XPB 545 – a new conductive Specialty Carbon Black for Coatings

Technical Information 1461

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Contents

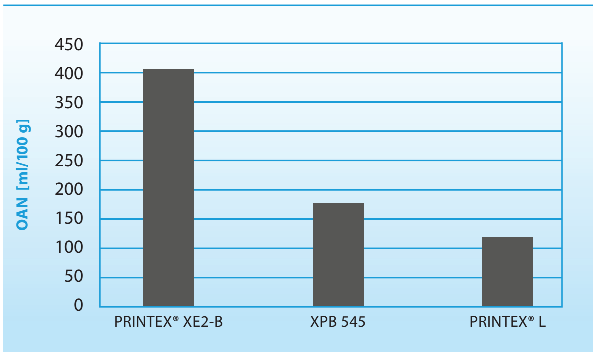
Introduction

Industrially produced Specialty Carbon Blacks are mainly characterized by primary particle size, specific surface area, structure, and surface chemistry. Mean primary particle size is a measure of the application technology properties of a Specialty Carbon Black. Specialty Carbon Blacks consist of primary particles that are closely connected via atom-atom bonds and form aggregates. These aggregates vary in structure and size.

The structure, or degree of branching, of Specialty Carbon Blacks depends on their Oil Absorption Number (OAN) (according to ASTM D 2414). Low structured, only slightly aggregated Specialty Carbon Blacks have low OAN values, for example in the range of 40 – 70 ml boiled linseed oil/100 g Specialty Carbon Black. In contrast, highly aggregated Specialty Carbon Blacks with OAN values over 100 ml/100 g are described as "Specialty Carbon Blacks with high structure." This term refers to Specialty Carbon Blacks that permit the development of high conductivity values in certain binders. Conductivity Specialty Carbon Blacks have a high or very high structure (see Figure 1).

Figure 1

OAN of various Specialty Carbon Blacks



Specialty Carbon Blacks have been used in the production of conductive coatings for a long time. The use of industrially produced Specialty Carbon Blacks to improve conductivity began much earlier, e. g. in the plastics industry. This may be due to the fact that it is much more difficult to make thin coating layers (partially) conductive.

Applications of Specialty Carbon Blacks in electrically-conductive materials can be divided into the two major categories of conductive and electrostatic utilization.

- **Conductive applications** such as connectors, switches, resistors, potentiometers, EMI shields (equipment against electromagnetic interference), and heating elements with PTC (positive temperature coefficient) require resistivity values below $5 \cdot 10^4\ \Omega$
- **Electrostatic applications** require resistivity values between $5 \cdot 10^4\ \Omega$ and $1 \cdot 10^8\ \Omega$[i]. This category includes products such as casings and containers of electrical devices, both of which are sensitive to static electricity, along with flooring and packaging materials for the electronics industry and applications for mining and other areas with explosion risks to prevent static electricity buildup.

Depending on the application, different Specialty Carbon Blacks are used for conductive or electrostatic coatings. The extra conductive PRINTEX® XE2-B allows formulating highly conductive coatings with low amounts of Specialty Carbon Blacks. For achieving best results, formulators need experience with grinding and pigment handling due to the very high specific surface area and structure of this grade.

On the other hand large amounts of PRINTEX® L have to be used for highly conductive applications with good performance in electrostatic coatings and conductive coatings with lower requirements.

Orion Engineered Carbons has now developed a new grade, XPB 545, which combines the advantages of easy Specialty Carbon Black handling and high conductivity in coatings. Compared to PRINTEX® L or the most conductive grades for coatings, low pigment loading results in highly Specialty Carbon Blacks conductive coatings (see Figure 2).

Like always in dispersion of pigments in the coatings industry, the concentration of Specialty Carbon Blacks in the mill base has to be adjusted to the type of Specialty Carbon Black used. Due to their high structure the highly conductive Specialty Carbon Blacks PRINTEX® XE2-B and XPB 545 have a much more intensive thickening effect than other Specialty Carbon Blacks. To produce the optimum mill base composition, the corresponding low concentration of these Specialty Carbon Blacks must be selected. This technical information brochure lists the mill bases that were used in the guideline table at the end. In the Let Down process, the Specialty Carbon Black concentration, related to non-volatile components, was adjusted to visualize changes, for example with regard to surface resistivity, jetness, or gloss.

All tests shown in this technical brochure were performed in water-borne acrylic/melamine stoving enamel based on BAYHYDROL® A 145 by Bayer MaterialScience and CYMEL® 327 by CYTEC Industries (see a ppendix for formulation details).

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

Experimental Black XPB 545

Figure 2 shows the different surface resistivity areas for extra-conductive PRINTEX® XE2-B, the Furnace Blacks PRINTEX® L, PRINTEX® L6, HIBLACK® 40B2, HIBLACK® 420B and the new experimental grade XPB 545.

