CONDUCTIVE COMPOUNDS

CABOT
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CABELEC® Compounds Processing Guide




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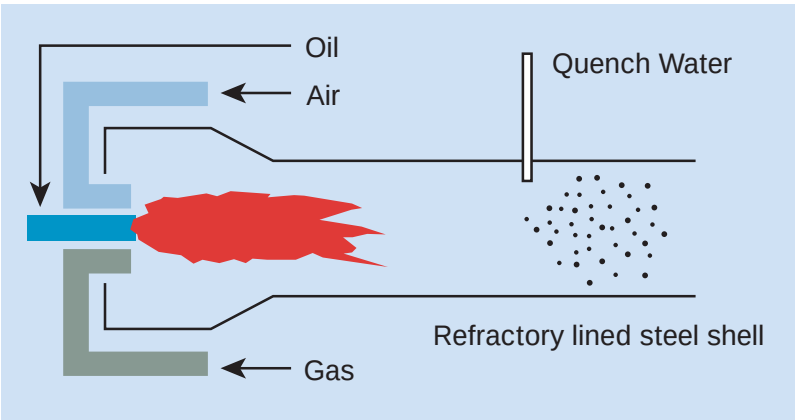
CABELEC compounds are a range of compounds that are electrically conductive thereby reducing the risk of electrostatic discharge. The conductive properties of the compounds are permanent. CABELEC compounds are based on a large variety of thermoplastic polymers and are designed to fulfil specific requirements related to electrical, rheological and mechanical properties. A range of CABELEC compounds is available for different processing techniques such as blown film extrusion, sheet and profile extrusion, injection moulding, blow moulding, etc.

Conductive carbon black

CABELEC compounds are carefully formulated products based on conductive carbon black. The type of carbon black, the addition level and the dispersion quality are key factors for achieving good conductivity – or low electrical resistivity.

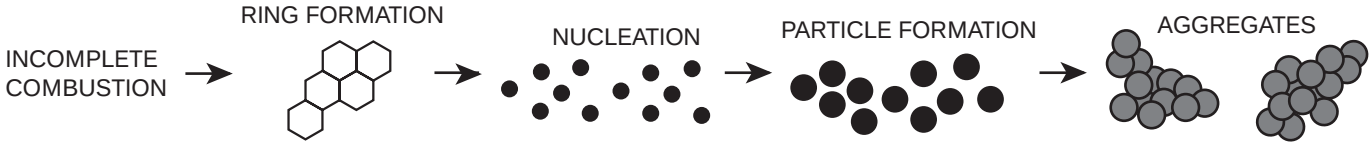
Carbon black is a particulate form of industrial carbon produced by thermal cracking or thermal decomposition of a hydrocarbon raw material. Many processes historically have been used to produce carbon black, but the most important now is the oil furnace process. It consists of atomising a heavy aromatic fraction of petroleum distillate into a preheated, closed furnace followed by cooling and collecting the formed carbon particles.

Carbon Black Oil Furnace Process



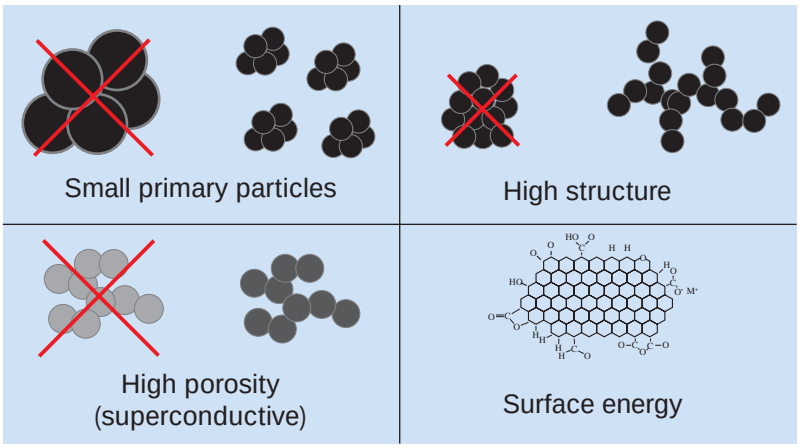
Electron microscopy inspection reveals that carbon black is composed of aggregates, which resemble fused clusters of spherical primary particles.

