Carbon Black Pigments for Conductive Coatings

Technical Information 1455

ENGINEERED CARBONS

Focused. Innovative. Responsive.

Contents

1. Introduction

Carbon Black is the ideal black pigment because it is lightfast, resistant to chemical attack and shows a deep black color that makes it superior to other inorganic pigments such as iron oxides. It is mainly used in two applications, pure black coatings for which the jetness is the dominating parameter, and gray coatings and paints, for which the tinting strength is more important. The first category includes Carbon Black Pigments with mainly small primary particle sizes, and the second one with medium to large particle sizes. The primary purpose of black and gray coatings is decoration and protection. Special applications for coatings often require electrical conductivity. Possible application fields include: the prevention of electrostatic charges e. g. in tank coatings, to guarantee the appliqué of a top layer via electrostatic charge or to avoid sparking in the proximity to explosives or microelectronics.

The application of Carbon Blacks to provide electrical conductivity to a coating system can be subdivided into two major classes comprising either electrostatic discharge (ESD) or conductive purposes.

Conductive applications[1] require a volume resistivity that is below $5 \cdot 10^4\,\Omega$ cm. These encompass electrical parts, such as connectors, switches, resistors, potentiometers or EMI shields (equipment against electromagnetic interference) as well as heating elements with PTC (positive temperature coefficient), which enables self-regulating power consumption. Special applications include corrosion-resistant electrodes and petrol-sensitive resistors.

Electrostatic discharge[1] applications require volume resistivity values between $5 \cdot 10^4\,\Omega$ cm and $10^8\,\Omega$ cm. These include products such as casings and containers of electrical devices, both of which are sensitive to static electricity. Additionally, flooring and packaging materials required by the electronics industry, and applications to prevent static electricity build-up in mining and other areas with explosion risks are also areas of application.

2. Electrical conductivity

2.1 Carbon Black characterization

Industrially produced Carbon Blacks are mainly characterized by the primary particle size, specific surface area, structure and surface chemistry. The mean primary particle size is a measure for application-technological properties of the Carbon Blacks. Carbon Blacks consist of primary particles which are almost spherical in shape. These primary particles that are formed during the initial Carbon Black formation stage fuse together building up three-dimensional branched clusters called aggregates. The aggregates represent a discrete, rigid colloidal entity that is the smallest dispersible unit[2]. A great variety exists concerning the size of the primary particles as well as the size and the shape of the aggregates. The primary particle size is measured by evaluating transmission electron-micrographs (TEM)[3]. The specific surface area of Carbon Blacks depends strongly on the primary particle size and displays an inverse correlation.

The Carbon Black structure has been defined quantitatively by Medalia[4] as the average number of particles per aggregate. Hence, the higher the structure is, the more branched the aggregates are. The structure of Carbon Blacks – the degree of branching – is determined by the oil absorption number (OAN; according to ASTM D 2414). Low-structured Carbon Blacks exhibit low OAN values, in the range of 40 – 70 ml paraffin oil/100g Carbon Black. Carbon Blacks showing OAN values in the range of 100 – 150 ml/100g are described as "Carbon Blacks with a high structure". Very high structured Carbon Blacks are represented by OAN values that are larger than 150 ml/100 g.

Orion Engineered Carbons offers a broad range of Carbon Blacks with varying electrical performance. It is not uncommon to find that the quantities of the widely used conductive Carbon Black PRINTEX® L6 that are needed to achieve the targeted conductivity are too high. This is due to the fact that other required properties are influenced in a negative manner. On the other hand the extremely high performance of extra-conductive Carbon Black PRINTEX® XE2-B may not be necessary. Therefore, Orion Engineered Carbons opted to create the medium-conductive Carbon Black Pigment XPB 545 based on an innovative Furnace technology. This offers a well-balanced performance across conductivity, dispersibility and cleanliness.

2.2 Carbon Black parameters influencing electrical conductivity

The present study focuses on electrically conductive systems containing Carbon Black. Therefore, the so-called "intrinsically" conductive Polymers are not included. This bulletin discusses issues associated with the formulation and application of electrically conductive coating systems.

Conductive Carbon Blacks are characterized by a high specific surface area (small primary particle size) as well as a high structure. The conductivity imparted to a coating system by Carbon Black depends primarily on the following parameters:

- Carbon Black loading
- primary particle size, specific surface area
- Carbon Black structure
- porosity
- surface oxide groups
- coating system/formulation (binder, dispersion additive, …), chemical nature, molecular weight and viscosity
- mixing and finishing process

Details of investigations on the influence of the above-listed parameters on the specific electrical resistivity are given next.

a) Influence of the primary particle size and concentration of Carbon Blacks on specific electrical resistivity

Several authors[5, 6] have reported that the primary particle size is the major Carbon Black parameter that influences the conductivity. In order to ensure electrical conductivity of Polymer compounds or coatings continuous networks for the transfer of charge between Carbon Black particles or aggregates are necessary, and are influenced by the distance between adjacent particles, aggregates or agglomerates. Electron tunneling, a quantum mechanical phenomenon, is the primary conduction path. According to this mechanism electrons can also pass through thin insulating Polymer films that separate the Carbon Black particles. Hence, direct contact between aggregates is not required. The tunneling current is an exponential function of the gap width between two particles. Rather than the length of the particle chains, it is the average width of the gaps between adjacent particles that determines the electrical conductivity of a coating system containing Carbon Black. Small changes in the gap width will strongly influence the conductivity. The intrinsic conductivity of Carbon Black aggregates has a limited influence. Wang, Wolff and Tan[7] have shown that in addition to loading, the main filler parameter determining the distance between aggregates is the specific surface area. Consequently, the smaller the primary particle and aggregate size at a fixed structure and filler loading are, the smaller the gaps will become (Figure 1).

Figure 1

Illustration of the influence of particle size. Halving the primary particle and keeping the filler loading constant drastically reduces the gap width between adjacent aggregates due to an 8-fold increase in the number of aggregates $4/3\pi R^3 = 8(4/3\pi (R/2)^3)$.

