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Black Pigment Selection Guide for Polyester Fibre Applications

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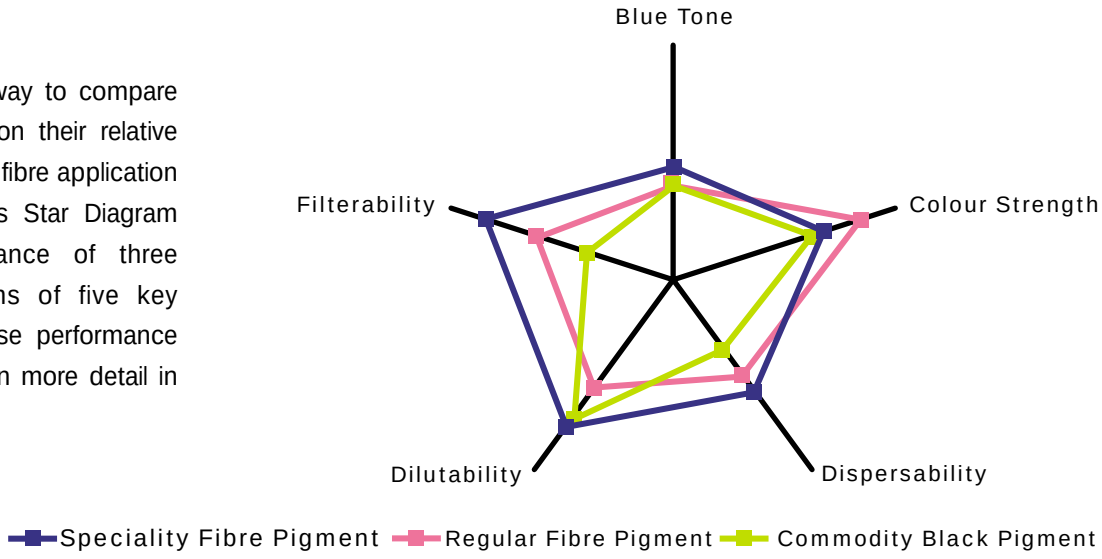
The aim of this brochure is to assist polymer masterbatch and compound producers with their choice of the highest value black pigments for polyester fibre applications.

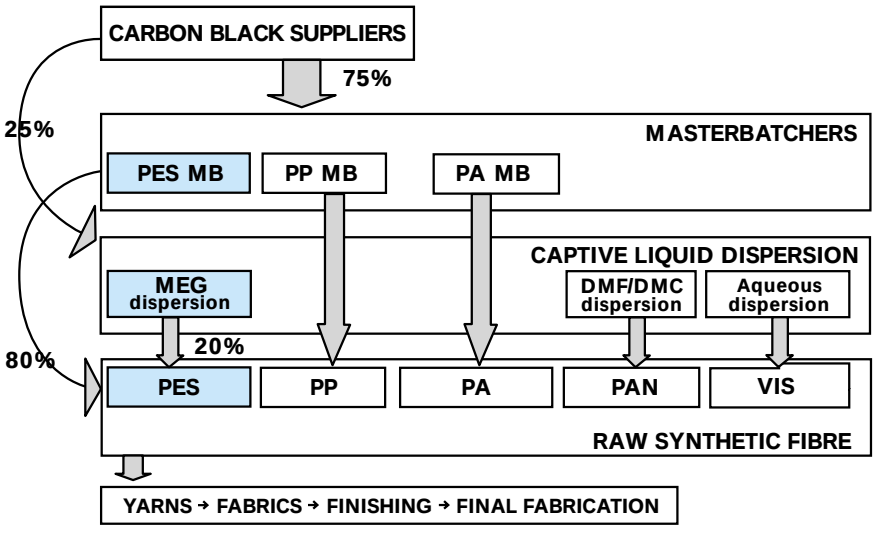
Star Diagram

A visual and accessible way to compare different black pigments on their relative suitability for the polyester fibre application is the Star Diagram. This Star Diagram compares the performance of three black pigments in terms of five key performance criteria. These performance measures are discussed in more detail in this guide.



Value Chain

The Value Chain pictured here represents how Carbon Black pigments cascade stream downwards into the fabrication of textile products. Generally two routes are practised for Melt Pigmentation (mass dyeing) of polyester (PES) fibres: the masterbatch route and the liquid dispersion route. The superior economics and flexibility of the masterbatch route makes it the preferred one absorbing the growth of the black melt pigmented polyester fibres market.



