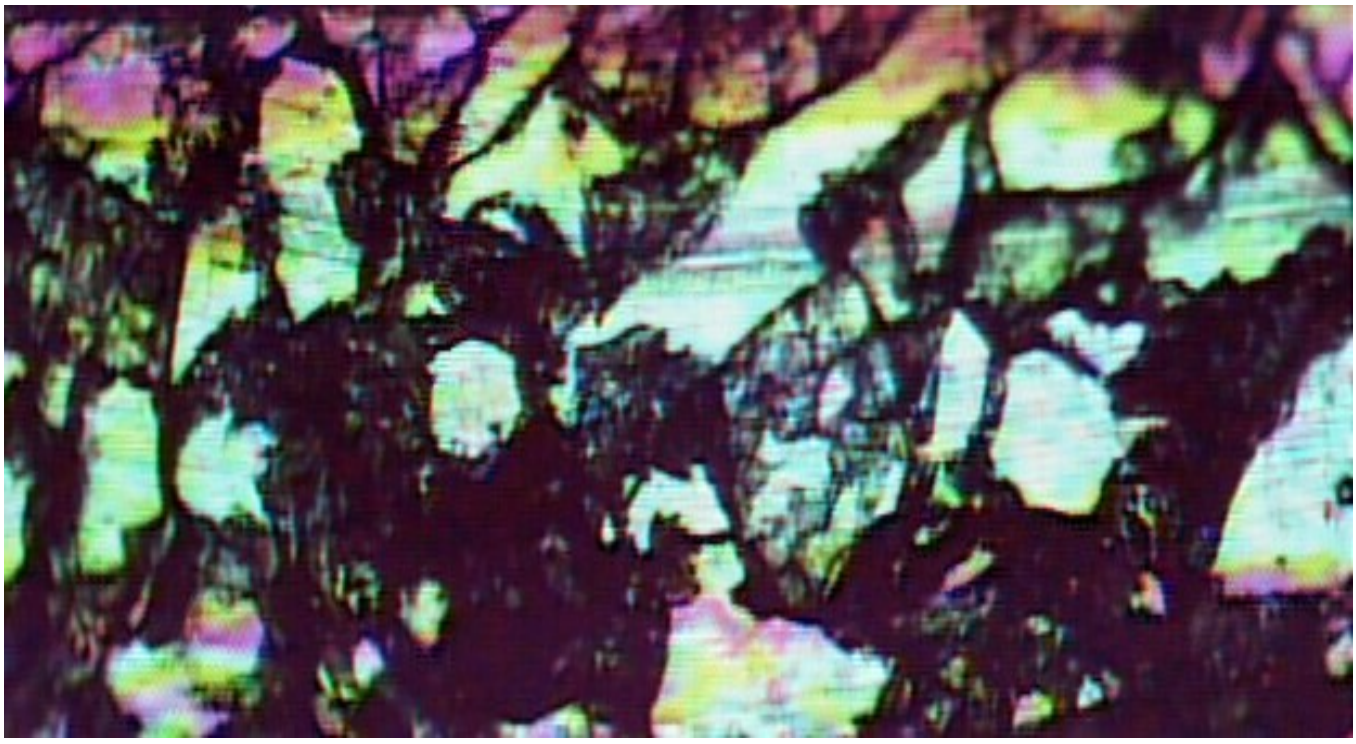
Braskem

TECHNICAL BULLETIN

Influence of carbon black amount in the properties of the ultra high molecular weight polyethylene (UTEC)



Innovation & Technology

I. INTRODUCTION

The carbon black is used in plastic due to its colors properties and also for UV protection. There are improvements in conductive and antistatic properties of the polymers, depending on the concentration in its composition.
The industrial process for the carbon black's production is based in the thermal decomposition (pyrolysis) or partial combustion of hydrocarbons. The carbon black is resulted of 90-99% of p-crystalline fine carbon, in spherical particle shape of colloidal size, disposed in agglomerated particles.
Great part of the UTEC market uses carbon black with diverse objectives, such as: pigment (mainly in recycling processes), antistatic, stabilizing of UV, to improve properties in general, etc.
This Technical Bulletin demonstrates the influence of the carbon black in the final properties of the UTEC.