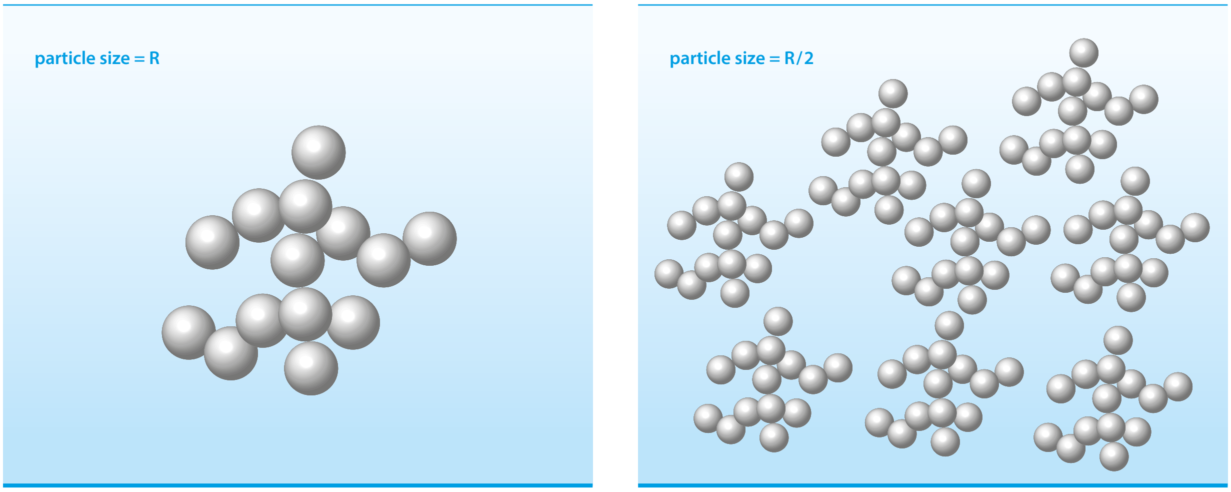
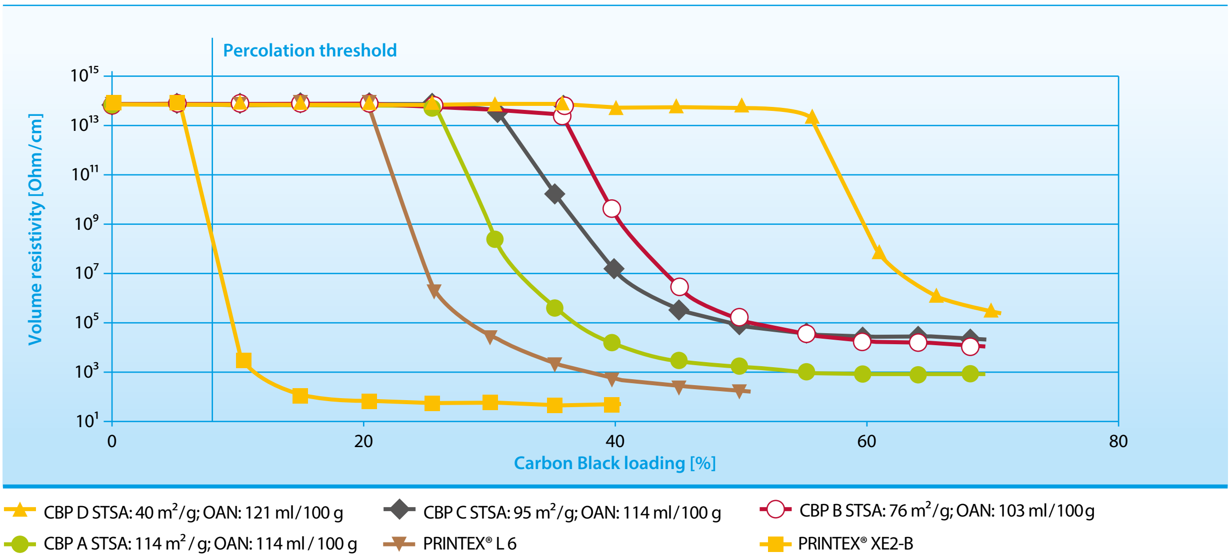


Figure 2 presents typical electrical resistivity data of compounds containing various Carbon Blacks as a function of loading. The critical loading, which is located at the strongest decrease of the resistance curve, is called percolation threshold[8]. Small shifts in the Carbon Black loading close to the percolation threshold cause major changes in the conductivity. Each of the curves approaches a similar asymptotic limit in conductivity. This limit is achieved at a much smaller degree of loading for high surface area blacks. The influence of the specific surface area can be very easily seen by comparing the blacks A, B and D, which differ only in surface area. The percolation threshold is reached at lower loadings for the Carbon Black A, the black with the higher surface area.

Figure 2

Volume resistivity as a function of loading for various Carbon Blacks at room temperature.



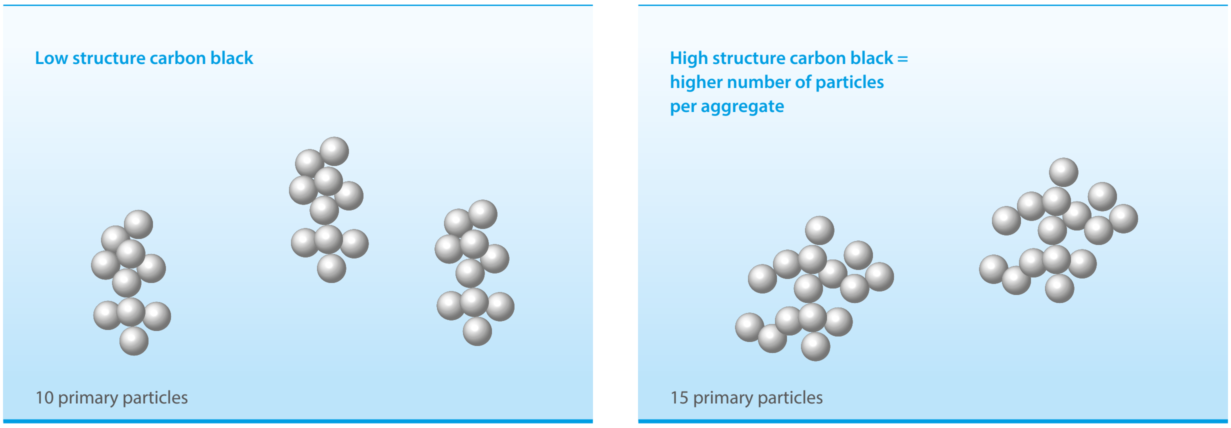
b) Influence of Carbon Black structure

Janzen's theory[8] predicts that high-structured blacks pass a low percolation threshold, and at a given loading, a high-structured black would be expected to have a higher conductivity than a low-structured black. Indeed, most conductive Carbon Blacks such as PRINTEX® XE2-B or acetylene black exhibit a high structure. However, Medalia[4] showed that standard Carbon Blacks at a fixed loading do not reflect this structure effect in various elastomers. As found in Figure 2, the effect of structure on conductivity is not immediately obvious (compare Carbon Black B with Carbon Blacks A and C). An explanation for this contradiction is that Carbon Blacks with a high structure are better dispersed than low-structured blacks under the same dispersion conditions. Figure 3 is an illustration of the influence of the Carbon Black structure on the distance between adjacent aggregates. Once more, at a similar dispersion we cannot draw a firm conclusion on the relationship between the structure and the inter-aggregate distance.

OEC-TI 1455-08/2013

Figure 3

Sketch to display the influence of different Carbon Black structures on the distance between adjacent aggregates.



To evaluate the influence of the Carbon Black structure on electrical resistivity in more detail, we tested three different PRINTEX® grades which vary in structure but not in specific surface area or primary particle size. The structure of the grades decreases as follows: PRINTEX® 3 > PRINTEX® 30 > PRINTEX® 300.

In Figure 4 the surface resistivity values of the aforementioned Carbon Blacks are plotted on a logarithmic scale at different Carbon Black concentrations in a water-borne acrylic/melamine test coating system. The graphs for PRINTEX® 3 and PRINTEX® 30 are very similar whereas the low-structured grade PRINTEX® 300 shows higher surface resistivity values.

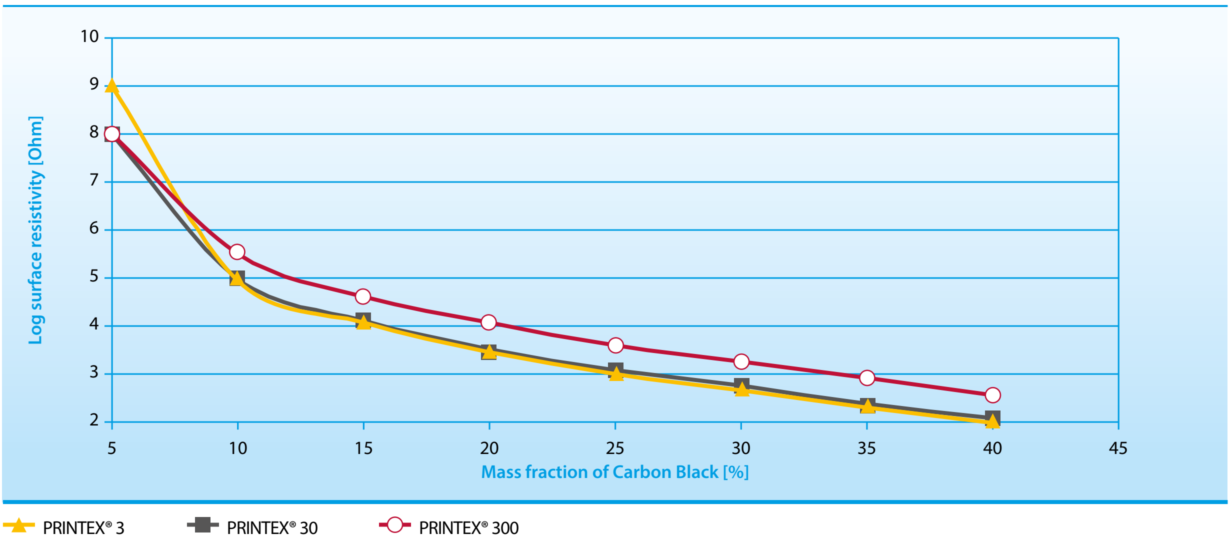
Table 1

Analytical data of different PRINTEX® Carbon Blacks.

