CABOT

SPECIALTY CARBON BLACKS
FOR CONDUCTIVE AND ESD APPLICATIONS

Performance and leadership in black plastics

Cabot Corporation is a global performance materials company and we strive to be our customers' commercial partner of choice. We have been a leading manufacturer of carbon black and other specialty chemicals for more than 130 years, and we have supplied additives to the plastics industry since its inception.

Our global reach enables us to work closely with customers to meet the highest standards for performance, quality and service. Our global production network and three applications development facilities provide our customers with global service capabilities as well as the latest technical innovations.

Global reach

We support customers around the world in our global production and applications development centers

- **North America**
  - Canada
  - Mexico
  - United States
- **South America**
  - Argentina
  - Brazil
  - Colombia
- **Europe, Middle East & Africa**
  - Belgium
  - Czech Republic
  - France
  - Germany
  - Italy
  - Latvia
  - Norway
  - Switzerland
  - The Netherlands
  - United Arab Emirates
  - United Kingdom
- **Asia Pacific**
  - China
  - India
  - Indonesia
  - Japan
  - Korea
  - Malaysia
  - Singapore

With approximately 4,500 employees worldwide, we continue to create a diverse environment rooted in values and sustainability.

We operate 44 manufacturing sites in 21 countries, all with local management teams. We have a global footprint in order to serve our customers throughout the world.

Delivering performance to increase conductivity and protect against electrical damage

We offer a range of carbon blacks that provide conductive or electrostatic dissipative (ESD) performance in plastics. Conductive plastics are used to protect against premature failure or damage due to electrostatic discharge in a variety of applications such as automotive fuel systems, electronic and electrical packaging and equipment and other plastics applications. Rendering normally resistive polymers electrically conductive has a wide range of uses; we provide a broad range of carbon blacks to fit these diverse and unique requirements. Whatever your needs, we have developed a conductive specialty carbon black that is designed for optimal performance.

Our brands

We supply a diverse product range of specialty carbon black products to meet performance and processability requirements across many industries and end uses. Offered in pellet and powder form, our long-established products for plastics include VULCAN®, ELFTEX® and BLACK PEARLS® specialty carbon blacks. While some of our products have performed successfully in plastic applications for more than 50 years and are top choices for the industry, we continue to innovate and develop new products to drive our customers' product performance.

Products for conductive and ESD applications

All carbon blacks are conductive, however, we have designed a range of conductive specialty carbon blacks to allow our customers to achieve optimal performance for their specific applications.

We consider three main attributes in the design of the carbon black for conductive and ESD applications:

- **Conductivity:** Ability to conduct electricity; measured by the surface or volume resistivity of a polymer at a given loading
- **Surface smoothness:** Ability to minimize surface defects and increase aesthetic quality of the final product
- **Dispersibility:** Ease with which a conductive carbon black can be incorporated into a formulation

Our products featured in Figure 1 are suitable for use in ESD applications. This chart provides a broad overview of product performance; your Cabot representative can provide guidance in selecting the product that will best meet your performance needs.

The applications that require normally insulative polymers to be electrically conductive, dissipative, or anti-static are broad. The role of carbon black is to dissipate electricity in a safe, controlled manner in order to protect against static electrical discharge that could cause immediate damage or premature failure. Figure 2 describes the different conductivity regimes for plastics.

The majority of ESD applications fall into three broad application groups:

- Electrical and electronics (E&E)
- Safety (molded parts)
- Automotive fuel systems

E&E products are particularly sensitive to static discharge, which can cause immediate, catastrophic failures of components or latent defects that significantly shorten product lifespan. To prevent uncontrolled static discharge, conductive packaging in the form of integrated circuit (IC) carrier tapes, thermoformed trays, rigid trays, boxes and corrugated board are used.

Conductive molded parts are required for safety in potentially explosive environments because they help prevent static charge build-up and can replace metal as a material of choice. Without ESD protection, uncontrolled static discharge can cause hazardous gases, powders, or liquids to explode. Pipes and other infrastructure for mines, gasoline stations and other sensitive areas are examples of environments that require ESD protection.

