure 4

Jetness tested in the alkyd-melamine formulation (following DIN55979) of various specialty carbon blacks in correlation to the primary particle size (mesuared by the internal method TGZ3)

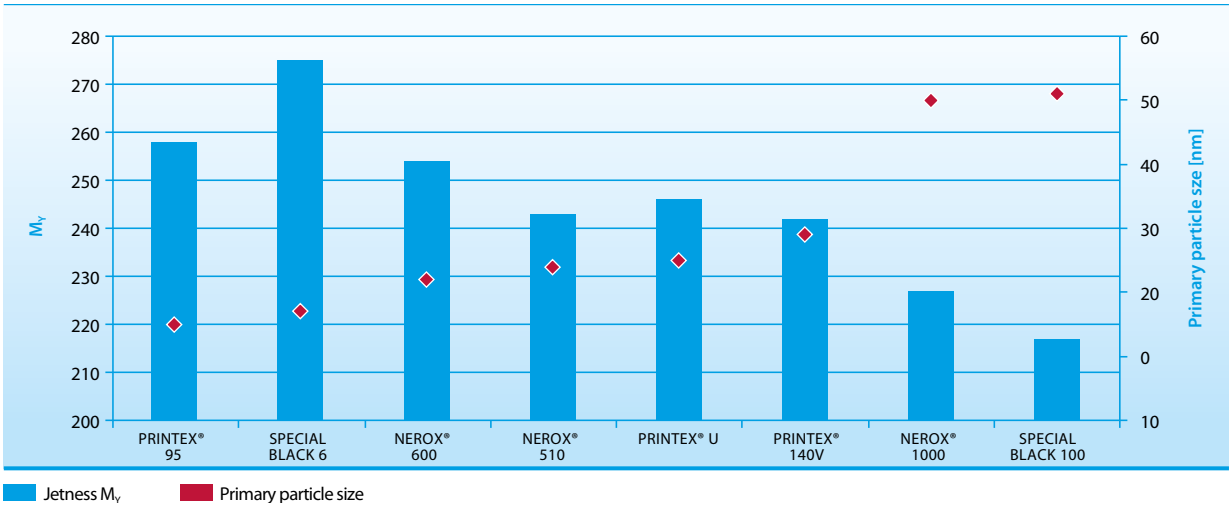
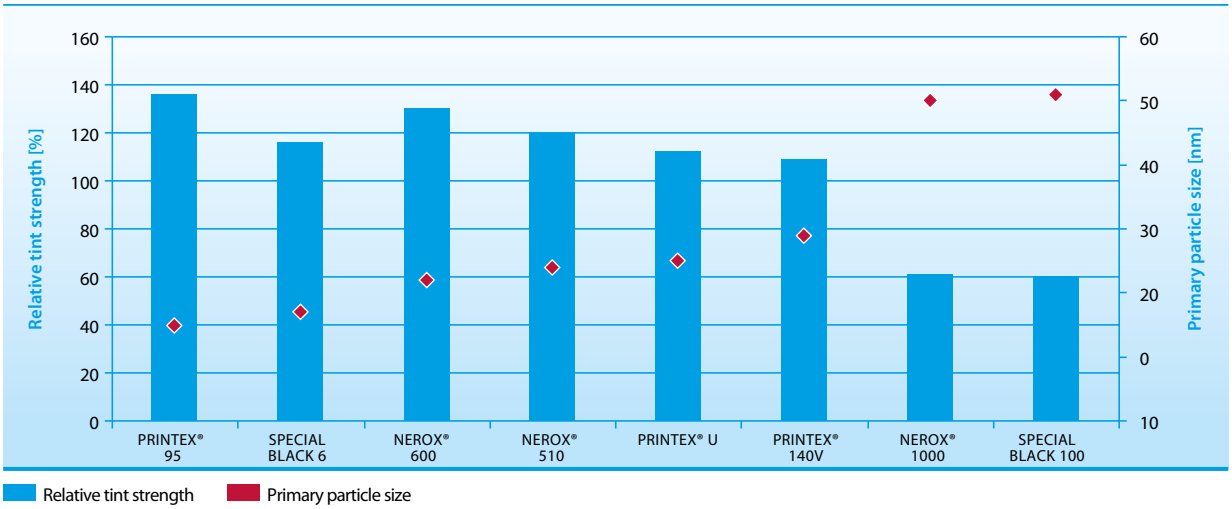