Carbon Black Pigment	OAN [ml/100 g]	STSA [m²/g]	Primary particle size [nm]
PRINTEX® 3	123	76	27
PRINTEX® 30	105	77	27
PRINTEX® 300	66	75	27

Figure 4

Specific surface resistivity as a function of Carbon Black concentration in the let-down. The Carbon Black Pigment concentration is related to the non-volatile content of lacquer (dry film).



The results can be interpreted as follows: at a given specific surface area of the Carbon Black a certain structure is necessary to get a sufficient dispersion. If a certain dispersion level is reached a further increase in structure gives no further or only limited effect.

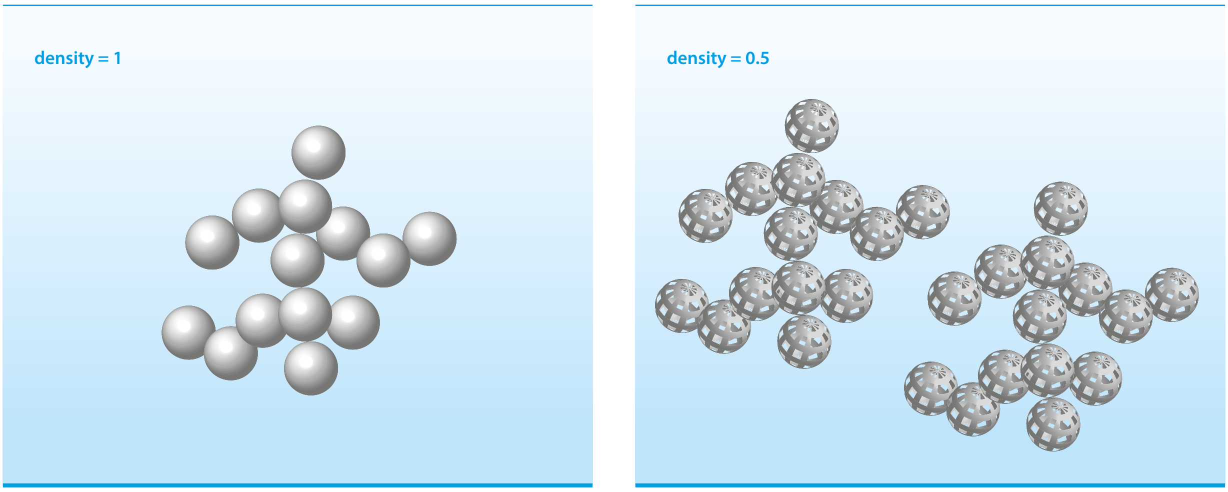
It is now understandable that high specific surface area Carbon Blacks always offer a high structure to guarantee a sufficient dispersion level. Nevertheless, the specific surface area is the major parameter ruling the electrical behavior. >>>

c) Influence of the Carbon Black porosity

While in most applications porous Carbon Black particles are not desired, it is an advantageous attribute for conductive purposes, due to the higher volume filling at a given weight loading. As shown in Figure 5, the number of particles per unit volume is increased at increased porosity, thus reducing the average inter-particle distance.

Figure 5

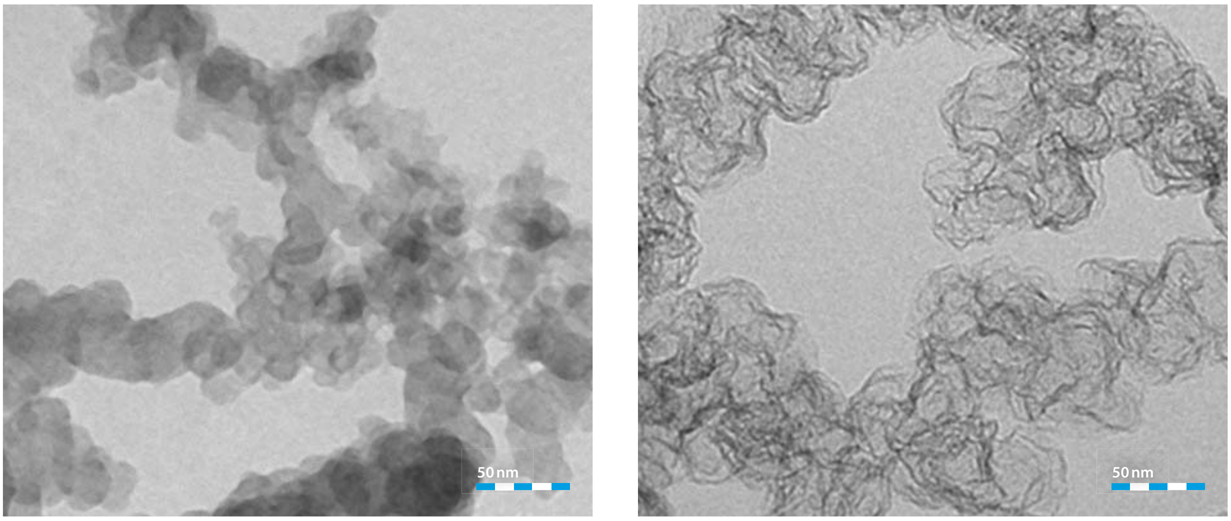
Sketch to display the influence of porous particles on the distance between adjacent aggregates.



Extra-conductive Carbon Blacks like PRINTEX® XE2-B exhibit an extremely high porosity. Figure 6 presents a comparison of high-resolution TEM images of the conductive Carbon Black PRINTEX® L6 (left) and the extra-conductive Carbon Black PRINTEX® XE2-B (right). In contrast to PRINTEX® L6 the particles of PRINTEX® XE2-B have a shell-like structure, which is measured as high porosity. This architecture is very unique for Carbon Blacks. This high porosity rather than surface area or structure is the key driver for the excellent conductivity behavior of PRINTEX® XE2-B.

Figure 6

High-resolution TEM images of a regular conductive Carbon Black, PRINTEX® L6 (left), and the extra-conductive Carbon Black, PRINTEX® XE2-B (right).