In automotive applications, dissipative performance is primarily required in fuel systems to prevent static build up around explosive fuels, but conductive moldings can also provide electromagnetic interference (EMI) shielding performance.

New applications for conductive plastics are continuously being developed — please contact your Cabot representative to discuss your particular requirement.

Figure 1:
Carbon blacks for conductive and ESD applications

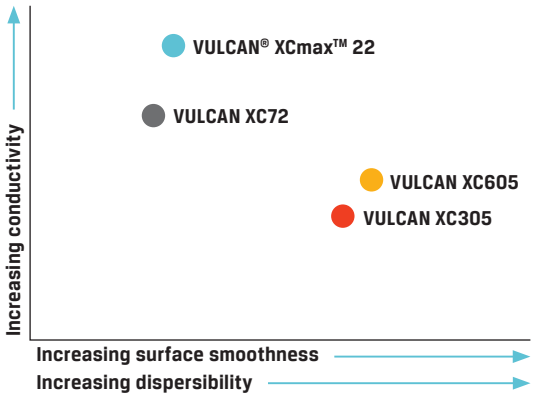
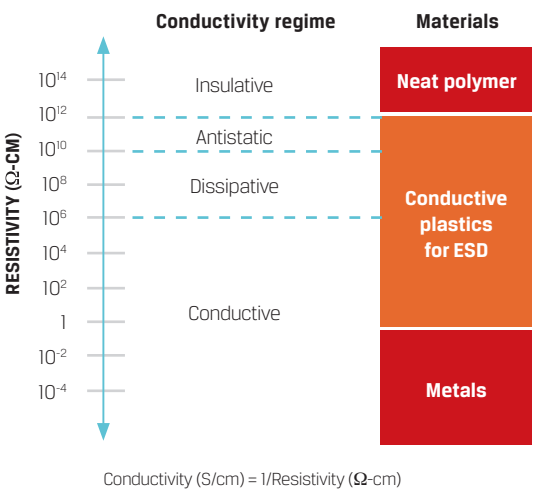
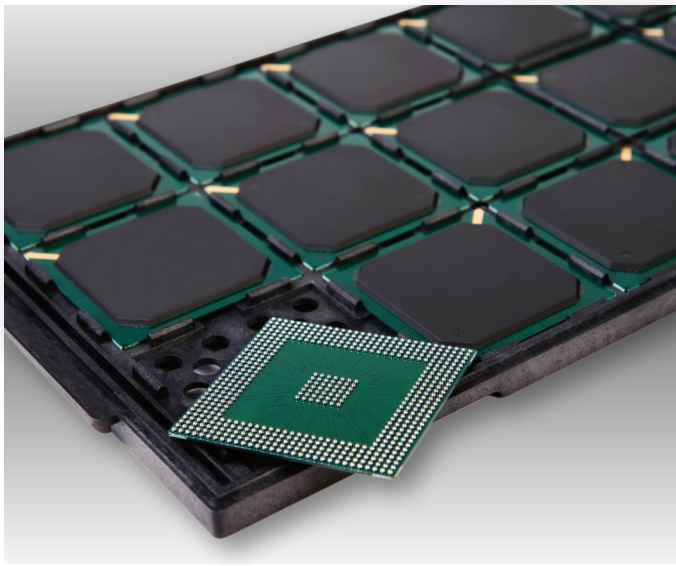


Figure 2:
ESD conductivity regimes



Conductivity (S/cm) = 1/Resistivity (Ω-cm)



Performance

Conductivity

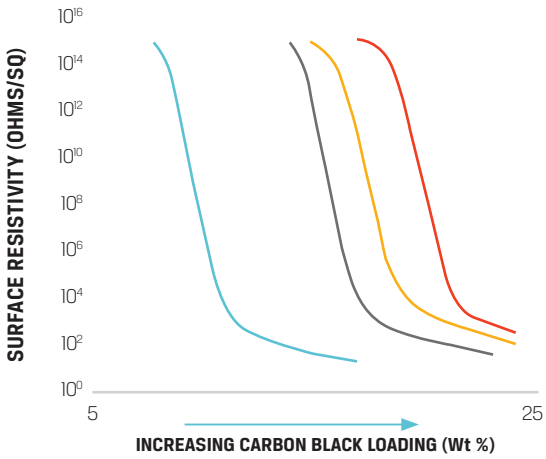
To properly select a conductive carbon black, formulators must consider the carbon black's effect on the physical properties, processability, and the compound cost at the loading required to achieve the desired conductivity. The ability of a carbon black to achieve conductivity performance is primarily a function of:

- Carbon black morphology (primary particle size and aggregate structure)
- Level of carbon black loading
- Dispersion quality
- Polymer matrix (level of crystallinity)

Figure 3 shows percolation curves demonstrating the loadings at which VULCAN XCmax™ 22 specialty carbon black, our most conductive carbon black, and VULCAN XC72, XC605, and XC605 specialty carbon blacks achieve the target conductivity.

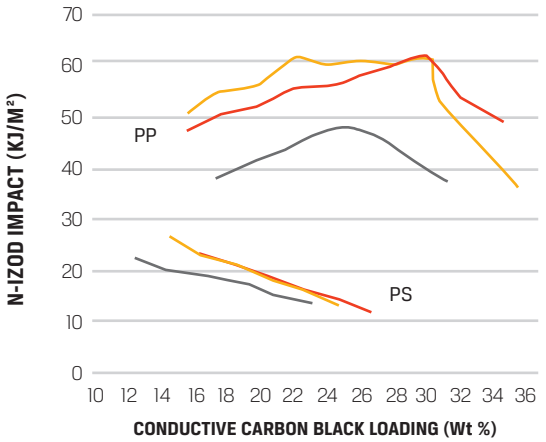
While higher levels of carbon black loading are desirable to improve conductivity, end-product mechanical properties are typically driven by the underlying polymer. Mechanical properties, such as tensile elongation or impact resistance are generally preserved by minimizing carbon black loading. However, carbon black typically has a reinforcing/stiffening effect that enhances the flexural performance of a polymer, as shown in Figure 4. For both polystyrene and polypropylene, VULCAN XC305 and VULCAN XC605 specialty carbon blacks offer the best impact strength among our products for ESD applications.

Figure 3:
Conductivity performance



Cabot specialty carbon blacks:
VULCAN® XCmax™ 22 VULCAN XC72
VULCAN XC605 VULCAN XC305

Figure 4:
Impact strength in polystyrene and polypropylene



Cabot specialty carbon blacks:
VULCAN XC72 VULCAN XC605 VULCAN XC305

Surface smoothness

The cleanliness of the carbon black is a key driver to provide an aesthetically-pleasing, defect free surface on molded parts. Surface smoothness performance in polystyrene is characterized in Figure 5.

Dispersibility

Good carbon black dispersibility is critical for achieving important attributes for conductive plastic molded parts:

- Optimal conductivity
- Surface smoothness
- Maximum retention of mechanical properties of the base polymer
- Improved yields in compounding equipment

Dispersibility is a measure of the level to which carbon black aggregates are evenly distributed in the compound. As shown in Figure 6, poor dispersion leads to only partial de-agglomeration of aggregates which can cause surface and mechanical defects. In contrast, excellent dispersion achieves full de-agglomeration and ensures a homogeneous distribution of carbon black within the polymer matrix.

Figure 5:
Surface smoothness in polystyrene

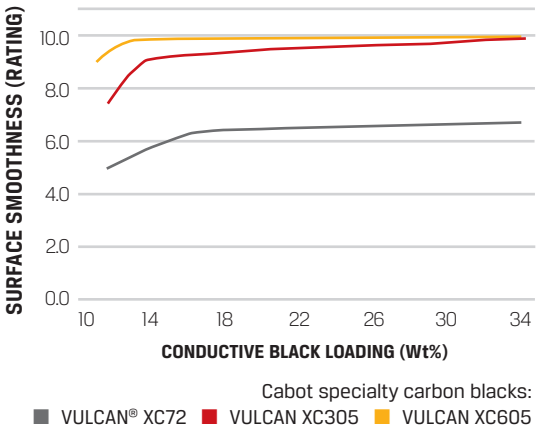
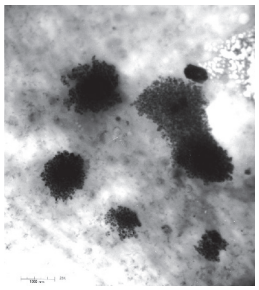
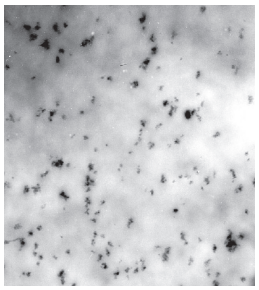