Figure 5

Relative tint strength tested in the alkyd-melamine formulation (following ASTM D 3265) of different specialty carbon blacks compared with the primary particle size (mesuared by the internal method TGZ3)

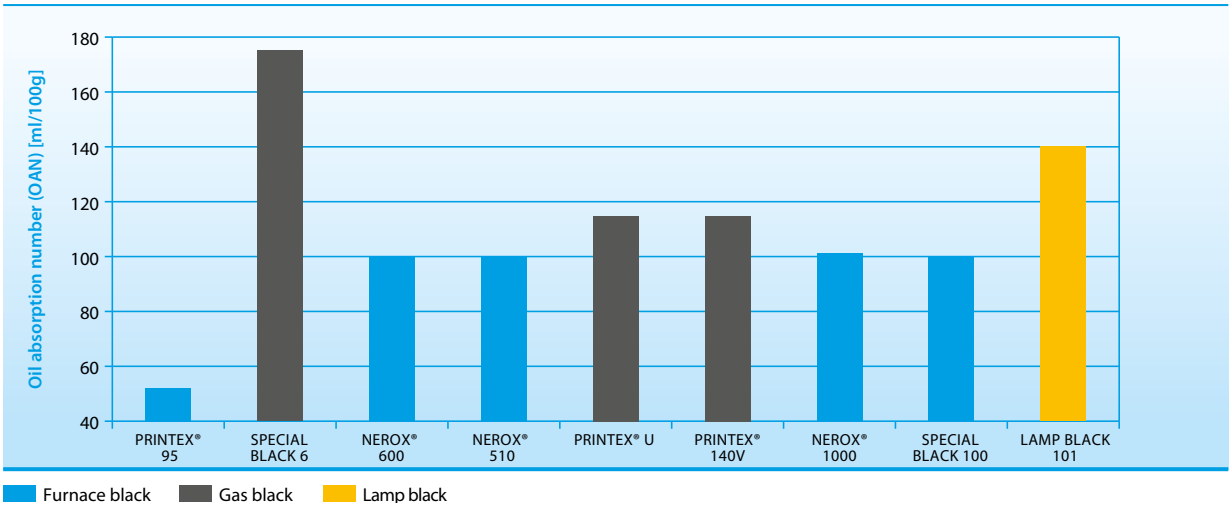


3.2 Structure

The oil absorption number (OAN, measured according to ISO 4656) is an indicator for the structure of specialty carbon blacks. It reveals if the primary particles, which are grown together to aggregates during the production process, have a three-dimensional configuration. Highly structured specialty carbon blacks provide easier wetting, higher viscosity and increased electrical conductivity.

Figure 6

Oil absorption number (ISO 4656) of various products from Orion Engineered Carbons. Specialty carbon blacks, produced by lamp black or gas black processes have a higher oil absorption number compared to furnace black



3.3 Surface chemistry

Depending on the production process all specialty carbon blacks contain different amounts of oxygen groups on their surface. The oxygen part is linked to chemical groups like ketone, anhydride, phenol, carboxyl or ether and is located mainly on the surface of each aggregate. Specialty carbon blacks, which are produced by the Degussa gas black process, have an oxygen content of between 4-6 % (volatile matter measured at 950°C, following DIN 5352).