Carbon black oil furnace process



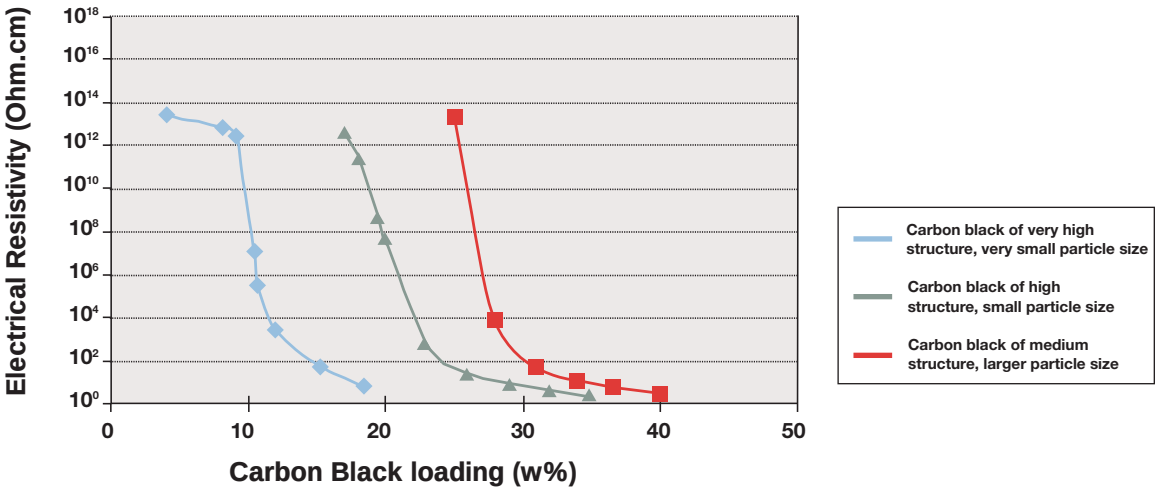
Both the aggregate size and shape, and the primary particle size, are controlling factors in determining carbon black performance. The following characteristics are key for a carbon black of good electrical conductivity:

Carbon black structure & properties



The addition level of carbon black in the polymer must be sufficient so that the carbon black particles touch, or are less than 10 nm away from each other. The relationship between the quantity of carbon black added and the electrical resistivity achieved is shown in the percolation curves below.

Examples of percolation curves



Processing CABELEC compounds

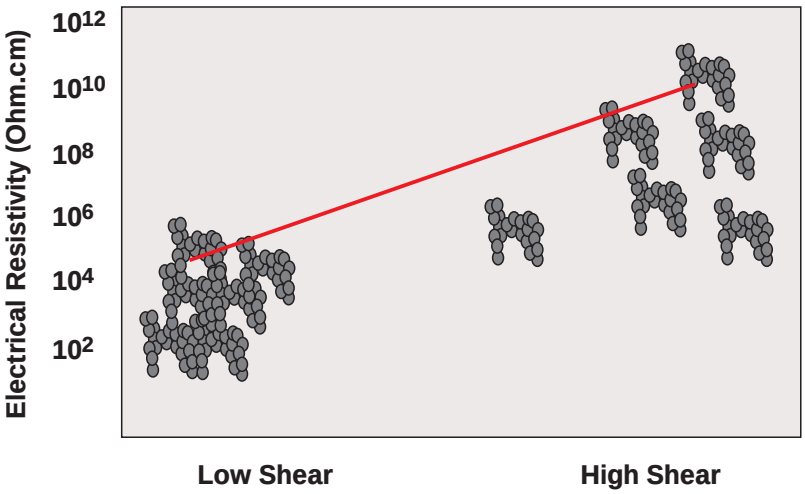
Predrying

As the carbon black contained in the compounds is hygroscopic, CABELEC compounds should be stored in a dry place. Before processing – unless specified in the Product Data Sheet for the specific grade – the compounds need to be predried. Processing a compound having too high a moisture content will result in, for example, surface blemishes in the injection moulded part, holes in the blown film, and so on.

Processing

CABELEC compounds can usually be processed on conventional processing equipment. To ensure good electrical and mechanical properties of the material, it is strongly recommended that the compounds be processed under low shear conditions. In fact, conductive carbon black filled compounds are highly shear sensitive. Too much shear deteriorates the carbon black structure and will result in higher electrical resistivity of the manufactured item.

Influence of shear on carbon black structure and electrical resistivity



Processing equipment and parameters should be carefully selected so that the shear generated is kept to a minimum. For more details please refer to the specific CABELEC processing sections.

Dilution

CABELEC products provide optimum performance when used alone i.e. without dilution with non-conductive raw materials. For this reason we do not recommend dilution. In some processing techniques dilution is performed via addition of regrind. One should keep in mind the fact that the regrind is increasingly "diluted " resulting in progressively lower fractions of conductive material in the finished part. Appropriate blending and feeding procedures are required to maintain the desired resistivity levels. Rigorous testing of the electrical resistivity is also strongly recommended.

Purging

After a CABELEC production run purging of the equipment is required. Due to its high carbon black content, CABELEC can be problematic when changing to a natural or light coloured material. It is generally recommended to purge with a natural, high viscosity resin and to clean the screw and barrel mechanically.

Extrusion

Applications

Conductive compounds are widely used in the electronics industry. Examples of applications are:

- Polystyrene carrier tapes
- Polystyrene thermoformed trays
- Polypropylene corrugated sheet
- Polyethylene/EVA foam

Conductive compounds are also used in industrial applications such as:

- Tubes, pipes, corrugated tubes for hazardous areas (mines, powder or chemical factories)
- Polyolefin monofilament fibres for antistatic big bags for handling of dangerous goods
- Conveyor belts

In order to comply with the ATEX norms, CABELEC conductive compounds can offer a valuable solution to producers looking for permanently conductive materials with a surface resistivity below 10^6 ohms/sq.