The new XPB 545 grade closes the gap between OEC's extra-conductive grade PRINTEX® XE2-B and our conductive grades PRINTEX® L and PRINTEX® L6 for the European and US market and the HIBLACK® 40B2 and HIBLACK® 420B grades for the Asian market. This is shown in Figure 2, which plots the surface resistivity values (as opposed to conductivity) of recommended Orion Engineered Carbons Specialty Carbon Blacks for conductive coatings in relation to the Specialty Carbon Black concentration in a water-borne acrylic/melamine test coating system.[1)] As expected, higher pigment loading resulted in lower surface resistivity and therefore, higher conductivity.

With the extra-conductive grade PRINTEX® XE2-B, coatings formulators can achieve very low surface resistivity values with a minimal Specialty Carbon Black concentration, but have to be experienced with grinding and pigment handling.

The conductive grades PRINTEX® L, PRINTEX® L6, HIBLACK® 40B2 and HIBLACK® 420B are easier to grind and handle, but require higher pigment loading in the coating to obtain the same performance as with PRINTEX® XE2-B.

Experimental Black XPB 545 fills the gap between these two areas. A medium loading of XPB 545 (12 % in the mill base) results in surface resistivity values in the mid-range. XPB 545 also offers better handling and grinding properties than PRINTEX® XE2-B.

Taking the various conductive Specialty Carbon Blacks, it is important to choose the right conductive Specialty Carbon Black for each application. The new XPB 545 opens up opportunities for highly conductive coatings that can do without the extra conductivity requirements associated with PRINTEX® XE2-B.

XPB 545 creates a coating film with deep jetness and high gloss. Figure 3 shows the jetness values of different Specialty Carbon Blacks in the water-borne coating test system in relation to an increasing Specialty Carbon Black concentration in the let down. Due to the high specific surface area of PRINTEX® XE2-B and XPB 545, only 12 % Specialty Carbon Black was incorporated into the mill base. While XPB 545 shows stable jetness values, the jetness of the coating with extra-conductive PRINTEX® XE2-B (see Figure 3) is decreasing rapidly with increasing pigment concentration. Orion Engineered Carbons conductive grades PRINTEX® L, PRINTEX® L6, HIBLACK® 40B2 and HIBLACK® 420B (see Figure 3) start on a much lower jetness level but show curve progressions that are similar to XPB 545.

Figure 2

Surface Resistivity in Ohm/sq of various Orion Engineered Carbons Specialty Carbon Black Grades especially recommended for increasing the Conductivity in Coatings in Relation to the Pigment Concentration in the Let Down. The Specialty Carbon Black Concentration in this Graph is shown in Relation to the non-volatile Component of Lacquer. Specialty Carbon Black Concentration in the Mill Base: PRINTEX® XE2-B: 6 %, XPB 545: 12 %, PRINTEX® L, PRINTEX® L6, HIBLACK® 40B2 and HIBLACK® 420B: 20 %.

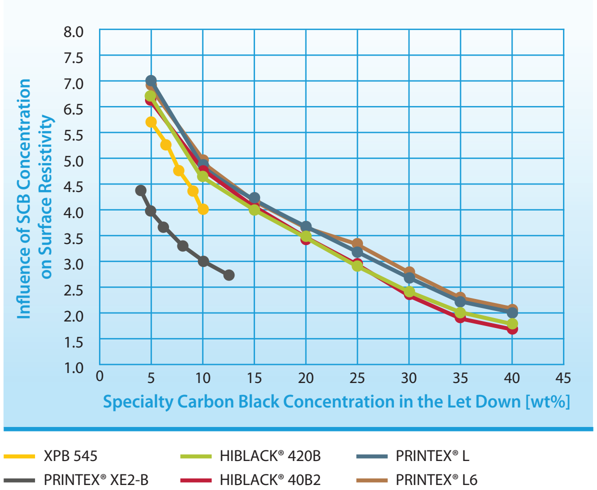
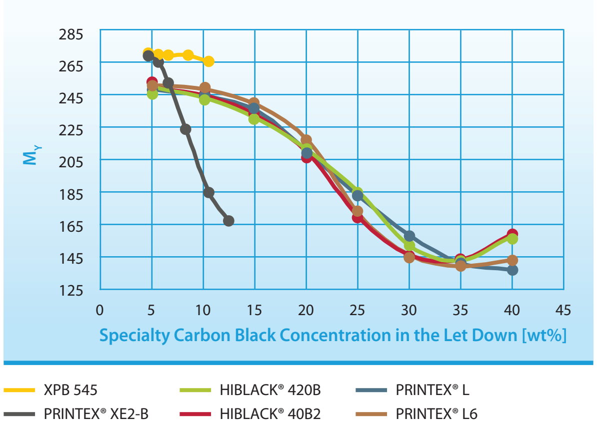


Figure 3

Jetness Values M_Y (direct Measurement) of Orion Engineered Carbons conductive Grades with increasing Specialty Carbon Black Concentration of the Coating; $M_Y = 100 \cdot \log(100/Y)$. The Specialty Carbon Black Concentration in this Graph is shown in Relation to the non-volatile Component of Lacquer.