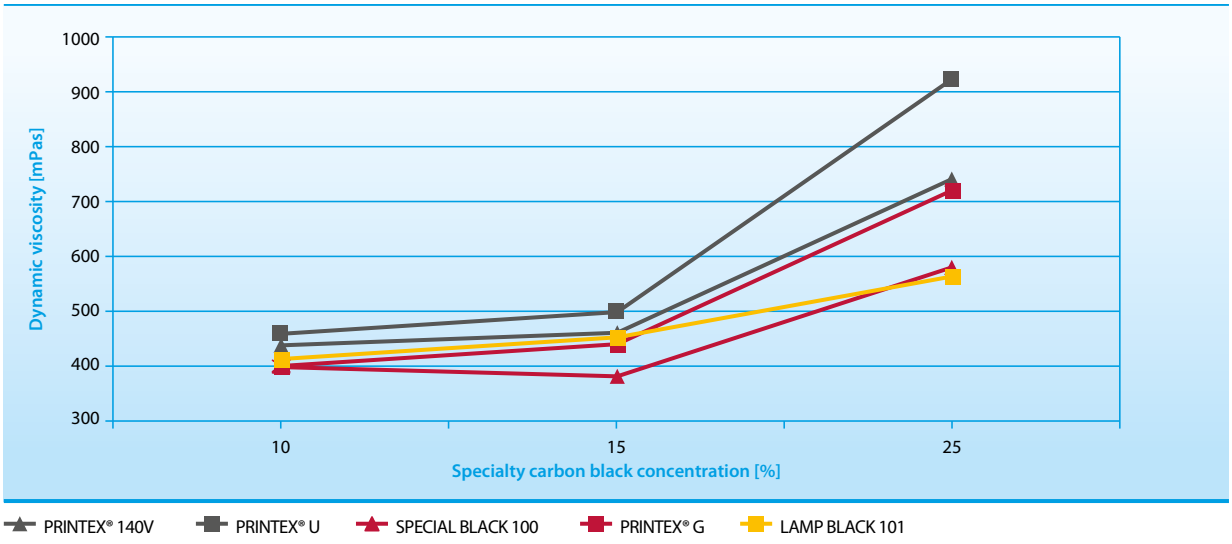
After-treated gas black pigments have additional oxygen-containing groups on their surface and the volatile matter increases up to 20%. Furnace black pigments have oxygen contents of less than 1%. For after-treated furnace black pigments the value of volatile matter increases up to 3%. Higher volatile content improves wettability, rheology and dispersion performance. Furthermore, a higher volatile content is typically associated with a lower, acidic pH-level.

3.4 Influence of specialty carbon blacks on the viscosity

Due to the addition of the specialty carbon blacks to the coatings formulation, an increase in viscosity can be observed. This behavior depends on the structure of the specialty carbon black. The oil absorption number (OAN) gives a statement about the structure of the aggregates. Higher structured specialty carbon blacks absorb more binders or wetting agents and therefore an increase in the viscosity of the liquid coating can be observed. On the other hand, the stabilization of high structured specialty carbon blacks is easier because an aggregate provides more possibilities for bonding or wetting. Low structured specialty carbon blacks have a lower viscosity increase, but are harder to stabilize in the coating.

Figure 7

Viscosity tested in a 2K-system based on DEGALAN® VP 4157/Desmodur® N 75 with 10 %, 15% and 25% specialty carbon black concentration calculated on the solid binder in the mill base formulation



Furthermore, the selection of wetting and dispersing agents has a big influence on the behavior of the viscosity in a coating system. Depending on the chemical base of the wetting and dispersion agent a strong reduction of the mill-base viscosity can be achieved. The best results can be achieved by using 70 – 100 % wetting agent (active substance) calculated to the amount of specialty carbon black. For solvent-borne coatings Orion Engineered Carbons recommends BORCHI® GEN 0451 or DISPERBYK® 163. Both wetting agents show a very good stabilization of the specialty carbon black in different binder systems. The wetting agents decrease the mill base viscosity. Therefore, a higher pigment loading of the mill base formulation can be achieved. For water-borne coatings TEGO® DISPERS 760W or DISPERBYK® 190 are recommended by Orion Engineered Carbons. These wetting agents cover the complete surface of the specialty carbon black, which results in a higher jetness and a strong bluish undertone. These properties are an indication of good deflocculation during the grinding process.

4 Applications

Industrial coatings cover a wide range of applications. Typical examples for industrial coatings are protective-, agricultural- and construction equipment coatings (ACE). Here, the focus is on the functionality of the coating. They are not limited to a specific type of binder, an application method or color. Corrosion resistance, adhesion, mechanical properties and chemical resistance are the main properties. However, the opacity of the dry film is highly dependent on the concentration of the color pigments in the liquid coating system. Nevertheless, the selection of the pigments, in particular of the specialty carbon black, plays a crucial role on the properties of the coating. Rheological behavior, viscosity and prevention of sedimentation can all be positively influenced by the selection of the right specialty carbon black.