II. BASIC CONCEPTS

Color depth and pigmentation power are used frequent when it has description of the plastics pigmentation with carbon black pigments, and are defined as it follows:
The **color depth** of a carbon black pigment is the intensity of the black color got with this type of pigment in particular. Lesser light reflection of a color material with a carbon black pigment, greater a color depth.
In contrast of whiteness force of white pigment, the **pigmentation power** of a carbon black pigment describes the capacity hide other color component, or to coat them with the black coloration. If the tonality of a color (white or colored) is darkened only slightly by the addition of a carbon black pigment, this calls pigmentation.
The color depth of a carbon black pigment and its pigmentation power increase in function of the size reduction of the primary particles and the structure.
During the plastics pigmentation with carbon black, one defined **subtom** develops in addition to the black color. This subtom can be Brown or blue, depending of the carbon black type used. However, it is necessary to make the distinction between the visual determination of a black pigmentation in **full tone** when seen from above or when visualized through a transparent section.

The **Figure 1** summarizes the effects of the size of primary particles and the structure in the color depth, pigmentation power and subtom of carbon black pigments. In this direction, the dispersability of the carbon black pigments is a important characteristic.

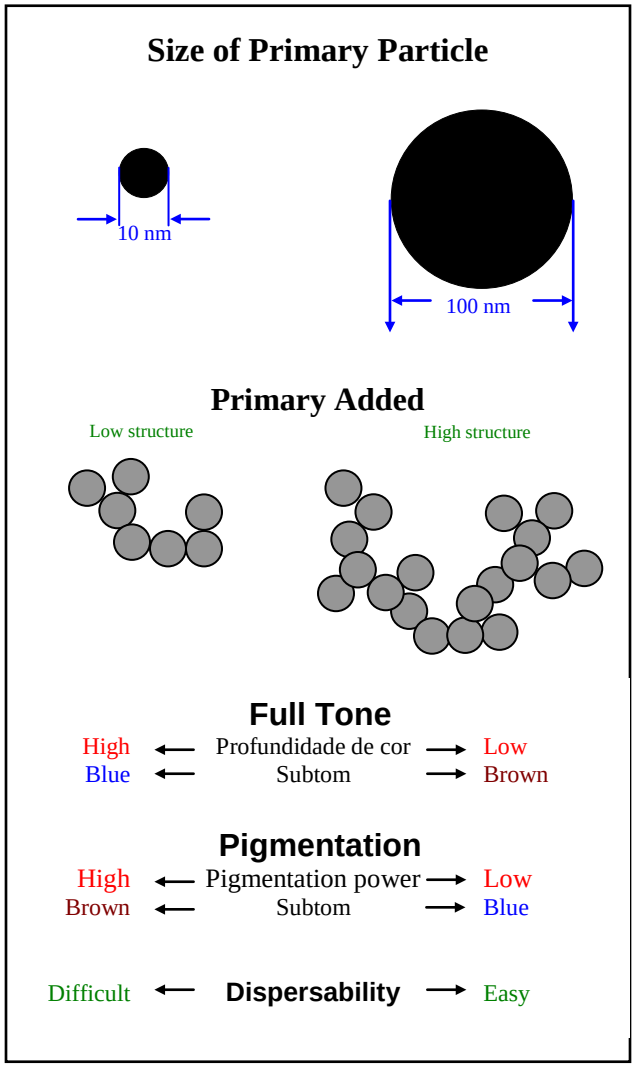


Figura 1:
The effects of the size of primary particles and the structure of the carbon black pigments in the color depth, pigmentation power e subtom in plastics.

The carbon black used in this study has average size of particle of 30nm, ou seja, presents low structure, pigmentation power relatively high and difficult dispersability.

III. UTEC WITH CARBON BLACK: Evaluation of the final properties

The properties of a Ultra High Molecular Weight Polyethylene are basically: high Resistance of the Impact e Abrasion amongst other mechanical properties, when compared with HDPE e others specific polymers as Nylon, PP, PA 66 e PVC. However, we will be evaluating the carbon black influence in the final properties of UTEC that, theoretically, suffer some alterations with addition from this pigment. The following concentrations of carbon black had been evaluated: 0, 1, 2 and 5%, mixed uniformly, to prevent the prompt formation of accumulations.
For this study, two samples with characteristics inside of the quality requirements had been selected: UTEC 3040 e UTEC 6541. The table below shows the main characteristics that differentiate the selected samples.

