orion

Delivering sustainable solutions

HIGH PERFORMANCE SPECIALTY CARBON BLACKS FOR CONDUCTIVE PLASTIC COMPOUNDS

Technical Information 1490 I EMEA

WHO WE ARE – ORION S.A.

Orion S.A. (Orion) is one of the worlds leading suppliers of carbon black. Orion produces a broad range of carbon black that includes furnace black, high-performance specialty gas black, acetylene black and lamp black. By offering an excellent balance of colorimetric properties, dispersibility, UV-protection, electrical conductivity and adjustment of mechanical and rheological properties they are used in several polymer applications, such as pressure pipes, fibers, cables, films and adhesives.

With over 1600 employees worldwide, Orion operates 15 global production sites and 4 applied technology centers, focusing on quality supply and collaborative partnerships with customers.

INTRODUCTION

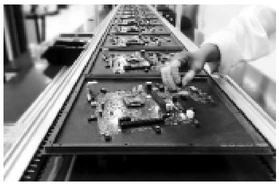
Most polymers are insulators. They do not conduct electricity. In many applications, such as electrical appliances, this is a very critical characteristic as it prevents short-circuiting and electrical shocks.

However, insulators can build up static charge leading to undesirable discharges when grounded. These electrostatic discharges are the reason for the unpleasant sparks people often experience in shopping malls, particularly during dry wintertime, but they can also destroy electronic components or even cause fires or explosions, when occurring in explosive atmospheres. Thus, there are numerous applications that require the use of antistatic or conductive materials. They include transport packaging of electronic components or chemicals, cables, floor coverings, conveyor belts, air conduits, as well as hoses in the mining and chemical industry.

The use of conductive or antistatic compounds prevents electrostatic discharges, ensuring safe and long-term use of the final part.

Field examples for end use of conductive or antistatic compounds

Spark discharge flammability, e.g. gas pump nozzle

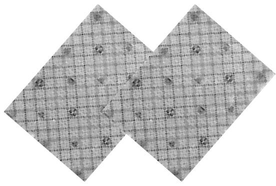


Transport boards for electronically sensitive devices

Electrical grounding and antistatic flooring

Power cables

Explosion-proof areas, e.g. ATEX



Antistatic packaging films

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ELECTRICAL CONDUCTIVITY OF COMPOUNDS

The basic principle of electrical conductivity relies on the flow of charge carriers, e.g. electrons or ions. The ability of a material to transport electrical charges is described by its electrical conductivity. The electrical conductivity is reciprocal to the resistivity. The higher the resistivity, the lower the conductivity.

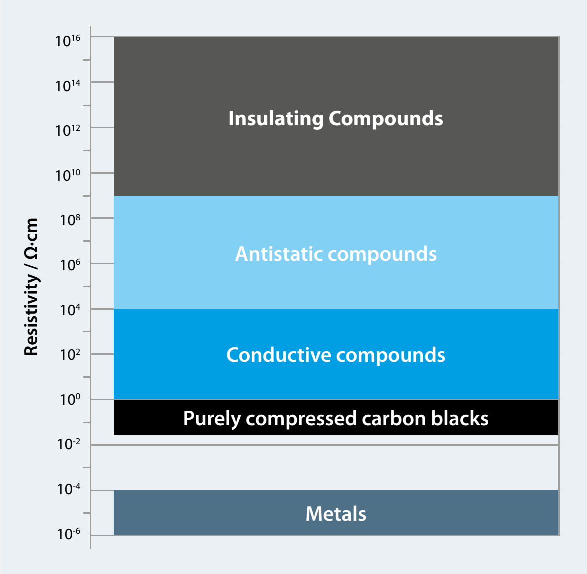
Generally, polymer compounds are classified in three categories depending on their resistivity:

- Insulating: higher than 10^9 Ω·cm
- Antistatic: between 10^9 Ω·cm and 10^4 Ω·cm
- Conductive: below 10^4 Ω·cm

While most of the polymers are electrically insulating, carbon blacks themselves are conductive due to their graphitic domains. Their conductivity, however, does not reach the level of metals.