The specialty carbon blacks from Orion Engineered Carbons, from the lamp black type to furnace blacks and gas blacks with a high color strength, can be used in this area. The selection of the specialty carbon black must be made in accordance with the specific requirements of each application.

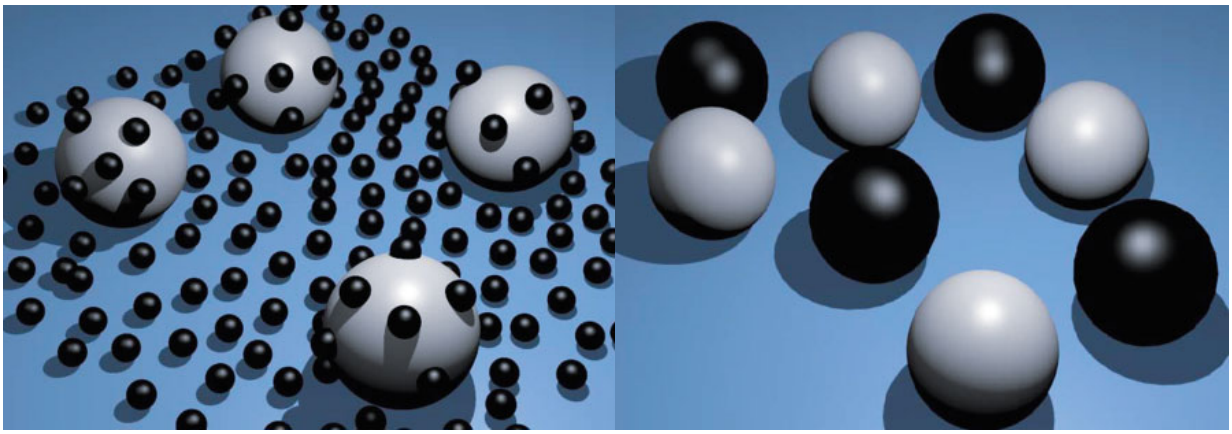
4.1 Architectural coatings

In coatings for architectural purposes, specialty carbon blacks are used primarily for tinting applications. Larger and easier-to-disperse specialty carbon blacks are often chosen as the pigment. The requirements for the tinting properties often include stability, floating behavior and bluish undertone. These requirements are met by LAMP BLACK 101 in terms of a perfect bluish undertone for grey coatings, or black coatings with a low to medium color intensity. LAMP BLACK 101 is very easy to incorporate into a paint with a high speed mixer. Due to the nearly neutral pH-level of 8.0, LAMP BLACK101 is perfect for use in solvent-borne as well as water-borne coatings. For water-borne coatings no additional neutralizition agent is needed in most cases.

In some applications long-term UV-protection is desirable. specialty carbon blacks additionally work as UV-absorbers and reduce the demand for decomposition of the binder. Specialty carbon blacks with smaller particle sizes have a higher surface area. Therefore, these kinds of specialty carbon blacks absorb more UV-light than the ones with larger particle sizes that consequently have a lower surface area. Thus, the smaller particle sized specialty carbon blacks provide better UV-protection for the binder than the larger particle sized ones. In solvent-borne coatings after-treated specialty carbon blacks like SPECIAL BLACK 6 or COLOUR BLACK FW 182 with their additonal functional groups, are easier to incorporate and stabilize. For water-borne coatings non-after treated furnace black pigments are typically the right choice. The non-polar surface of e.g. COLOUR BLACK FW 171 enhances the compatibility with all kinds of water-borne binders. The pH-level of these kinds of specialty carbon blacks simplifies the final adjustment of the pH-value. Furthermore, the amount of neutralizing agent can be minimized.

Figure 8

Comparison of surface covering between smaller and larger particle sized specialty carbon blacks