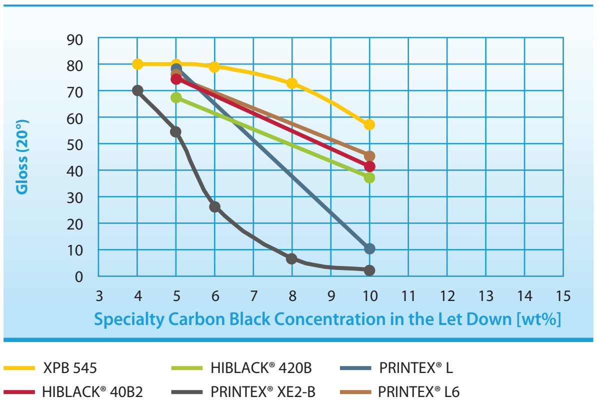


XPB 545 also shows improved properties in terms of gloss. XPB 545 achieves the highest gloss values (see Figure 4), which can be advantageous for detecting defects on coated surfaces.

1) Conductivity and resistivity of a heterogeneously composed material are always system characteristics which depend on factors including dispersing and processing conditions, and therefore do not represent a constant parameter.

Figure 4

Gloss Values (at 20°) of Orion Engineered Carbons conductive Grades with increasing Specialty Carbon Black Concentration of the Coating. The Specialty Carbon Black Concentration in this Graph is given in Relation to the non-volatile Component of Lacquer.



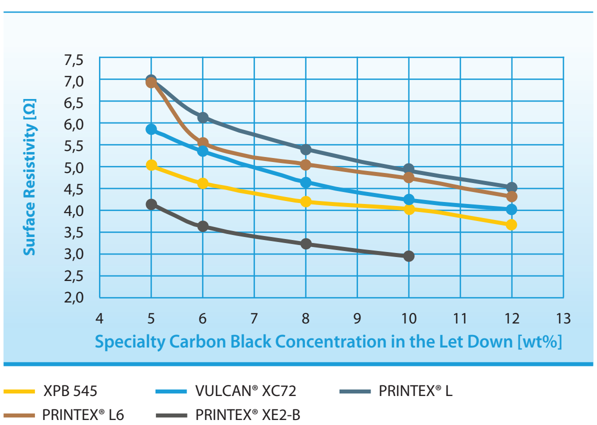
Comparison with VULCAN® XC72 by Cabot Corporation

Figure 5 compares the logarithmic surface resistivity values related to Specialty Carbon Black concentrations of the competitor VULCAN® XC72 by Cabot Corporation with selected Orion Engineered Carbons grades. For a valid comparison, all formulations in this graph were prepared with 6 % Specialty Carbon Black in the mill base.

PRINTEX® L and PRINTEX® L6 show equal performance in terms of surface resistivity. VULCAN® XC 72 achieves slightly lower resistivity, but it is topped by XPB 545 that can attain even lower surface resistivity values. The lowest resistivity values of the coatings with extra-conductive Specialty Carbon Blacks were observed for PRINTEX® XE2-B in the range of 3 – 4.5 Ω.

Figure 5

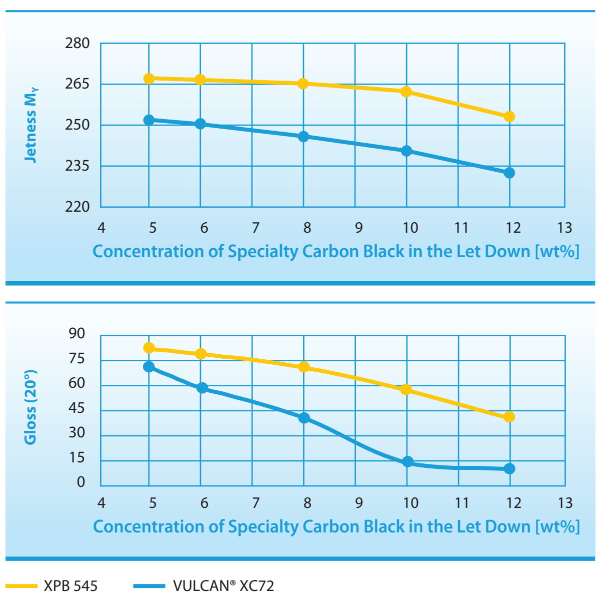
Comparison of Surface Resistivity of selected conductive Specialty Carbon Blacks with VULCAN® XC72 by Cabot Corporation. The Specialty Carbon Black Concentration in this Graph is given in Relation to the non-volatile Component of Lacquer.