Table 1 – Basic characteristics of the samples

Sample	Molecular Weight (x 10^6 g/mol)	Average Size of Particles (μm)
UTEC 3040	2,5 a 3,5	150 a 230
UTEC 6541	7,0 a 9,0	110 a 150

III.A. Density

Two types of density for characterization of the UTEC are considered: the **bulk density**, that is related with the material still in the particulate phase (dust) and the **relative density**, that is determined in the molded product already. Both largenesses are express in g/cm^3. Bellow, the figures 2 e 3 show the variation of the densities with the increase of the concentration of carbon black.

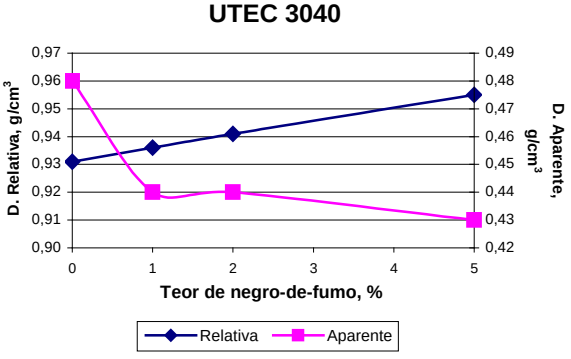


Figure 2:
Influence of the CB concentration in the densities of UTEC 3040

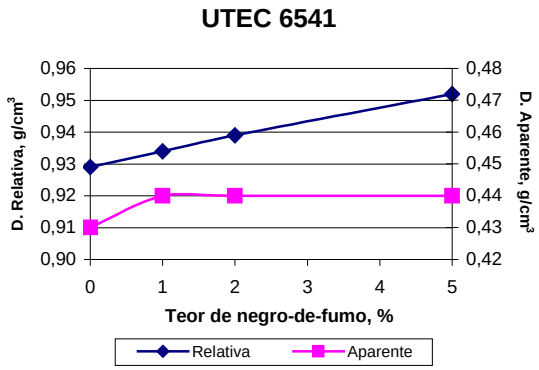


Figure 3:
Influence of the CB concentration in the densities of UTEC 6541

It can observed that the behavior of the relative density of the UTEC 3040 is similar of the UTEC 6541, or either, increases gradual with addition of the carbon black. The bulk density is influenced of more critical form, with addition of the carbon black, especially in the UTEC 3040, possible due to form of the particle and/or porosity, while that the UTEC 6541 has its bulk density practically unchanged.

III.B. Shore D Hardness

In the Hardness assay, measures, basically, the depth that an identification (needle), submitted to a standard weight, perforates the sample. It has two forms of measures: **instantaneous** (inst), that is the measure of the depth that the needle penetrates initially or **after a period of time** (15s).
The Shore Hardness, for begin directly related with the relative density, presents a similar behavior to the displayed in the figures 2 and 3, as it shows the graphs of the figures 4 and 5:

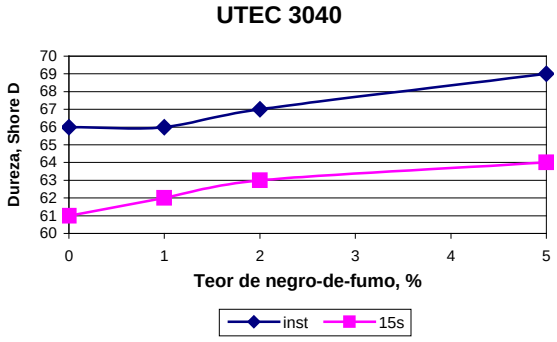


Figure 4:
Influence of the CB concentration in the Shore Hardness of UTEC 3040

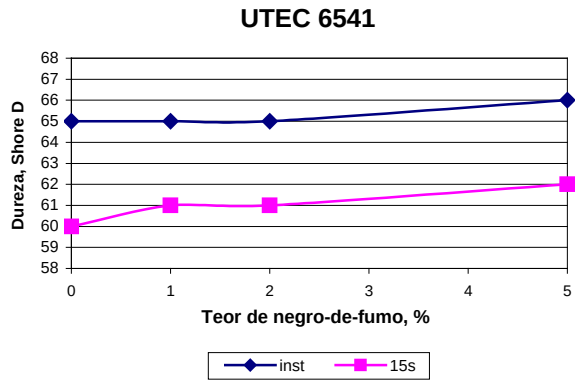


Figure 5:
Influence of the CB concentration in Shore Hardness of UTEC 6541

The graphs of the figures 4 and 5 show that the UTEC 3040 presents greater influence of the carbon black in its Hardness, relation to the UTEC 6541.