The porosity of Carbon Blacks can be divided into two categories, open and closed porosity. Open porosity can be in the form of small pores in the order of nanometers of an undefined shape. Internal voids that are not accessible to the surface are closed pores. Detecting the porosity of Carbon Black is not limited to TEM images. Typically, gas adsorption techniques are used: nitrogen adsorption (BET surface area) and the statistical thickness surface area (STSA) are most common. The BET method for nitrogen surface area determination was developed by Brunauer, Emmet and Teller[9]. Due to its small size the nitrogen molecule is able to enter pores. Therefore, nitrogen surface area measures not only the external surface area but also the surface area belonging to pores, called internal surface area. The STSA is also based on nitrogen adsorption isotherms and is a measure of only the external or accessible surface area. The V_a-t plot method developed by deBoer[10] provides information on the size and size distribution of pores as well as the specific surface area of the Carbon Black. Hence, the gap between the BET and STSA number is a measure of the porosity of a Carbon Black.

d) Influence of the oxidation level of Carbon Blacks

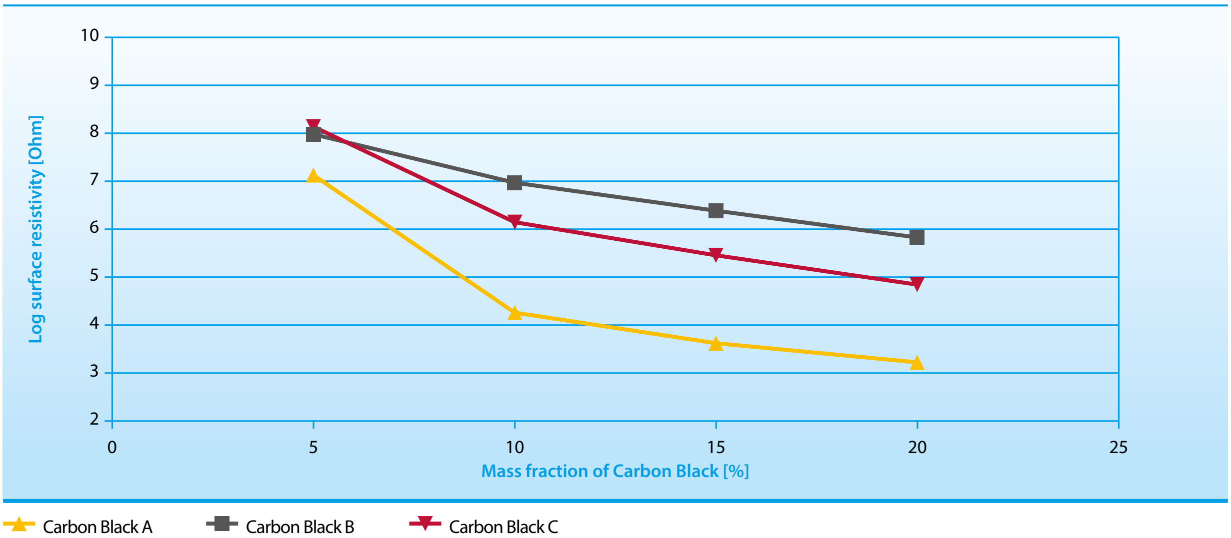
It is also important to evaluate the influence of the surface chemistry of Carbon Blacks on conductivity phenomena. A simple measure for the surface groups (carboxylic, hydroxylic, quinonic and lactonic groups) is the content of volatile matter at 950 °C that is determined according to DIN 53552.

To demonstrate the influence of surface oxidation on the conductivity of coatings, a non-oxidized Carbon Black A and two oxidized Carbon Black samples B and C were tested. For the latter two experimental grades, different oxidation processes were used. In doing so various oxygen containing functional groups in different concentrations were formed on the surface of the Carbon Black. All three tested grades are very similar in specific surface area, structure and particle size distribution. The corresponding specific surface resistivity is plotted as a function of the Carbon Black concentration in the let-down (Figure 7). Due to the very high specific surface area of all grades, the surface resistivity level – especially for Carbon Black A – is very low.

Comparing oxidized and non-oxidized grades, a significantly lower surface resistivity for the non-oxidized Carbon Black A can be recognized. Higher resistivity values are observed for both after-treated experimental grades. Whether this effect can be interpreted by a kind of insulating layer on the Carbon Black surface, as discussed in the literature, is questionable. An increase in the inter-aggregate distances caused by a better interaction with one of the ingredients is a better explanation.

Figure 7

Specific surface resistivity as a function of Carbon Black concentration in the let-down. The Carbon Black concentration refers to non-volatile constituent of lacquer (dry film).



3. Experimental investigations

3.1 Selection of suitable Carbon Blacks

In summarizing all the information from chapter 2 it can be concluded that Carbon Blacks with a high specific surface area and high structure should be the right choice to reach the percolation threshold at low Carbon Black concentrations. Extra-conductive Carbon Blacks are typically characterized by high porosity. As already noted, high >>> porosity in Carbon Blacks is undesirable for most applications. However, but for conductive purposes it is very advantageous.

The following table summarizes the Carbon Blacks which were evaluated in the following experiments.

Table 2
Analytical data of all investigated Carbon Blacks.

CBP	BET [m²/g]	STSA [m²/g]	OAN [ml/100 g]
XPB 545	375	235	175
PRINTEX® XE2-B	1000	950	420
PRINTEX® L6	270	125	126
PRINTEX® L	150	90	120
HIBLACK® 40B2	125	102	150
HIBLACK® 600L	235	220	72
Ketjenblack® EC-300J	810	420	345
VULCAN® XC 72	240	130	174
VULCAN® XC 605	60	59	148
ENSACO® 350G	770	525	320

3.2 Measurement of conductivity

The experiments described below were conducted in water-borne acrylic/melamine stoving enamels and the specific surface resistivity was measured on coated glass plates. The measuring instrument was a Loresta-GP MCP-T610 manufactured from Mitsubishi Chemical Analytech, with the 4-pin measuring electrode ASP and measuring adapter RMH 110, also by Mitsubishi Chemical Analytech, with a spring pressure of 240 g/pin and 5 mm pin-distance. The measurement range was from 10 mΩ up to 10 MΩ. The graphs and tables show mean values from three measurements with good reproducibility. In the following figures the concentration of Carbon Black is always related to non-volatile constituents of the lacquer (dry film). The layers applied on glass plates have a dry film thickness of approximately 40 µm.

3.3 Guideline formulations in a water-borne acrylic/melamine stoving enamel coating system

The formulation of the conductive water-borne acrylic/melamine stoving enamel coating is composed of the acrylate resin Bayhydrol® A 145 from Bayer Material Science and the melamine resin CYMEL® 327 from ALLNEX S.a.r.l.

The dispersion of pigments is a critical factor for coating quality and strongly depends on the formulation, the Carbon Black type as well as its concentration. Consequently, the loading in the mill base was adjusted based on the type of Carbon Black used.

It is very important to note that the high conductive Carbon Blacks, PRINTEX® XE2-B and XPB 545, have a stronger thickening effect than the other Carbon Blacks mentioned due to their very high surface area. In order to produce the optimum mill base composition, a correspondingly low concentration of these Carbon Blacks was used. For all experiments the mill bases were used as described below (Table 3). In the let-down process, the Carbon Black concentration relative to non-volatile matter was adjusted to provide measureable changes in surface resistivity.

Table 3

Guideline formulations for extra-conductive and conductive Carbon Black grades.

Mill base	PRINTEX® XE2-B	XPB 545	PRINTEX® L/ PRINTEX® L6	HIBLACK® 40B2 / HIBLACK® 600L beads
Dist. water	20.9	29.4	26.6	26.6
Bayhydrol® A 145, 45 % from Bayer Material Science	73.1	58.6	53.4	53.4
Carbon Black	6	12	20	20
Total	100	100	100	100
Carbon Black concentration	6	12	20	20
Concentration of the binder solution	35	30	30	30
Let-down				
Mill base	52.3	26.4	41.7	41.7
Bayhydrol® A 145, 45 % from Bayer Material Science	26.2	49.4	37	37
CYMEL® 327, 90 % in isobutanol, from ALLNEX S.a.r.l.	8.2	8.1	7.6	7.6
Dist. water	13.3	16.1	13.8	13.8
Total	100	100	100.1	100.1
Total Carbon Black concentration	3.15	3.17	8.33	8.33
Carbon Black concentration related to non-volatile matter	8	8	20	20
Ratio AY:MF	80:20	80:20	80:20	80:20

The pre-dispersion was done with a Pendraulik, LR 34, tip speed: 8 – 10 m/s, disc diameter: 40 mm for 5 min.