Market Segmentation

The synthetic fibre market can be usefully segmented as depicted below. The polyester (PES) fibre segment dominates the textile fibre applications, both as continuous fibre (textile filament yarn) as well as staple fibre. Approximately 70% of the melt pigmented polyester filaments and staple fibres are black. Each sub-segment is discrete in its performance requirements vis-à-vis the carbon black pigment and its masterbatch. We demonstrated this in a schematic form in the table for the two key performance requirements: Colour Strength and Filterability/Spinability.

Segment	Sub-segment	Preponderance Polymer Type	Colour Strength	Filterability & Spinability
Textile filament yarn (up to 10 dtex)	supermicro (<0.5 dtex) micro (0.5 - 1.0 dtex) fine (1.0 - 2.5 dtex) medium (2.5 - 7.0 dtex) coarse (7 - 10 dtex)	**PES** > PA **PES** > PA > PP > VIS **PES** > PA > PP > VIS **PES** > PA > PP **PES** > PA > PP	●●●●● ●●●● ●●● ●● ●	●●●●● ●●●● ●●●● ●●● ●●
Industrial filament yarn (3-15 dtex)	safety belts ropes/nets industry fabrics others	**PES** PA > **PES** PA > **PES** PA > **PES**	● ● ● ●	●● ●● ●● ●●
Staple fibres (up to 300 dtex)	cotton type (1.3 - 2.8 dtex) woollen type (3.3 - 10 dtex) carpet type (10 - 300 dtex)	**PES** > VIS > PAN > PP **PES** > PAN > VIS > PP PP > PA > PAN	●●● ●●	●●●● ●●●
BCF (bulk continuous fibre-carpet-8-20 dtex)		PA > PP		
Monofilaments (20 - 400 dtex)		PP		
Special fibre types				

● = indicates degree of importance of the performance requirements

Performance Measures

We have defined the performance measures for the black melt pigmented polyester fibre application. We have organised them into performance measures of primary and secondary importance:

Primary Performance Measures

– Colour Strength
– Filterability/Spinability
– Blue Tone
– Masterbatch Dilutability
– Carbon Black Dispersability

Secondary Performance Measures

– Carbon Black Moisture Pick-up
– Carbon Black Pellet Quality
– Chemical Cleanliness (Processing smell)
– Light Fastness
– Equipment Wear
– Tenacity …

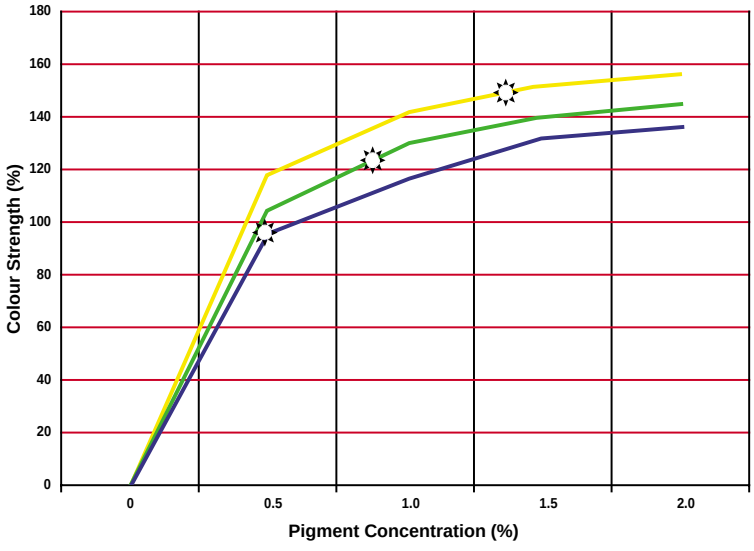
We describe hereafter each of the Primary Performance Measures in more detail.