Equipment requirements for extrusion of CABELEC compounds

CABELEC compounds can be processed on conventional extrusion equipment although it is important to select the optimum processing conditions. To ensure good electrical and mechanical properties of the extruded part, it is strongly recommended that the CABELEC compound be processed under conditions of low shear.

A general purpose screw of L/D ratio of 20-30/1 with a long feed section is recommended. The compression zone should be of low compression ratio. The die can be a general purpose type of standard to large size in order to avoid any restriction of flow.

Extruders with mixing elements, restrictions in the barrel, high compression ratios, melt pumps or tight screen packs should be avoided. Low screw speeds are recommended. It is also important to avoid beads on calender rolls, to optimise nip roll temperatures and to match extrusion and haul-off speeds.

Optimum guidelines for processing of CABELEC compounds

Processing parameter	Settings versus natural polymer
Barrel temperatures	10-20°C higher
Melt temperatures	10-20°C higher
Die temperatures	20°C higher
Extrusion speed	Lower

Coextrusion

For conductive sheets, coextrusion can be used provided that a high volume resistivity is acceptable. The external conductive layers can be coextruded with a non-conductive middle layer, using cheaper polymers or recycled material which will be encapsulated in the film construction ("sandwich" structure).

Dies

When extruding conductive sheets, it is sometimes necessary to have a temperature differential between the external and internal part of the die: the external part being hotter. This is to compensate for the longer flow path of the external part of the sheet compared to the internal part. However a temperature gradient in the sheet can cause additional shear negatively affecting the conductivity.

Stretching

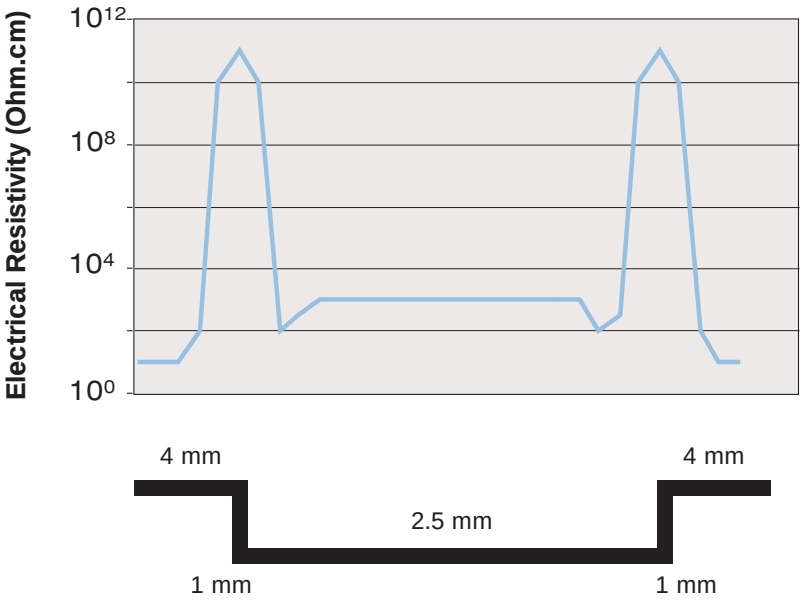
After extrusion, stretching should be very limited because it increases the distance between the carbon black structures thereby negatively affecting the conductivity. Ideally the die gap should be the same as the sheet thickness. This is particularly important when extruding monofilaments.

Calenders

If the extruded sheet has to pass between two calenders (nips) for cooling, it is recommended that the upper roll is set at a temperature 6-10° C above the lower roll. Another important factor is to avoid beads on the nips, minimising additional shear on the material.

Thermoforming

Special care needs to be taken during the thermoforming process due to the varying degrees of shear to which different parts of the sheet are subjected. Conductivity can be lost in vertical sections due to separation of the carbon black structures. In other words, the surface resistivity will be highest in the thinnest parts of the thermoformed article as illustrated below:



Troubleshooting guide

Some potential problems that can occur with CABELEC compounds are:

Problem	Potential cause	Recommendations
Lack of conductivity	Shear too high Too much regrind Dilution too great Material too stretched	Increase temperature, reduce speed Reduce or remove regrind Reduce or remove natural resin Avoid stretching after extrusion Avoid nip beads Ensure homogeneous cooling by adjusting temperatures of calenders and die
Inhomogeneous surface resistivity	Non-homogeneity related to thermoforming process	Increase thickness, review thermoforming design avoiding excessive stretching
Poor surface finish	Moisture	Dry CABELEC compound according to guidelines in product data sheet
Die deposit	Moisture	Dry CABELEC compound according to guidelines in product data sheet
Voids	Moisture	Dry CABELEC compound according to guidelines in product data sheet

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