III.C. Properties of Traction

The addition of carbon black in Ultra High Molecular Weight Polyethylene, diminish a little to the tensile strength in the final product with the increase in the carbon black concentration. This behavior is illustrated in the figures 6 e 7.

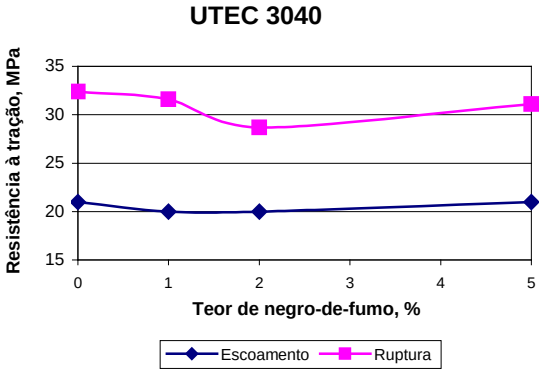


Figura 6:
Influence of the CB concentration in the tensile strength of UTEC 3040

It can be observed that, in the case of the UTEC 3040, the curve of tensile strength present a minimum in 2 % of carbon black, while that in the UTEC 6541, the behavior is decreasing, from 1,0% of carbon black.
The tensile strength in the draining, pratically not influenced by the addition of carbon black, in the UTEC 3040. Already in the UTEC 6541, the same presents a light increasing behavior.

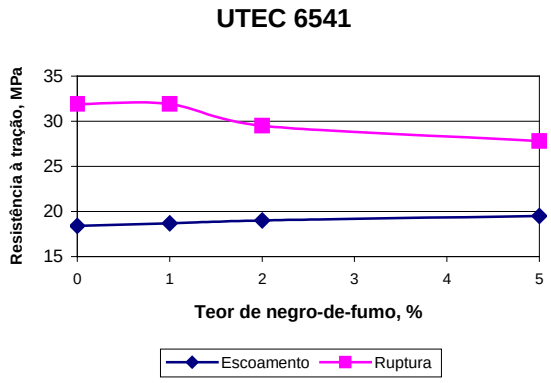


Figure 7:
Influence of the CB concentration in the tensile strength of UTEC 6541

The deformations in the draining and the rupture diminish with the addition of carbon black, in the UTEC 3040.

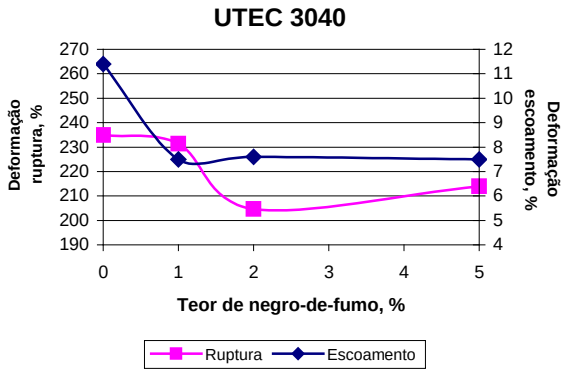


Figure 8:
Influence of the CB concentration in the deformation of UTEC 3040

Already in the UTEC 6541, the deformation in the draining does not suffer variation, while that the deformation in the rupture falls from 1,0% of carbon black.

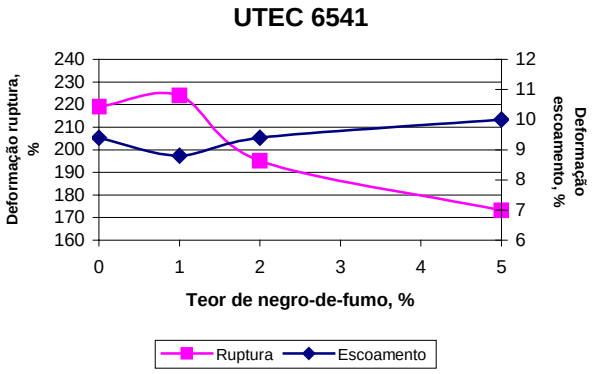


Figure 9:
Influence of the CB concentration in the deformation of UTEC 6541

The deformations are related with the application in which the product will be submitted, or either, the better or worse concept is relative to the characteristics waited during the application.