Colour Strength

The Colour Strength is a measure of the total visible light absorbency of the pigmented polyester yarn. The higher the total visible light absorbency, the darker, blacker or jetter the polyester yarn will be. The Colour Strength is dependent on:

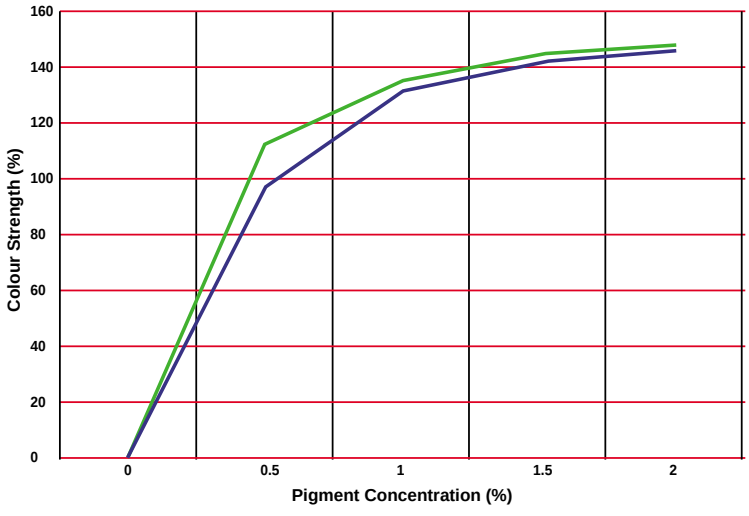
- the type of black pigment used
- the pigment concentration in the fibre
- the titre of the fibre
- the dullness level of the fibre
- the texturisation of the fibre

Fibre Colour Strength vs. Pigment Type & Pigment Concentration



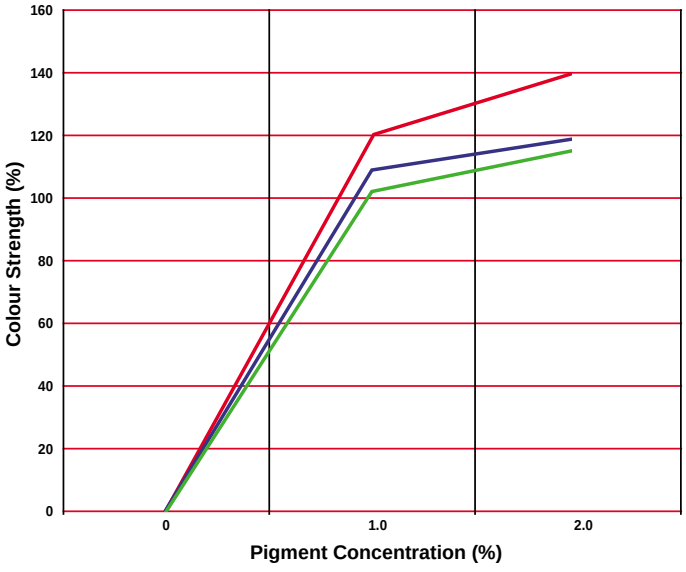
Low Strength Type
Medium Strength Type
High Strength Type
Equal Blue Tone (b* = -0.4)

Fibre Colour Strength vs. Fibre Titre



1.7 dtex
3.6 dtex

Fibre Colour Strength vs. Dullness Level & Texturisation



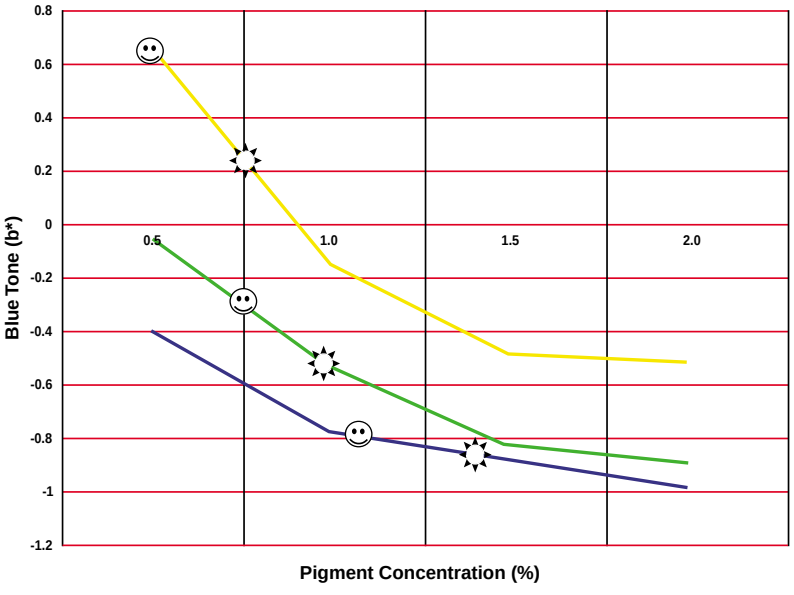
brilliant & flat
semi-dull & flat
semi-dull & texturised

Blue Tone

A lot of misunderstanding exists around this performance measure. Very often it is a visual appreciation. Hence one confuses Blue Undertone with Colour Strength. We define Blue Tone as the undertone of polyester fibre samples measured within the CIELAB co-ordinates, e.g. the b*-value. The Blue Tone is dependent on:

- the type of black pigment used
- the pigment concentration in the fibre
- the titre of the fibre
- the dullness level of the fibre
- the texturisation of the fibre.