4.2 Electro deposition coatings (EDC)

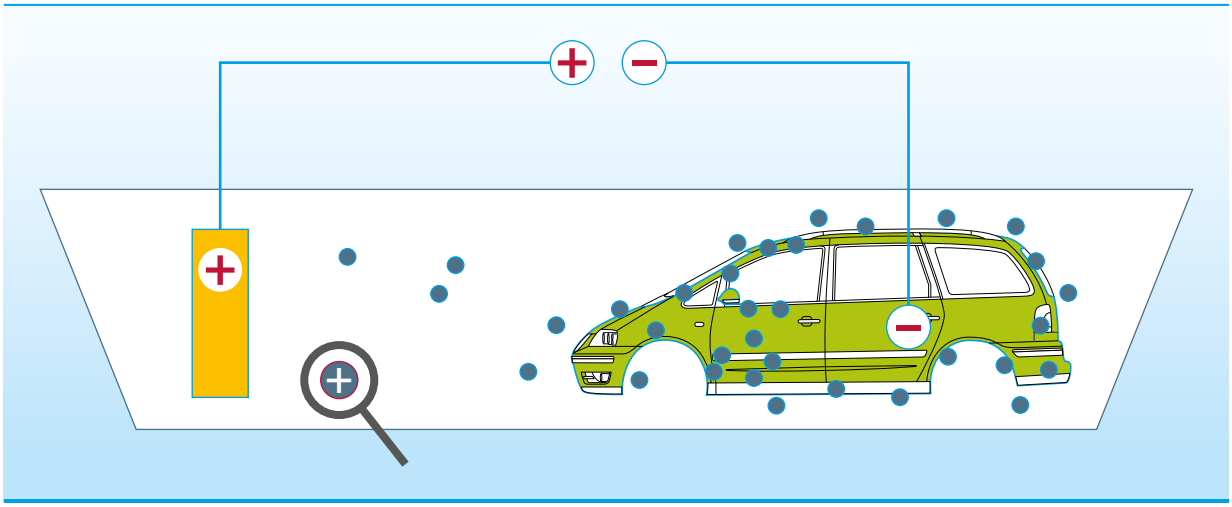
This process is used for applying coatings on metal substrates, mainly in the automotive industry. The advantages are a very uniform dry film thickness of the coating and a high speed automatic application. Highly efficient utilization of the coating reduces costs. The dry film thickness depends on the voltage which is applied between both electrodes. A simple rule applies: the higher the voltage is, the higher the film thickness of the dried film will be. The main function of electro deposition coatings is to protect the galvanized steel underground from corrosion.

There are two different types of electro deposition coatings: anodic deposition coatings and cathodic deposition coatings. In both cases one of the electrodes is the object which has to be coated.

Figure 9 shows an example of a process that is used in applying cathodic deposition coatings. The positively charged paint moves to the negatively charged object that is mainly made out of pre-treated steel.

Figure 9

... shows a simplified example of electro-deposition coatings process. Positvely charged paint moves to the negatively charged cathode, for example a car body



The coating must be ionisable and only a small amount of soluble ionics are allowed. Variations in the ionic content will have a significant influence on the controlling of the parameters in the electro deposition coatings bath. For instance voltage adjustment will be especially very difficult. Therefore, all the raw materials must have a very small residual ionic content. Orion Engineered Carbons recommends PRINTEX® 200 for ED-Coatings. PRINTEX® 200 has an extremely low surface area in addition to a low oil absorption number compared to all other furnace black grades. The second positive effect is the very low electrical conductivity of the aqueous extract, which results from a special stripping process after production. The extremly low conductivity of its aqueous extract is a reflection of the very low ionic content of PRINTEX® 200. Additionally, the non-polar surface of PRINTEX® 200 enhances the compatibility with water-borne binder systems.

4.3 High temperature resistance coatings

The main focus of a thermal protective coating is temporary heat resistance without jeopardizing the performance, for example loss in corrosion resistance and chemical resistance. Binders must be very temperature stable, so epoxys or silicon-based binders are widely used. For cross linking a choice between melamine resins or dicyandiamide powders can be made. Most of the time a black color is preferred, because only slight changes in the color can be detected after exposure.

For all heat resistance coatings Orion Engineered Carbons recommends PRINTEX® 60 with an extremly low loss in weight at higher temperatures compared to all other specialty carbon blacks. During the production of PRINTEX® 60 the oxygen content in the closed furnace reactor can be easily controlled. Therefore, it is possible to produce PRINTEX® 60 with a very low amount of oxygen-containing groups on the surface. The behavior of the specialty carbon black PRINTEX® 60 does not change under high temperatures.