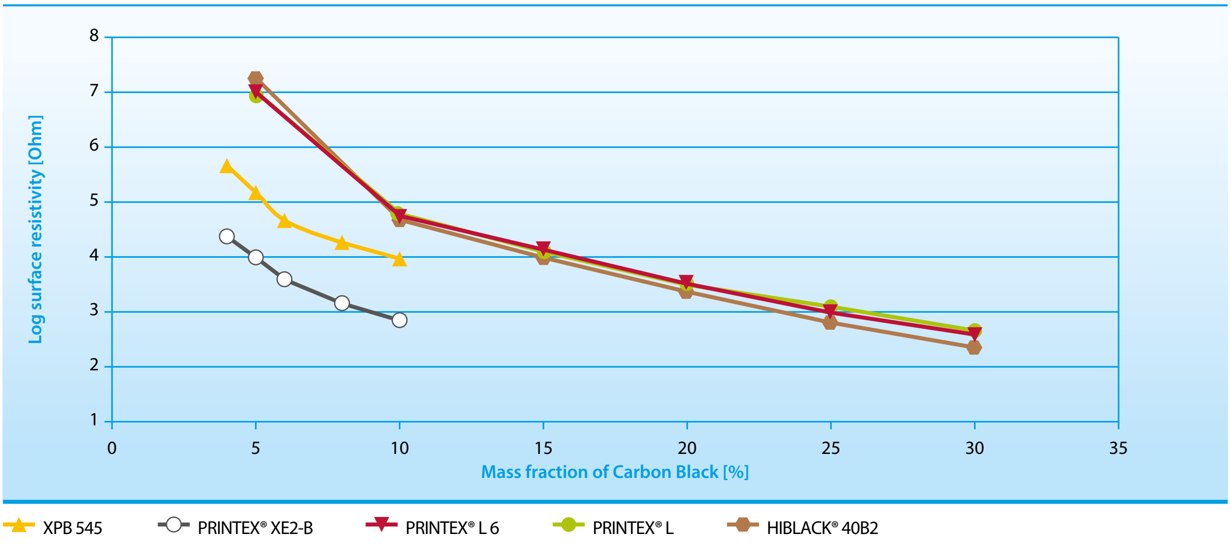
The dispersion was carried out by a LAU Disperser DAS 200 or BA S 20 for 1 h using 540 g chromanit steel pearls with a diameter of 3 mm and 80 g mill base. After dispersion the mill bases were let-down and applied on a glass plate (130 mm x 90 mm x 1 mm) with a bar (wet layer thickness: 200 µm).

3.4 Influence of Carbon Black concentration

Figure 8 shows the specific surface resistance for different types of Carbon Black as a function of Carbon Black concentration in a water-borne acrylic/melamine stoving enamel coating system. PRINTEX® XE2-B exhibits a resistance of about 420 Ω (equal to the logarithmic value of 2.6) at a content of only 10 % by weight, while the standard conductive Carbon Blacks used for comparison require a concentration of about 30% by weight to reach this value. Mechanical characteristics, such as adhesion and flexibility of the coating film can be deleteriously affected by high Carbon Black loadings. Therefore, systems which limit Carbon Black loading are highly preferred and the extra-conductive Carbon Blacks are the better choice for the balance of conductivity and mechanical performance.

Figure 8

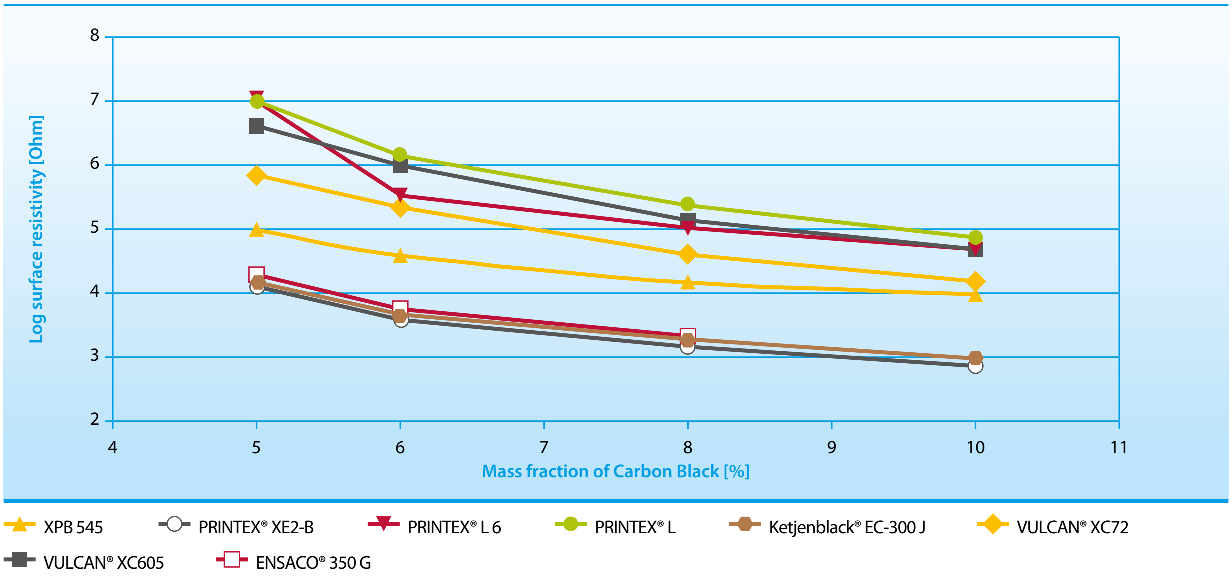
Surface resistivity for different types of Carbon Black as a function of concentration in water-borne acrylic/melamine stoving enamels.



The new product XPB 545 offers a resistivity performance between the extra-conductive PRINTEX® XE2-B and the conductive grades like PRINTEX® L, PRINTEX® L6 or HIBLACK® 40B2 (Figure 8). At relatively low concentrations of 4 to 6 % of XPB 545 the electrical resistance decreases rapidly. Comparing the Carbon Blacks XPB 545, PRINTEX® XE2-B and HIBLACK® 40B2 at the same resistivity level of 10 Ω (equal to the logarithmic value of 4.0), only 8.7 % of XPB 545 versus 5% of PRINTEX® XE2-B and 15 % HIBLACK® 40B2 are necessary. This puts XPB 545 in the rank of medium-conductive Carbon Blacks.

Figure 9

Specific surface resistivity of various Orion Engineered Carbons and competitor Carbon Blacks as a function of the Carbon Black content in water-borne acrylic / melamine stoving enamels.

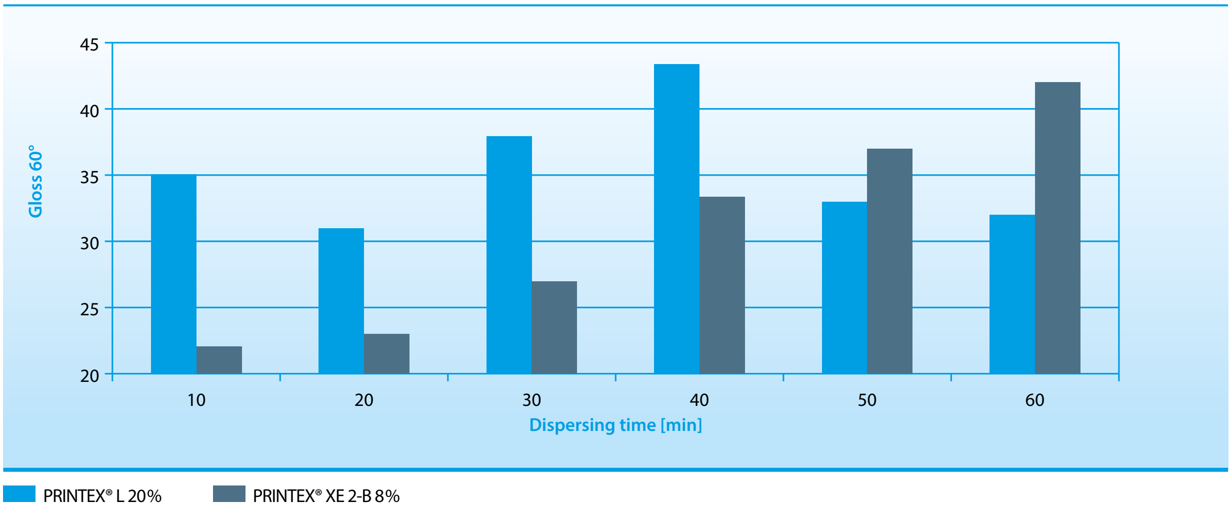


A comparison between several Carbon Blacks from Orion Engineered Carbons and selected competitive materials like Ketjenblack® EC-300J from Akzo Nobel, VULCAN® XC 72 and VULCAN® XC 605 from Cabot Corporation and ENSACO® 350 from TIMCAL is presented in Figure 9. All formulations in this graph were prepared with 6 % Carbon Black in the mill base.