Fibre Blue Tone vs. Pigment Type & Concentration

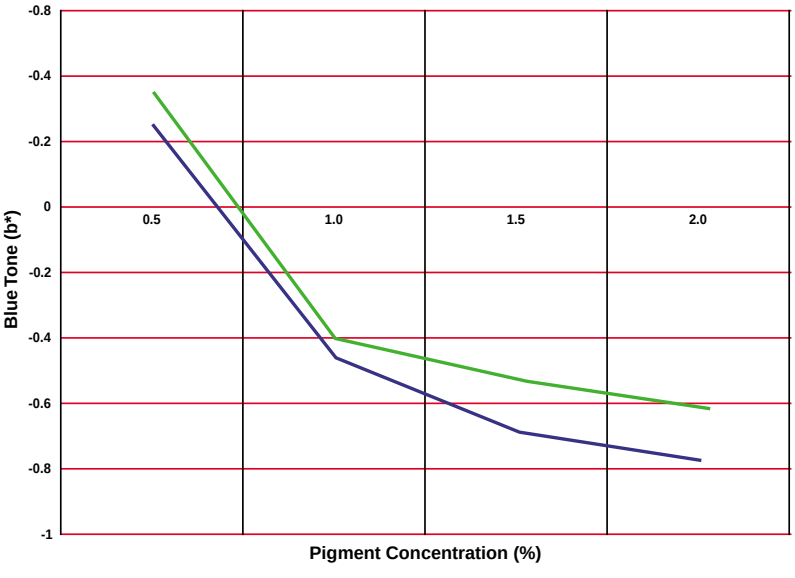


Low Strength Type
Medium Strength Type
High Strength Type

Colour strength of 130%

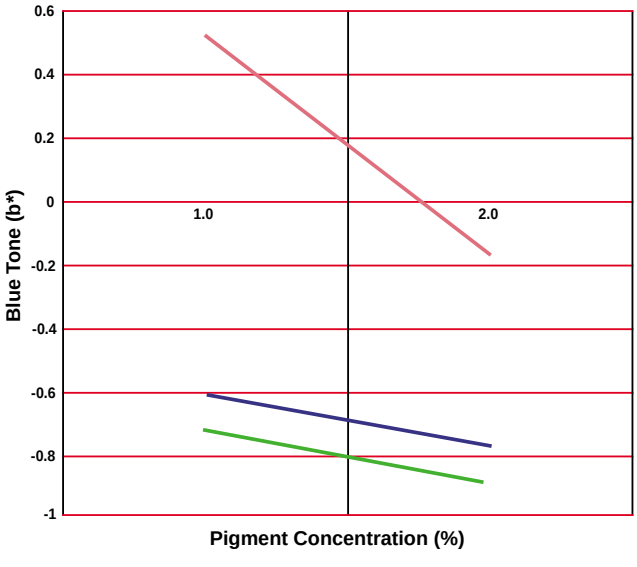
Colour strength of 120%

Fibre Blue Tone vs. Fibre Titre



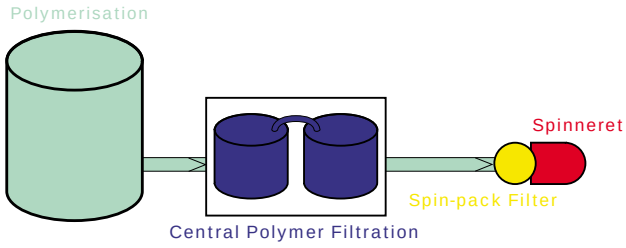
1.7 dtex
3.6 dtex

Fibre Blue Tone vs. Dullness & Texturisation

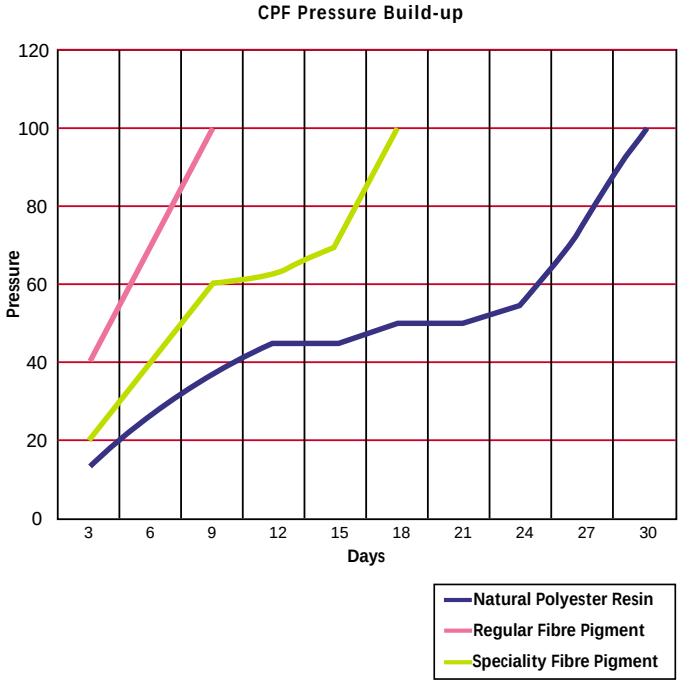


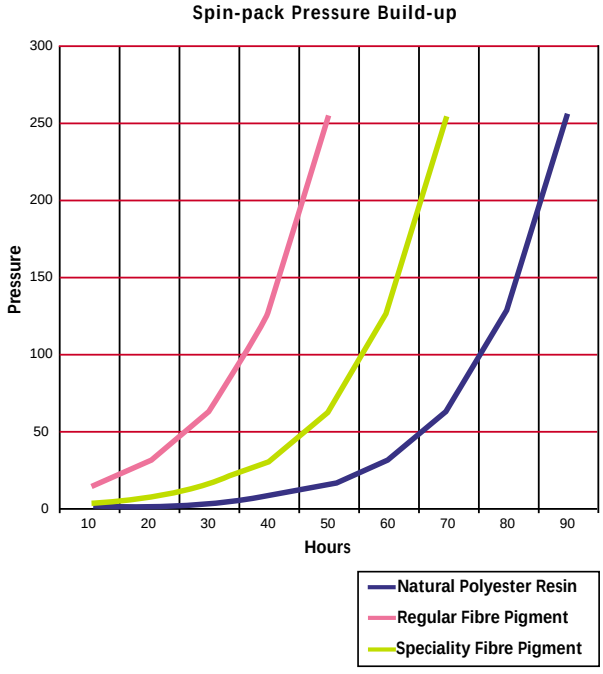
brilliant & flat
semi-dull & flat
semi-dull & texturised

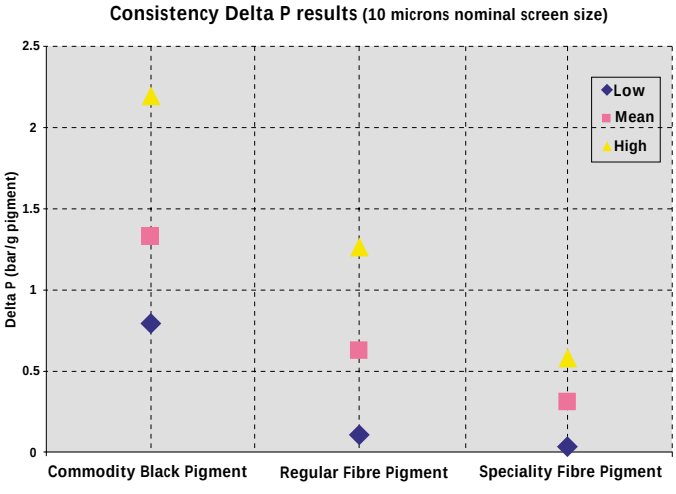
Filterability/Spinability



Filterability is a measure indicating the operational life-time of filter media on polyester fibre production lines. We normally encounter two types of filtration systems on industrial fibre production lines. Firstly, the CPF or Central Polymer Filtration system is a duplex filtration system with two alternating canisters each filled with metal candle filters (cartridge filters). Secondly, the Spin-pack filter system, very often a metal powder pack, is installed just before the spinneret. The frequency with which candle filters and spin-packs need to be replaced and/or cleaned is an important cost factor in the polyester fibre production. Elements which determine this cost are: filter cleaning charge, filter replacement cost, labour, down-time, waste material, capacity limitation, inconsistent process/quality due to frequent interruption of the production, etc.