As shown in Figure 6, the new XPB 545 can achieve higher jetness and gloss values in the water-borne conductive acrylic melamine test stoving enamel compared with VULCAN® XC72. Both formulations were prepared with a 6 % Specialty Carbon Black weight concentration in the mill base. Accordingly, lower pigment loading with XPB 545 achieves a similar performance as VULCAN® XC72.

Figure 6

Jetness M_Y (direct measurement) and Gloss Values (20°) of the Competitor Conductive Grade VULCAN® XC72 by Cabot Corporation with increasing Specialty Carbon Black Concentration of the Coating; $M_Y = 100 \cdot \log(100/Y)$. The Specialty Carbon Black Concentration in this Graph is given in Relation to the non-volatile Component of Lacquer.



Formulation Guideline

The formulation of the conductive acrylic/melamine water-borne stoving enamel coating is based on the acrylic resin Bayhydrol® A 145 by Bayer MaterialScience and the melamine CYMEL® 327 by CYTEC Industries.

Formulations Guidelines for extra-conductive and conductive Specialty Carbon Black Grades are given below:

Mill Base	PRINTEX® XE2-B	XPB 545	PRINTEX® L / PRINTEX® L6 / HIBLACK® 40B2 / HIBLACK® 420B
Dist. Water	20.9	29.4	26.6
Bayhydrol® A 145, 45 % by Bayer MaterialScience	73.1	58.6	53.4
Specialty Carbon Black	6	12	20
Total	100	100	100
Specialty Carbon Black Concentration	6	12	20
Concentration of the Binder Solution	35	30	30
Let Down			
Mill Base	52.3	26.4	41.7
Bayhydrol® A 145, 45% by Bayer MaterialScience	26.2	49.4	37
CYMEL® 327, 90% in Isobutanole, by CYTEC Industries	8.2	8.1	7.6
Dist. Water	13.3	16.1	13.8
Total	100	100	100.1
Total Specialty Carbon Black Concentration	3.15	3.17	8.33
Specialty Carbon Black Concentration related to non-volatile Matter	8	8	20
Ratio AY : MF	80 : 20	80 : 20	80 : 20
Surface Resistivity on Glass	$1.5 \cdot 10^3\ \Omega$	$1.9 \cdot 10^4\ \Omega$	**PRINTEX®L**: $3.3 \cdot 10^3\ \Omega$ **PRINTEX® L6**: $3.4 \cdot 10^3\ \Omega$ **HIBLACK® 40B2** and **HIBLACK® 420B**: $2.4 \cdot 10^3\ \Omega$

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

Dispersion was done with a LAU-disperser DAS 200 or BA S-20 for 1 h using 540 g Chromanit steel beads with a diameter of 3 mm and 80 g mill base. After dispersion the mill bases were let down and applied to a glass plate (130 mm • 90 mm • 1 mm) with a bar (wet layer thickness: 200 µm).

Measuring Method

All experiments described in this technical information involved measurements of the surface resistivity on coated glass plates, using a Loresta-GP MCP-T610 instrument manufactured by Mitsubishi Chemical Analytech, with a 4-pin measuring electrode ASP 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 to 10 MΩ. The graphs and tables show mean values from three measurements.

Summary

By improving its furnace reactor technology, Orion Engineered Carbons has been able to develop a new Specialty Carbon Black that is especially suitable for enhancing the conductivity of coatings. This new Experimental Black XPB 545 owes its outstanding performance to

- Customized broad aggregate size distribution
- High specific surface area
- Very high structure
- Clean surface

These properties allow for reaching high conductivity values with small amounts of XPB 545.

The conductivity level obtainable with XPB 545 is only slightly below the achievable conductivity values with extra-conductive Specialty Carbon Blacks.

At the same time, the product showed outstanding jetness and gloss levels compared to a competitor product and other Orion Engineered Carbons product grades.

All tests in this brochure were performed in a water-borne acrylic/melamine stoving enamel test coating system.

Technical Data of XPB 545	
BET (ASTM D6556)	375 m^2/g
STSA (ASTM D 5816)	235 m^2/g
OAN (ASTM D 2414)	175 ml/100 g
Ash (DIN 53586 A)	≤ 0.5 %

Due to the possible variations in the upcoming scale-up process of this experimental product, all given data remain preliminary.

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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 0966

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

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