PRINTEX® L and PRINTEX® L6 display similar levels of surface resistivity to VULCAN® XC 605. VULCAN® XC 72 achieves slightly lower resistivity levels, but it does not reach the performance level of XPB 545, which demonstrates even lower surface resistivity values. The lowest resistivity values of coatings were observed for the extra-conductive Carbon Black Pigments PRINTEX® XE2-B, Ketjenblack® EC-300J and ENSACO® 350G.

Figure 10

Development of gloss (60 °) as a function of dispersing time in water-borne acrylic/melamine stoving. 20 % PRINTEX® L and 8 % PRINTEX® XE2-B total in the dried coating film.



The dispersion of pigments is crucial to the final coating's performance and hence special care must be taken. Consequently, the gloss value and the fineness of grind were investigated as a function of the dispersing time (Figure 10 and Figure 11). Both parameters are indicators for the achieved dispersion level. The higher the gloss and the lower the fineness of grind are the better the Carbon Black particles' dispersion is. For PRINTEX® XE2-B, with a Carbon Black concentration of 8 %, the gloss value increases with dispersion time as expected. In contrast, the gloss of PRINTEX® L, with a Carbon Black concentration of 20%, runs over a maximum and achieves the highest value at a dispersing time of 40 minutes.

Figure 11

Development of fineness of grind as a function of dispersing time in water-borne acrylic/melamine stoving enamels.

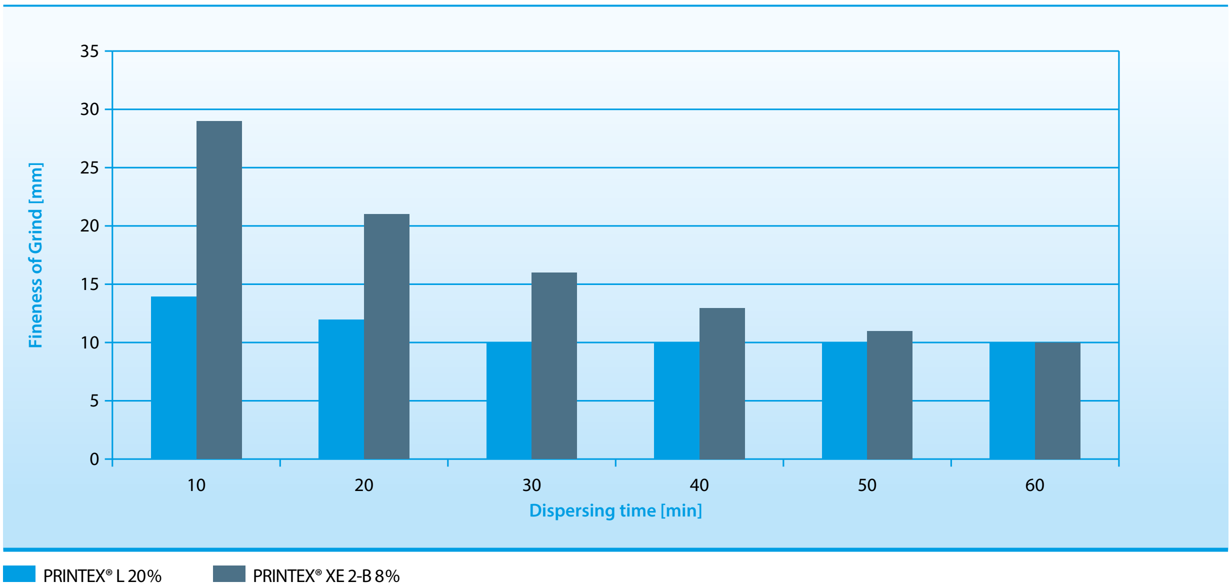
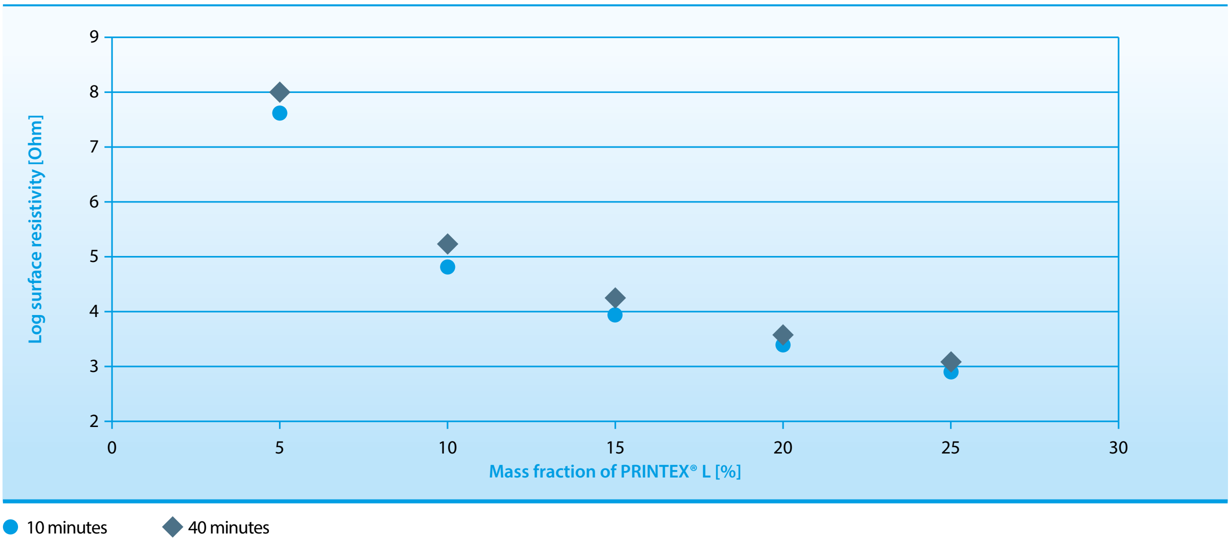


Figure 11 displays that the fineness of grind decreases with increasing dispersing time. Furthermore, it can be recognized that for PRINTEX® XE2-B a longer dispersing time is needed to achieve the same Fineness of grind level as with PRINTEX® L.

Figure 12

Specific surface resistivity as a function of Carbon Black concentration for different dispersion times (10 and 40 minutes) in a water-borne air-drying coating at room temperature.



The influence of dispersion time on the specific surface resistivity was analyzed for various Carbon Black concentrations for the Carbon Black PRINTEX® L (Figure 12). It can be seen that the surface resistivity decreases with increasing Carbon Black concentration due to a better dispersion caused by higher shear forces created during grinding. Furthermore, the influence of the dispersing time on conductivity measured at 10 and 40 minutes can be seen: the shorter the dispersion time, the higher the conductivity.