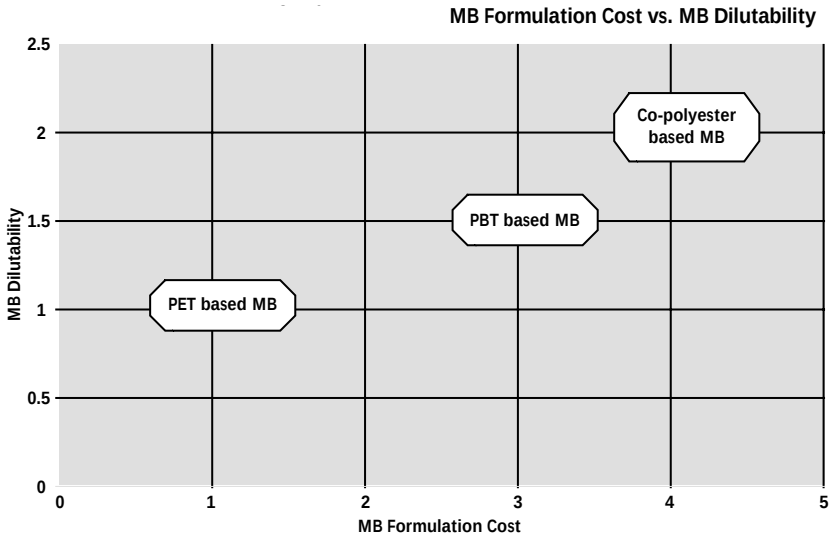


Spinability covers effects like filament breakages, maximum spin yields and picking. Most masterbatch producers serving the polyester fibre market have developed an in-house filter test (Delta P test) in order to simulate and predict filterability/spinability performance. Cabot, as speciality pigment supplier to this market, has developed such test methodology. This Delta P test helps us in developing new pigment qualities for fibre applications (speciality fibre pigment) as well as monitoring the quality consistency of the existing speciality fibre pigment grades.

Masterbatch Dilutability

Masterbatch Dilutability covers the ease with which the pigment is released by the carrier resin and is evenly distributed in the polymer matrix or polyester fibre. When Masterbatch Dilutability falls short, spinability problems will occur and/or non-homogeneous fibre pigmentation will occur. This Performance Measure is dependent on:

- Melting Point Carrier Resin
  (Tm lower ☛ Dilutability higher)
- Molecular Weight or Melt Viscosity Carrier Resin (MW lower ☛ Dilutability higher)
- Type of Carbon Black Pigment
- Loading of the Carbon Black Pigment
  (Loading lower ☛ Dilutability higher)
- Presence of Low Melting Point Additive(s)
  (Tm lower ☛ Dilutability higher)
- Masterbatch Pellet Geometry
  (Pellet smaller ☛ Dilutability higher)



The industry uses low melting point polyester carrier resins, co-polyesters (Tm 190-200 °C) and PBT (Tm 220 °C) as opposed to PET (Tm 260 °C), to overcome these problems, but this goes with a substantial cost penalty. The influence of the different black pigment grades on Masterbatch Dilutability can be approximated and compared by measuring the melt viscosity of a given masterbatch formulation. The selection of the correct black pigment can save substantial formulation cost when Masterbatch Dilutability is critical.

Carbon Black Dispersability

Carbon Black Dispersability is the ease with which the pigment can be wetted with the masterbatch carrier resin and subsequently de-agglomerated. This performance measure is dependent primarily on the morphology of the black pigment. It can be approximated by calculating the strength of an agglomerate, in other words the attractive force one needs to overcome to separate the agglomerates into discrete carbon black aggregates. This measure is independent of the system one uses to disperse the black pigment.

Cabot has designed black pigments for the polyester fibre application to offer polymer masterbatch and compound producers the best balance of colour strength, blue tone, filterability, dilutability and dispersability. This technical brochure is designed to allow you to select the black pigment that will deliver the best value to your application. Cabot representatives can provide you a Star Diagram comparing those pigment grades of your interest, please call them for further details on the Cabot product line.

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