Figure 6:
Dispersibility comparison

Poor dispersibility
(partial de-agglomeration)



Excellent dispersibility
(full de-agglomeration)



Processability

Compounding

Carbon blacks require a substantial amount of shear to disperse properly in plastics. For conductive composites, shear input must be optimized to attain maximum conductivity. As mixing time increases, conductivity increases as a result of improved dispersion until a conductivity plateau is reached. Additional mixing after this point eventually results in decreased conductivity because the carbon black conductive network deteriorates. Since shear input during mixing is influenced by resin type, carbon black type and loading, and type and condition of mixing equipment, compounding procedures for conductive composites must be optimized individually to avoid under- or over-dispersion of the carbon black. Orientation of a conductive composite during processing affects the distribution of the carbon black aggregates and results in greater conductivity in the direction of orientation rather than perpendicular to it.

Polymer compatibility

We offer carbon black products that can be used in almost all polymer systems. We have significant experience in using basic polyolefins and styrenic-based polymers, as well as high-performing thermoplastics. Resin type influences the degree of conductivity in a carbon black composite. Highly crystalline resins tend to impart slightly higher conductivity than less crystalline resins at a given carbon black loading. Crosslinking a conductive composite tends to reduce conductivity as a result of lower density and less crystallinity.

Product data

Product	Description
VULCAN® XCmax™ 22	Family of super-conductive specialty carbon blacks designed for critical applications demanding conductivity at very low loadings to maintain mechanical properties.
VULCAN XC72 **VULCAN XC72R**	Highly conductive carbon black for power cable and ESD applications where low loadings are required.
VULCAN XC605	Premium conductive carbon black for demanding ESD applications requiring superior dispersibility, surface smoothness and mechanical properties.
VULCAN XC305	Standard conductive carbon black design offering electrostatic protection for sensitive devices and components, IC trays and boxes, corrugated boards and safety packaging for hazardous goods.

Note: All products listed are in pellet form except VULCAN XC72R specialty carbon black, which is a fluffy form of VULCAN XC72 specialty carbon black.

Additional references

This Product Application Guide provides specific information about our specialty carbon blacks for use in conductive and ESD applications. For other application-specific product recommendations and broader product portfolio information, please visit cabotcorp.com or contact your Cabot representative.

NORTH AMERICA
Cabot Corporation Business
and Technology Center
157 Concord Road
P.O. Box 7001
Billerica, MA 01821 - USA
Technical service
T +1 800 462 2313
Customer service
T +1 678 297 1300
F +1 678 297 1245

SOUTH AMERICA
Cabot Brasil Industria
e Comericio Ltda.
Rua do Paraiso 148 - 5 andar
04103-000 Sao Paolo,
Brazil
T +55 11 2144 6400
F +55 11 3253 0051

EUROPE
SIA Cabot Latvia
101 Mukusalas Street
Riga, LV-1004,
Latvia
T +371 6705 0700
F +371 6705 0985

MIDDLE EAST & AFRICA
Cabot Dubai
P.O. Box 17894
Jebel Ali Free Zone
LOB 15, Office 424
Dubai
United Arab Emirates
T +971 4 8871800
F +971 4 8871801

ASIA PACIFIC
Cabot China Ltd.
558 Shuangbai Road
Shanghai 201108
China
T +86 21 5175 8800
F +86 21 6434 5532

JAPAN
Cabot Specialty Chemicals Inc.
Sumitomo Shiba-Daimon Bldg. 3F
2-5-5 Shiba Daimon,
Minato-ku
Tokyo 105-0012
Japan
T +81 3 6820 0255
F +81 3 5425 4500

CABOT

cabotcorp.com

9/2016