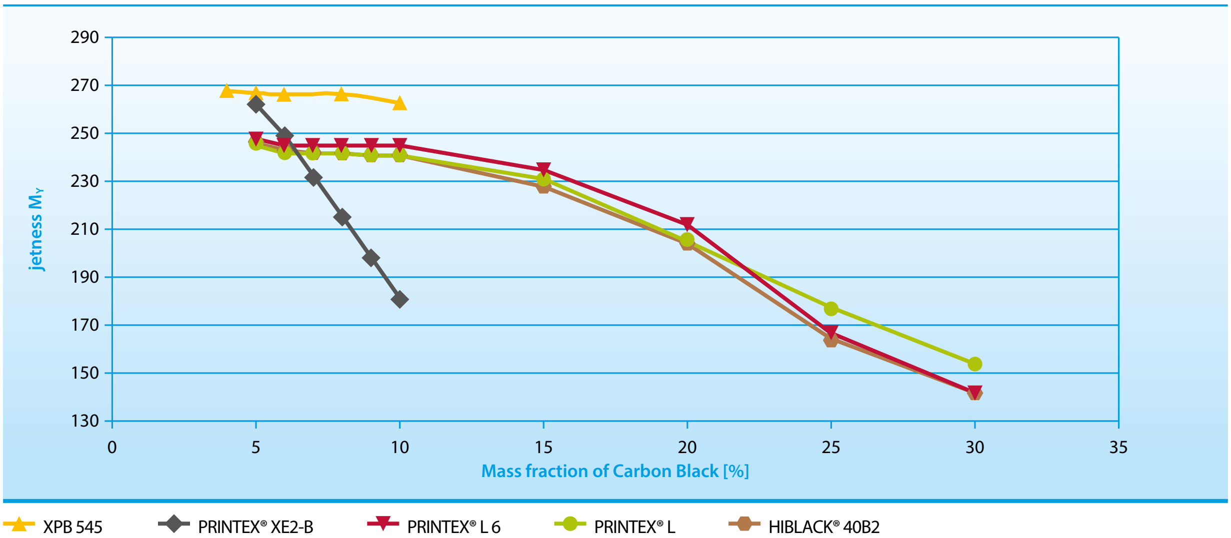
It can be concluded that the Carbon Black concentration and the dispersion time have to be adjusted well to get the optimum balance of electrical conductivity and gloss.

3.5 Optical characteristics of the conductive coatings

In addition to the electrical characteristics of coatings, questions often arise concerning coloristic properties like jetness, undertone and gloss of these coatings. The conductive blacks PRINTEX® L, PRINTEX® L6 and HIBLACK® 40B2 behave very similarly in terms of jetness (depth of color given as the M_Y-value; $M_Y = 100 \cdot \log(100/Y)$ (Figure 13). The extra-conductive black PRINTEX® XE2-B exhibits higher jetness values at low Carbon Black concentrations up to 8 %. The new product XPB 545, whose conductivity lies between extra-conductive and conductive blacks, offers a high jetness level of M_Y ~ 265 - even at higher Carbon Black concentrations as seen in Figure 13. Due to the high specific surface area of PRINTEX® XE2-B and XPB 545, a maximum of 10% Carbon Black Pigment could be incorporated into the mill base.

Figure 13

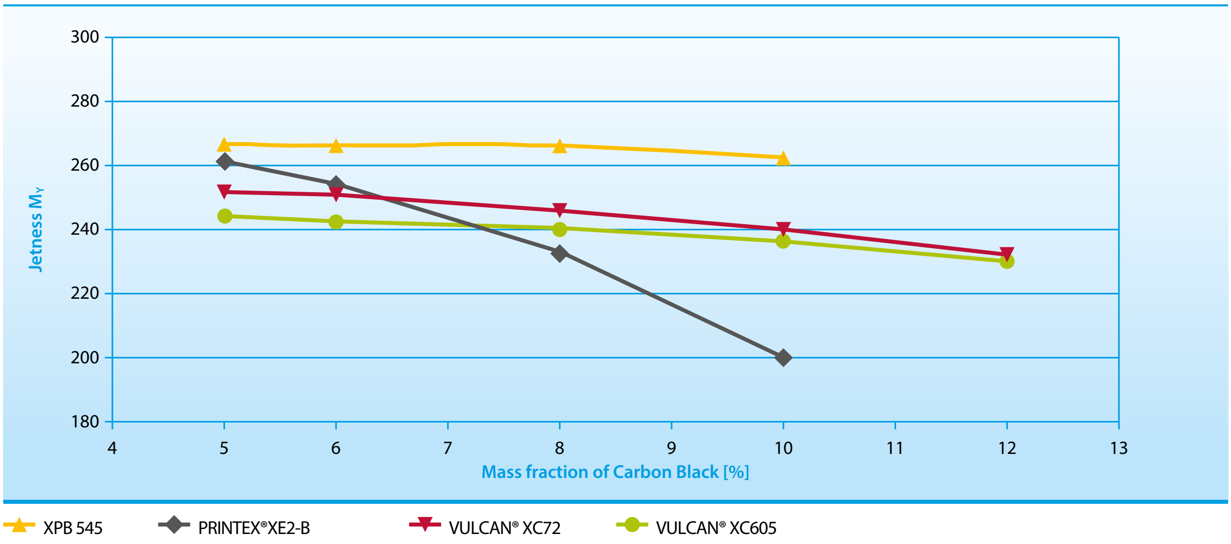
Jetness M_Y at various concentrations for different Carbon Blacks in water-borne acrylic/melamine stoving enamels; $M_Y = 100 \cdot \log(100/Y)$.



The jetness of various competitor Carbon Blacks in the water-borne coating test system as a function of the concentration in the let-down is shown in Figure 14. XPB 545 stands out by exhibiting very stable jetness values for all tested Carbon Black concentrations. This contrasts with the observation that the jetness of coatings containing PRINTEX® XE2-B decreases rapidly with increasing pigment concentration (Figure 14). An explanation for this behavior of the extra-conductive Carbon Blacks is their poor dispersion level at higher concentrations. The conductive grades from Orion Engineered Carbons PRINTEX® L, PRINTEX® L6 and HIBLACK® 40B2 as well as the competitive products VULCAN® XC 72 and VULCAN® XC 605 have a clearly lower jetness level but show similar curve progressions to XPB 545.

Figure 14

Jetness M_Y (direct measurement) of various Carbon Blacks as a function of Carbon Black concentration of the coating; $M_Y = 100 \cdot \log(100/Y)$.



The undertone values dM ($dM = 100 \cdot (\log X_n/X - \log Z_n/Z)$; positive dM value: bluish undertone; negative dM value: brownish undertone) were measured for the aforementioned Carbon Black types as a function of the filler concentration. At low Carbon Black concentrations the undertone is less bluish, but turns more bluish with increasing concentrations. A maximum in dM value is reached at a total pigment concentration of about 20 % in the dry coating film. Thereafter, the undertone starts to decrease and displays less bluish shade. A low dM value is a strong indicator for poor stability accompanied by re-flocculated Carbon Black Pigments. Thus, after passing a maximum concentration the Carbon Black aggregates come very close to each other which enhances re-agglomeration of the aggregates and larger agglomerates are formed. No maximum in dM could be reached for XPB 545 up to a Carbon Black concentration of 10% (Figure 15).

Figure 15

Undertone value dM ($dM = 100 \cdot (\log X_n/X - \log Z_n/Z)$) at various concentrations for different Carbon Blacks in water-borne acrylic/melamine stoving enamels.