Figure 1

Typical categorization of compounds according to their resistivity



ACHIEVING ELECTRICAL CONDUCTIVITY IN COMPOUNDS

To induce electrical conductivity in compounds, carbon black is added to the polymer matrix. The carbon black aggregates need to build a network to achieve uninterrupted conductive pathways throughout the material for the transfer of electrical charges. The distance between the carbon black aggregates is key to the electrical conductivity of the compound. The smaller the distance and the higher the number of paths formed, the lower the transition resistance and the better the electrical conductivity of the compound. That is, concentration of carbon black is a key parameter in achieving conductivity.

The relation of the carbon black concentration with the resistivity is shown in the percolation curve (Figure 3). It is only after a certain amount of carbon black in the polymer matrix, that the resistivity starts to decrease due to the formation of a continuous carbon black network. After this point, the resistivity decreases by several orders of magnitude (percolation zone) until it asymptotically approaches a minimum which is significantly higher than that of pure compressed carbon black (10^{-1}–10^{0} Ω·cm). That is, the percolation zone is the concentration where the compound passes over from insulative to conductive.

Figure 2

Illustration of carbon black distribution in a polymer compound

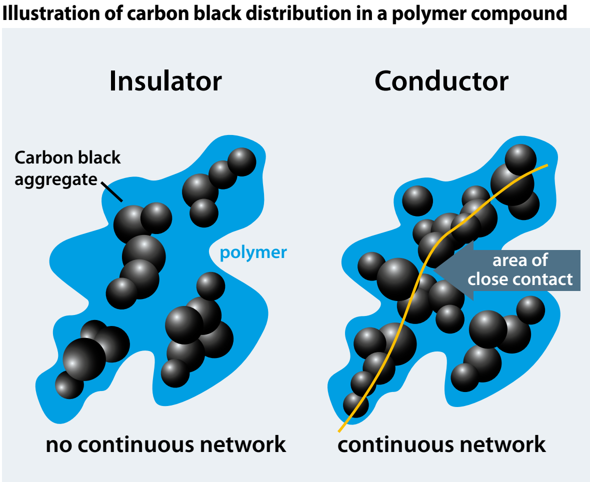
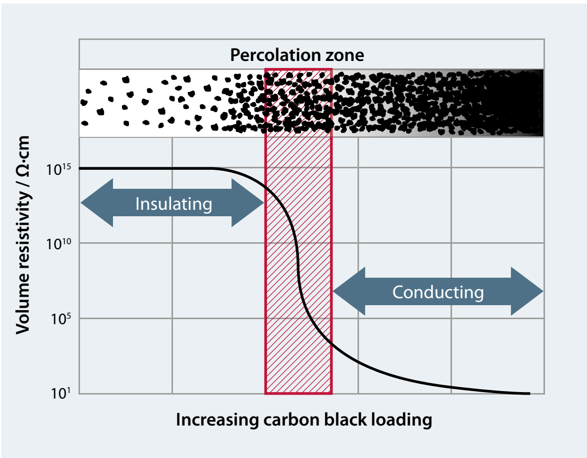


Figure 3

Example of a percolation curve



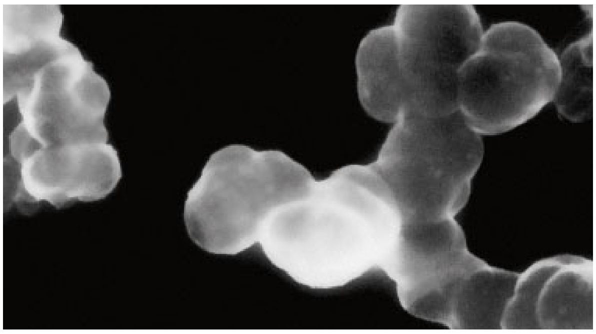
Generally, one of the key objectives is developing conductive compounds with consistent resistivity while keeping a good balance between overall polymer properties.

The conductivity of the final product depends primarily on these factors:

- Carbon black morphology & concentration
- Polymer type and selection
- Dispersion of carbon black in polymer
- Design of final product

Figure 4

Microscopic picture of a carbon black aggregate (smallest dispersible unit)



CONDUCTIVE CARBON BLACK

Carbon black is extremely well-suited to make plastics conductive. Carbon black is competitively priced, widely applicable, easily processable, stable to aging, safe and largely chemically inert. In principle, every carbon black is electrically conductive. With special conductive carbon blacks, however, it is possible to achieve percolation at low concentration. This has the advantage that other polymer properties, such as processability, mechanics, flowability, specific weight and moisture absorption are less impacted.