III.D. Resistance of the Charpy Impact

The resistance of the impact was not influenced significantly for the addiction of carbon black, as we can see in the figures 10 and 11. The variation was inside of the intrinsic band of error of the method.

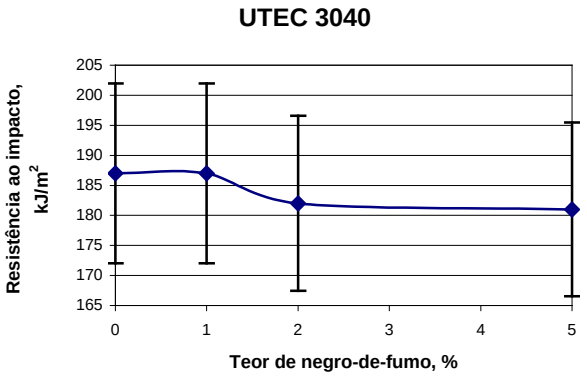


Figure 10:
Influence of the CB concentration in the resistance of the impact of

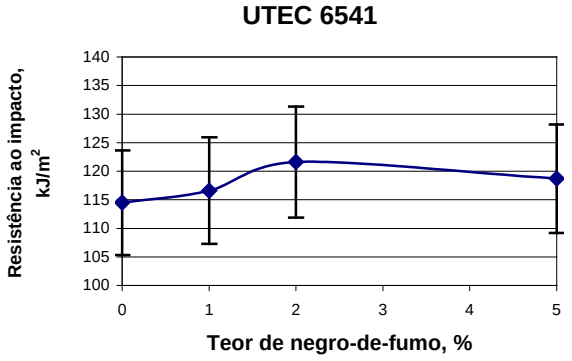


Figure 11:
Influence of the CB concentration in the resistance of the impact of

III.E. Resistance to the Abrasion

The **abrasion index** is used to quantify the consuming suffered for the sample when the same is submitted, for a time of 24h, to an abrasive environment. This index is inversely proportional to the **resistance to the abrasion**, or either, how much bigger it will be, minor will be the resistance to the abrasion of the analyzed sample. The Express value in the abrasion index is relative to the consuming suffered in the steel (standardized type).
The analyzed samples present different behaviors being about resistance to the abrasion. The figures 12 and 13 show the behavior of the resistance to the abrasion with the addiction of the carbon black in the UTEC 3040 e 6541.