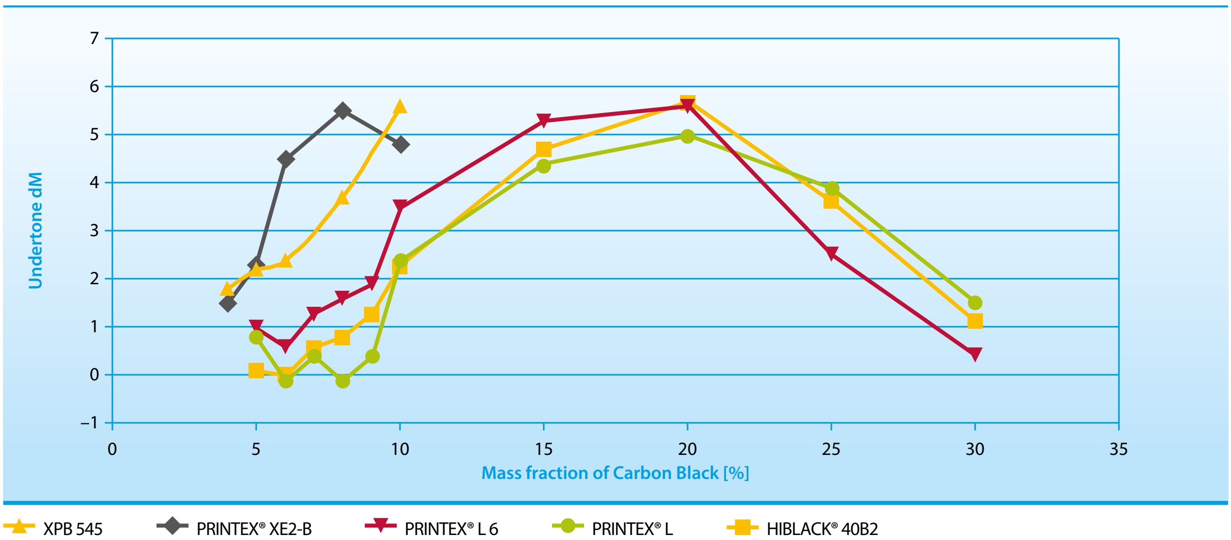


Figure 16

Gloss values at 20° as a function of Carbon Black concentrations in water-borne acrylic/melamine stoving enamels.

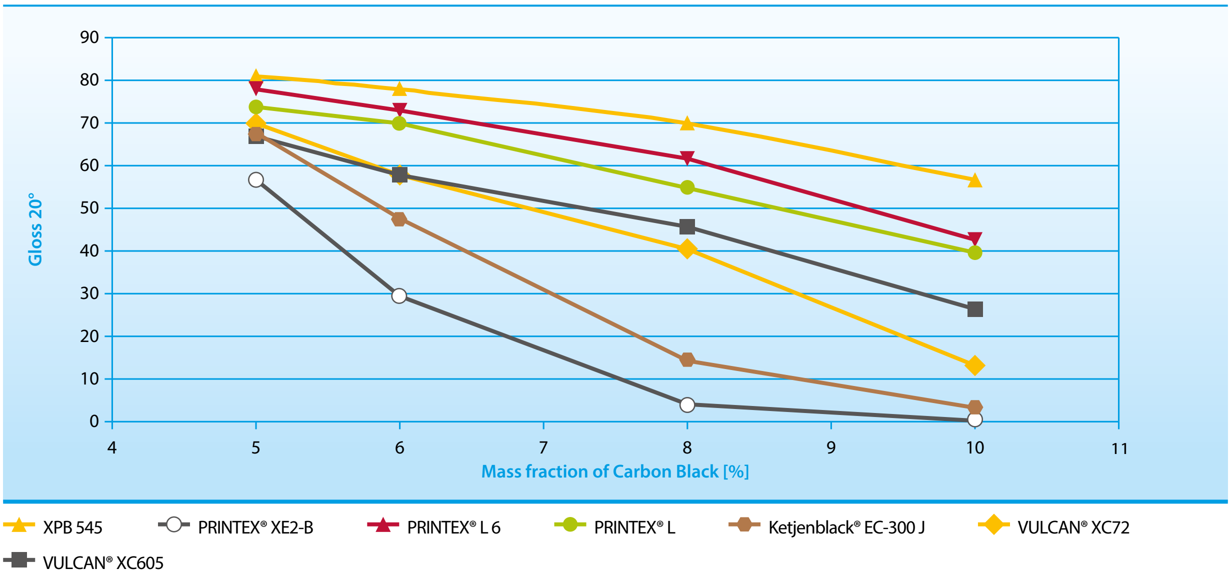


Figure 16 exhibits gloss data at 20° for different Carbon Blacks with increasing Carbon Black concentration.
In terms of gloss, XPB 545 shows the highest gloss values indicating that the dispersion level is the best at all concentrations compared to the alternative Carbon Blacks. Nevertheless, a strong decrease in gloss (20°) is observed for all grades with increasing Carbon Black concentration in the coating. The decrease is most pronounced for the extra-conductive grades Ketjenblack® EC-300J and PRINTEX® XE2-B. These coatings become more matt with increasing Carbon Black content.

4. Summary

In this technical bulletin the influence of various Carbon Black parameters such as primary particle size, structure and porosity on the electrical resistivity was illustrated. Dependencies were evaluated using a defined set of Carbon Blacks. Based on an understanding of the critical Carbon Black parameters Orion Engineered Carbons has developed the new medium-conductive Carbon Black XPB 545.

A range of Carbon Blacks was investigated in water-borne acrylic/melamine stoving enamels. In this test system, the influence of dispersing time on electrical resistivity as well as jetness, undertone and gloss of several Carbon Blacks was evaluated as a function of Carbon Black concentration.

It has been clearly demonstrated that the new, medium-conductive Carbon Black XPB 545 produces the highest conductivity values at concentrations significantly lower than conventional conductive Carbon Blacks. This special Carbon Black type also offers the advantage of easier and better dispersibility compared to extra-conductive blacks like PRINTEX® XE2-B. Higher jetness values, more bluish undertone and gloss values at higher Carbon Black concentrations can now be achieved.

In conclusion, it was demonstrated that less material is necessary to override the percolation threshold by using high surface area blacks. It is well-known that such blacks are difficult to disperse. XPB 545 offers a good balance regarding dispersibility, achieving the percolation threshold with low amounts of Carbon Black and achieving good coloristic properties at the same time.

5. Literature

[1] H. Ferch, „Die Technologie des Beschichtens – Pigmentruße", Hrsg.: Dr. U. Zorll, 1995, Vincentz Verlag Hannover, ISBN: 3-87870-426-7

[2] J.-B. Donnet, R.C.Bansal and M.-J. Wang, Carbon Black Science and Technology, 2nd Edition, Marcel Dekker Inc.,116 (1993)

[3] ASTM D 3849, TGZ3 – internal direct measurment methode

[4] A.I. Medalia, J. Colloid Interface Sci. 32, (1970) 115

[5] A. Voet, , Rubber Chem. Technol. 54, (1981) 42

[6] W.F. Verhelst, K.G. Wolthuis, A. Voet, P. Ehrburger and J.-B. Donnet, Rubber Chem. Technol. 50, (1977) 735

[7] M.-J., Wang, S. Wolff and E.-H. Tan, Rubber Chem. Technol. 66 (1993) 178

[8] J. Janzen, J. Appl. Phys. 46, (1975) 966

[9] S. Brunauer, P.H. Emmet and E. Teller, J. Am. Chem. Soc. 60, (1938) 309

[10] B. C. Lippens and J. H. deBoer, J. Catalysis 4, (1965) 966

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
Hahnstraße 49
60528 Frankfurt am Main
Germany
Phone +49 69 36 50 54 100

EMEA@orioncarbons.com

Asia Pacific

Orion Engineered Carbons Trading (Shanghai) Co., Ltd.
BM Intercontinental Business Centre, Room 3701-3702
100 Yutong Road
200070 Shanghai, China
Phone +86 21 6107 0895

APAC@orioncarbons.com

Global Corporate Headquarters

Orion Engineered Carbons S.A., 6 Route de Trèves, L-2633 Senningerberg, Luxembourg, Phone +352 27 04 80 60

www.orioncarbons.com

OEC-II XXXX-02/2013