Conductive carbon blacks generally display a high specific surface area (small primary particle size) and a very high structure. The higher the surface area of a carbon black the higher the concentration of aggregates per unit volume in the compound. This reduces the distance from one aggregate to the next and, therefore, increases conductivity (figure 5). The very high structure supports the dispersion. The dispersion is essential for an effective build-up of the conductive pathway.

Depending on the further processing and intended use of the conductive polymer compounds (e.g. injection molding, extrusion, blow molding), the requirements for the carbon black can vary greatly. Orion offers in depth expertise and an extensive portfolio of conductive carbon blacks ensuring the best option for each application.

Figure 5

Illustration of the specific surface area at same carbon black weight

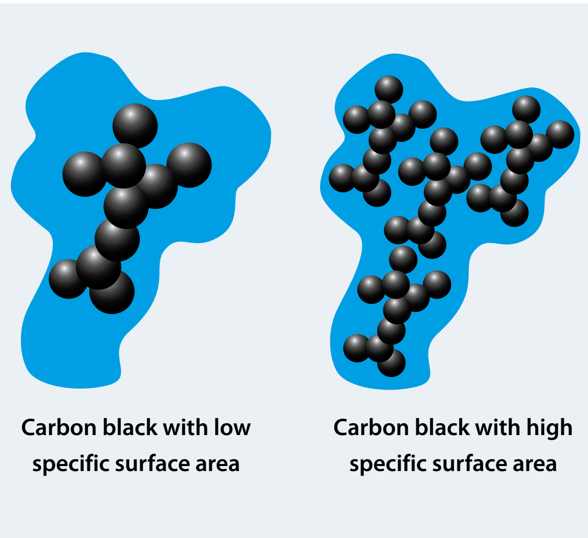
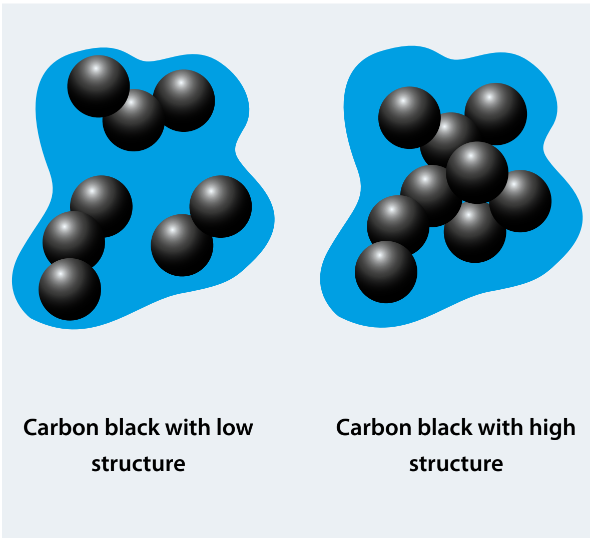


Figure 6

Illustration of low and high structure carbon black



PORTFOLIO OF CONDUCTIVE CARBON BLACKS

Table 1

		APPLICATION	
	DELIVERY FORM	WIRE & CABLE	CONDUCTIVE & ANTISTATIC COMPOUNDS
PRINTEX® HV	Beads	●	
PRINTEX® MV	Beads	●	
PRINTEX® kappa 10	Beads	●	●
PRINTEX® kappa 20	Powder		●
PRINTEX® kappa 60	Beads	●	●
PRINTEX® kappa 70	Beads		●
PRINTEX® kappa 100	Beads & Powder	●	●
PRINTEX® XE2 B	Beads		●

Figure 7

Percolation curve of selected conductive carbon blacks in PE-LD
Percolations curves will differ depending on the polymer and process used. Below example of the performance of different conductive carbon blacks in PE-LD injection molded plaques.