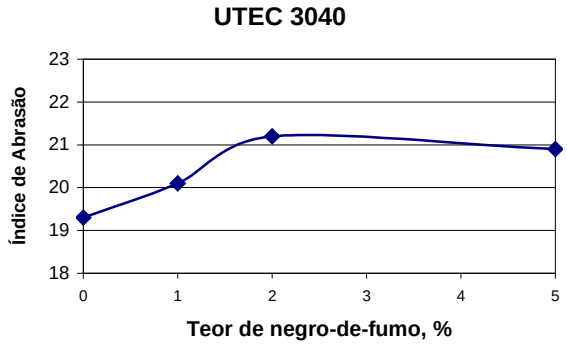


Figure 12:
Influence of the CB concentration in the abrasion index of UTEC

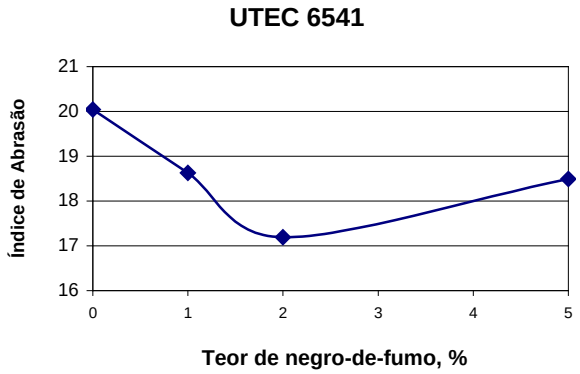


Figure 13:
Influence of the CB concentration in the abrasion index of UTEC 6541

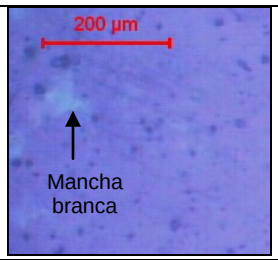
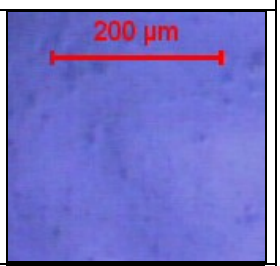
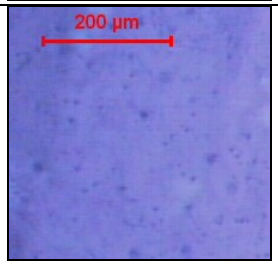
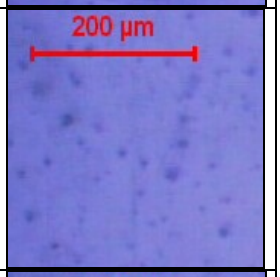
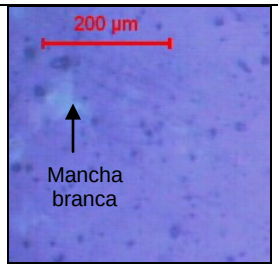
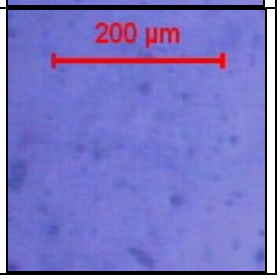
The UTEC 3040 is less resistant to abrasion with the addition of up to 2,0% of carbon black and stabilizes up to 5,0% of carbon black, while that, in the UTEC 6541, the inverse happens accurately, or either, the resistance increases up to 2,0% of carbon black and diminishes with 5,0%.

III.F. Dispersability

One of the characteristics most important to evaluate the effectiveness and quality of a pigment is its dispersability, as also the affinity between the pigment and polymer.

The size of primary particle of the carbon black is the main characteristic that goes to conduct the dispersive behavior of the carbon black in the polymer, as also its compatibility with the grain sized profile of the same, in special in case of the Ultra High Molecular Weight Polyethylene.
To evaluate the dispersability of the carbon black, plates of UTEC additive with 0,5, 1,0 e 2,0% of carbon black had been made so that through photos taken off to the optic microscope, let us can distinguish the dispersability in accordance with the employed concentration of pigment. The table 2 shows the dispersion of the carbon black in the UTEC 3040 e 6541, respectively.

Table 2 – Dispersion of the Carbon Black in the samples of UTEC

C.B. (%)	UTEC 3040	UTEC 6541
0,5		
1,0		
2,0		

Making an evaluation of the images, gotten from the increase of 100x in the microscope, the dispersability of the carbon black in the UTEC is considered difficult, therefore the ultra high molecular weight polyethylene does not flow, accurately due to the highest molecular weight, disabling the mixture with the carbon black during the transformation process to hot. This becomes the dispersability of the carbon black weak in this material, therefore it depends exclusively on efficiency of the mixture to cold.
Analyzing the photos of the table 2, notices that the UTEC 6541 presents greater dispersability of the carbon black when compared with UTEC 3040, what can be evidenced by the white spots that had appeared in the images taken off with the samples of UTEC 3040. This is due to the grain size profile of the UTEC 6541, that it is intrinsicly finer (table 1).

III.G. General evaluation of the properties

The table below shows a summary of the influence of the carbon black in the main properties of UTEC.

Table 3 – Summary of the behavior of the carbon black in the properties of UTEC

PROPERTIES	UTEC 3040	UTEC 6541
Bulk density	↓	↗
Relative density	↑	↑
Shore D hardness	↑	↑
Tensile strength in the rupture	↘	↘
Tensile strength in the draining	↔	↔
Deformation in the rupture	↘	↓
Deformation in the draining	↓	↔
Resistance of the impact	↔	↔
Resistance to the abrasion	↘	↗
Dispersability	Difícil	Fácil
Legend: ↑ it increases very, ↓ it diminishes very, ↗ it increases little, ↘ it diminishes little, ↔ it does not influence.		

IV. CONCLUSION

The addition of carbon black in the UTEC does not compromised its final properties, when concentration of up to 5,0% of carbon black is used.
The pigmentation with carbon black in the UTEC and the resins of ultra high molecular weight in general, is characterized by the weak dispersability, due to possibility of mixture only to cold. However, it is recommends the use of, in the maximum, 2% of carbon black for UTEC pigmentation, so that the final properties of the product are not modified significantly.
In the applications that demand a bigger quality of superficial finishing, the grades of UTEC more adjusted are the ones that present fine granulometria (between 100 and 150 µm), as for example, the UTEC 6541.