Table 2

Moisture loss and losses in weight at 250°C with air supplied as a function of time for two specialty carbon blacks with similar primary particle sizes

Specialty carbon black	Dyring loss (1 h, 105°C) [%]	Loss of weight at 250°C [%] after hours					
		0,5	24	48	96	144	195
PRINTEX® 60	0,8	0	0	0	0	0	0
PRINTEX® U	2,2	0,1	0,1	0,2	0,7	1,7	1,7

Table 3

Data on the thermal stability of specialty carbon blacks from thermogravimetric studies. The data on the long term thermal stability represent assumptions

Specialty carbon black	Short test		Long-term test at 250°C [hours]
	Max. temperature [°C]	Long-term temperature [°C]	
PRINTEX® 60	500	400	>200
PRINTEX® U	450	300	100

4.4 Coil coating

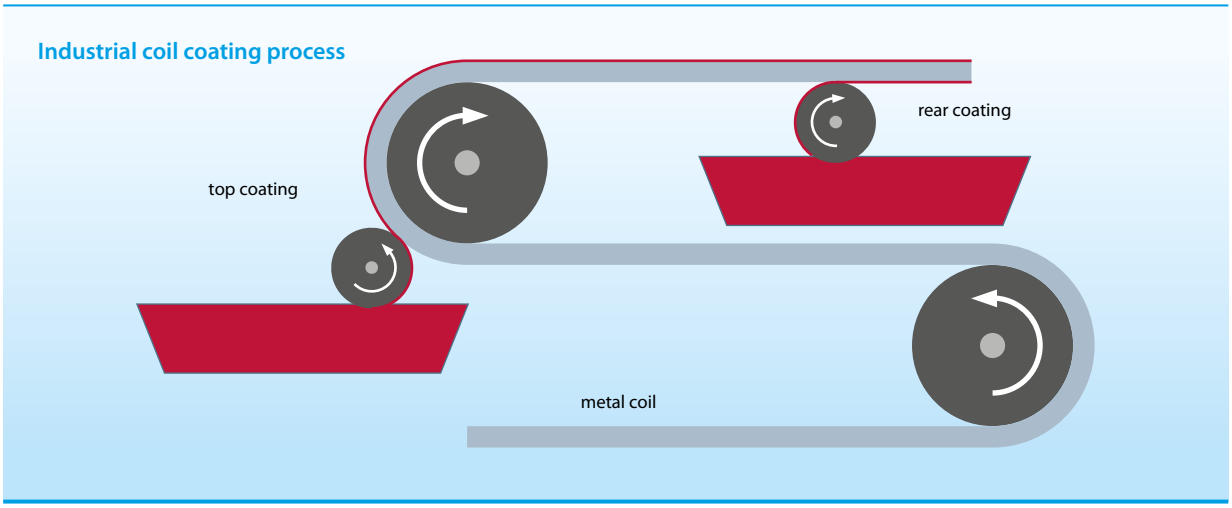
Metals that are covered using the coil coating production process have a wide range of applications. They are mostly used in facades for functional industrial buildings. However, even home appliances such as washing machines, microwave ovens and refrigerators are partially made of coil-coated sheets (a competitive process for this application is powder coating). Some other possible applications are: light boxes, shutters, roofing systems (very common in North America and Scandinavia), computer cases, metal furniture, cassette systems for interior ceilings and special transportation applications such as trailer bodies, trailers and caravans.

For the coil coating process, almost exclusively, dip galvanized steel or aluminum is recommended. After unwinding and coating the metal coil, which can be up to two meters broad, the metal is rolled up for delivery.

The curing conditions for coil coating can be described as short and very hot. Normally, the curing time is less than 30 seconds and the peak metal temperature is up to 260°C (500°F).

Figure 10

Simplified coil coating process for mass production



In general, solvent-based coatings are used for this kind of application. Water-based coatings have a problem with rapidly increasing temperatures (e.g. blisters). As a standard, the specialty carbon black SPECIAL BLACK 4 from Orion Engineered Carbons is very well established. Its narrow particle size distribution and after-treated surface increases the compatibity with all kinds of polyester, which is the dominating binder system for coil coating. The after-treated surface enhances the interaction between the binder and specialty carbon black. Thus, SPECIAL BLACK 4 shows superior stabilization compared to other specialty carbon blacks without the need to add an additional surfactant. The jetness of SPECIAL BLACK 4 is well balanced for most applications, both glossy as well as very mat coatings. In addition, the influence on viscosity is moderate.