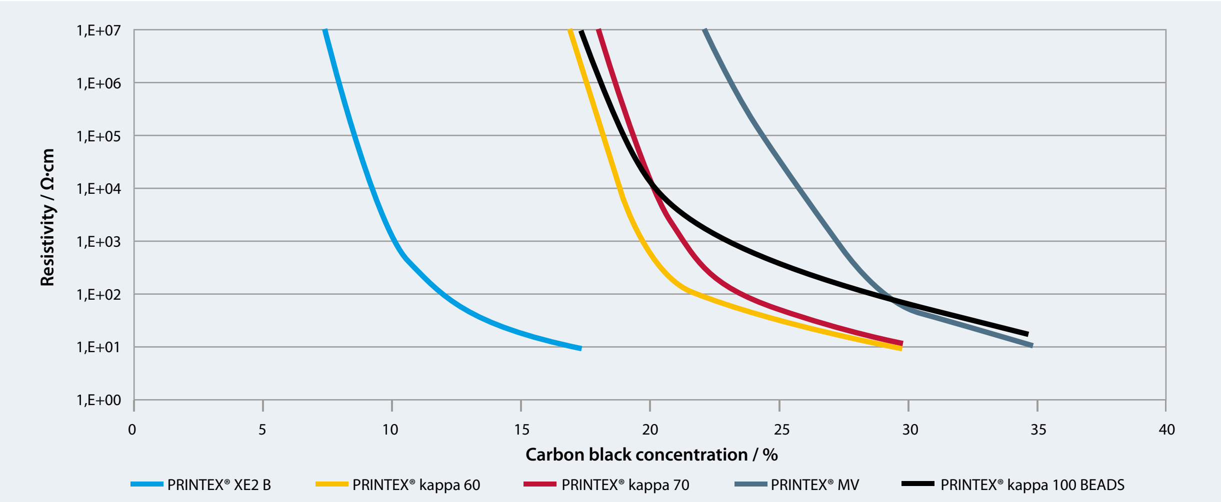
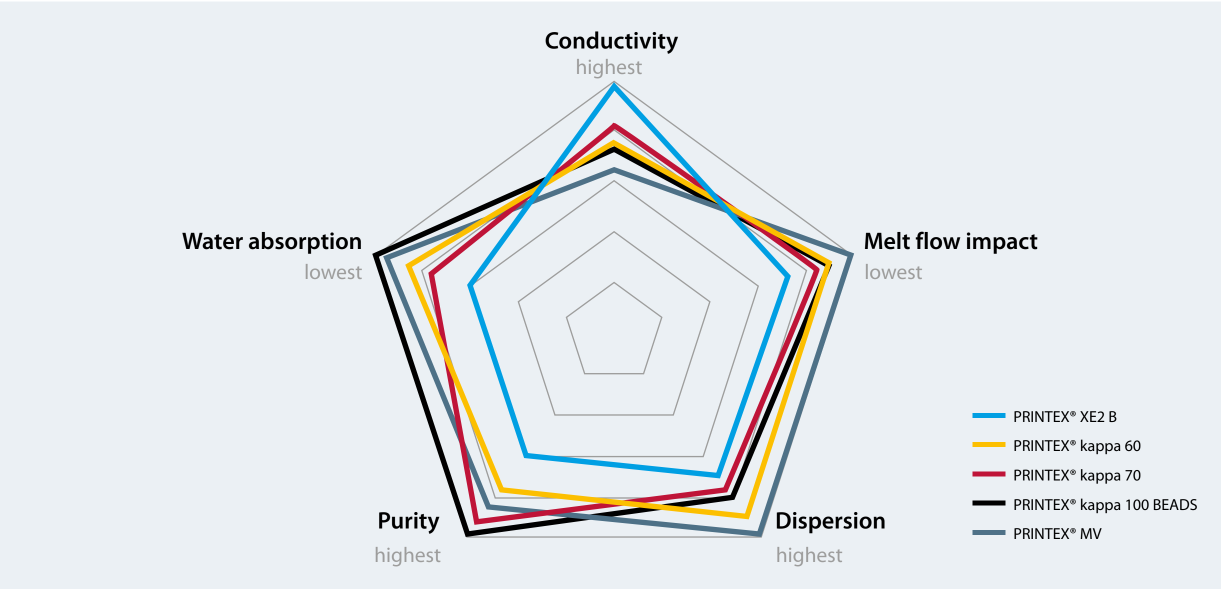


Figure 8

Comparison of selected carbon blacks based on key characteristics relevant for the conductive compound



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