4.5 Heavy duty coating

The coating has to protect the metal surface from all aggressive media in the environment including humidity, salts and acid rain. For example, the requirements for hot deserts are totally different compared to offshore platforms.

Typically two different types of coatings are used

Solvent-borne anticorrosion coatings

Very high quality protective films are obtained with solvent-borne coatings. When the anticorrosion coating has been applied, the protective film is formed by vaporizing all the solvents out of the film. Depending on the chemistry of the solvents used and the wet film thickness, the drying process of the protective film can take up to several hours. If the drying process is forced, there might be a problem with substrate adhesion between the applied coating and the metal surface. Generally, protective coatings have a dry film thickness of between 30 – 300 µm and a soft surface. The challenge is to achieve a smooth surface without orange peel, runners or craters after application. The biggest advantage of solvent-based anticorrosion coatings is the independence of humidity during application and drying. Therefore, this kind of coating is usable all over the world without any problems. Orion Engineered Carbons firstly recommends SPECIAL BLACK 4 for solvent-borne anticorrosion coatings. This is because of good dispersion behavior in all kinds of solvents and binders (polar or non-polar). The amount of dispersion agent can be adjusted without loss in the stabilization behavior. Furthermore, sedimentation can be handled more easily.

Water-borne anticorrosion coatings

Water-based anticorrosion coatings contain a solvent content of less then 10 %. The drying times of water-borne anticorrosion coatings depend on the temperature and humidity during the application and on the co-solvent, which is used for controlling the drying behavior and surface optics. If the surface of water-borne anticorrosion coatings dries too fast the evaporation process of water may be stopped in between. The consequences can be poor or extremely reduced corrosion protection. Transportation and storing of water-borne anticorrosion coatings need to ensure a frost-free supply chain. For water-borne anticorrosion products Orion Engineered Carbons recommends PRINTEX® U or PRINTEX® V. The narrow particle size distribution, which is characteristic for all gas blacks, has a positive influence on the stabilization of the specialty carbon black in different binder systems. The slightly polar surface, consisting of different oxygen-containing groups, enhances the dispersion properties in a water-borne coating system.

5 Summary

In this technical information we give an overview of some applications in industrial coatings. Nevertheless, only a few different applications are mentioned. Furthermore, we have additional technical informations available:

Specialty carbon blacks Technical Data Europe
(Product overview)

Specialty carbon blacks in modern coating systems
(Industry information)

Specialty carbon blacks for UV curing printing inks
(TI 1257)

Specialty carbon blacks for powder coatings
(TI 1293)

Specialty carbon blacks for conductive coating applications
(TI 1455)

Orion Engineered Carbons is able to offer a suitable specialty carbon black for any kind of coating. Due to a vailability of different binder systems, wetting agents or application variations, there is always more than one solution on how to choose the best specialty carbon black.

The technical experts from Orion Engineered Carbons are able to recommend a suitable specialty carbon black for all requirements . Please contact us for detailed recommendations.

All the technical data in this technical information are for guidance purposes only. They are guideline values at the time of printing.

References

1.) "Specialty carbon blacks in modern coating systems" Company publication of Orion Engineered Carbons GmbH, Frankfurt, 2017

ENGINEERED CARBONS

Focused. Innovative. Responsive.

The Americas

Orion Engineered Carbons LLC
1700 City Plaza Drive, Suite 300
Spring, TX 77389
USA
Phone +1 832 445 3300

AMERICAS@orioncarbons.com

Europe/ Middle East/ Africa

Orion Engineered Carbons GmbH
Frankfurter Straße 60 - 68
65760 Eschborn
Germany
Phone +49 6196 771 929 100

EMEA@orioncarbons.com

Asia Pacific

Orion Engineered Carbons (China) Investment Co., Ltd.
Room 2301, 2302, 2307, BM InterContinental Business Center
100 Yutong Road, Jing'an District, Shanghai 20007
P. R. China
Phone +86 21 6107 0966

APAC@orioncarbons.com

Incorporated in Luxemburg

Orion Engineered Carbons S.A., 6, Route de Trèves, 2633 Senningerberg, Luxembourg, Phone +352 270 48 06 0

www.orioncarbons.com

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