

MASTERBATCHES



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Masterbatches for Injection Moulding



Table of contents	PAGE NR
Introduction	2
Black masterbatches	3
Black masterbatches for engineering thermoplastics	7
White masterbatches	8
Pharmaceutical white masterbatches	9
Additive masterbatches	10
Grade summary	14

Introduction

Cabot is a world leader in the manufacture of masterbatches and speciality compounds for the plastics industry, with manufacturing facilities in the UK, Belgium, Italy and Hong Kong. Fully equipped Product and Manufacturing Support Laboratories and extensive Sales Offices ensure that Cabot maintains the highest level of support for its customers.

Cabot's range of **PLASBLAK®**, **PLASWITE®** and **PLASADD®** masterbatches offers a differentiated selection for a wide range of injection moulding applications. Each grade has been specifically designed to meet particular performance criteria as will be explained in the following sections.

Polymer specific and universal masterbatches are included and there is also a range of innovative masterbatches for engineering plastics. End applications include domestic and pharmaceutical containers and closures, crates and buckets, toys, as well as automotive and large industrial mouldings.

Each of Cabot's masterbatches for injection moulding is specifically designed in terms of key performance criteria important to injection moulded plastics applications. The key properties common to each masterbatch type are **dilution**, **compatibility** and **dispersion** which are defined as follows:

Dilution: the ease with which the masterbatch mixes with and distributes throughout the fabricator's polymer resin. More details can be found in the Cabot brochure "Dispersion and Dilution".

Compatibility: a measure of the match between the masterbatch carrier and the fabricator's polymer resin.

Dispersion: the extent to which the pigment or additive is wetted out and de-agglomerated within the masterbatch carrier resin. More details can be found in the Cabot brochure "Dispersion and Dilution".

These and other performance criteria are discussed in more depth for each masterbatch type i.e. **black**, **white** and **additive** in the following sections.



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Black Masterbatches

■ Colouration

Colouration is fundamental to the performance of black masterbatches. **Key colouration criteria** can be defined as follows:

Jetness (or masstone): the absorbance of the total visible light by the black coloured moulded plastic part. This can be measured by the L^* value within the CIELAB co-ordinates: the more jet the product, the lower the L^* value. More details can be found in the Cabot brochure “Color Measurement for Carbon Black Filled Plastics”.

Undertone: the blueness/yellowness of the moulded part measured within the CIELAB co-ordinates. A negative b^* value indicates a blue undertone: the more negative the value, the bluer the undertone. More details can be found in the Cabot brochure “Color Measurement for Carbon Black Filled Plastics”.

Gloss: the amount of light reflected by a moulded part: the higher the reflectance, the higher the gloss.

Tinting strength: the ability of the black masterbatch to reduce the amount of reflected light so masking any colour given by the processor’s polymer resin e.g. coloured recyclate. The tinting strength of a black masterbatch can typically be measured from the reflectance of a grey compound after mixing with a white pigment or by the L^* value of the grey compound within the CIELAB co-ordinates.

Fig. 1: Selection of Grades by Colouration

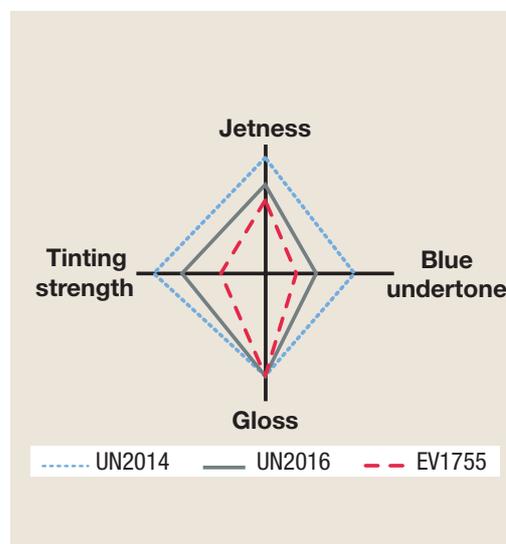
Low colouration, low tint, brown tone, good gloss	Medium colouration, medium tint, good gloss			High colouration high tint, blue tone, good gloss
	Brown tone	Brown tone	Blue tone	
EV1755				UN2014
PS3294	PS4255	UN2016	PT4778	EG3807
PE2272	PS4256	PP2631	PE2813	PA3785
	LL2633	PP3585		SA3176
	PE4884	PP3393		PS0469

■ Star Diagram showing colouration performance properties of Universal Black Masterbatches

A visual and accessible way to compare different black masterbatches with respect to their colouration properties is the star diagram. This star diagram compares 3 of Cabot’s universal black masterbatches in terms of the 4 key colouration criteria. These comparisons are made for **black** coloured moulded parts.

The 4 criteria are dependent on the type of carbon black present in the masterbatch, whilst gloss is also affected by the masterbatch carrier system which should be as compatible as possible with the polymer resin being moulded. In many applications, it is important to have the desired pigment tone, blue tone often being preferred.

Fig. 2



Performance improves from chart centre

■ Processing

In addition to colouration, there are other important factors to be considered when selecting the most appropriate masterbatch for use in a given application. The processing performance of a masterbatch encompasses the following parameters, the first 3 of which were previously defined on page 2:

- Dilution
- Dispersion
- Compatibility
- Temperature stability

Masterbatch **dilution** is dependent on its viscosity and it is preferable for the melt flow index of the masterbatch to be as near as possible to that of the fabricator's polymer resin. As carbon black severely reduces the flow properties of the masterbatch carrier resin, it is difficult to formulate a black masterbatch with the same melt flow index as the processor's polymer resin; therefore as high a melt flow index black masterbatch as possible should be used for injection moulding.

The masterbatch melt flow index values are shown in figure 3, along with suggested addition rates and specific gravity information.

Fig. 3: Summary of Properties Relevant to Processing

PRODUCT CODE	SUGGESTED ADDITION RATE	MELT FLOW INDEX		SPECIFIC GRAVITY
		%	g/10 min	
UN2014	1 - 2		38 (21.6kg/190°C)	1.22
UN2016	1 - 2		33 (10kg/190°C)	1.22
EV1755	1 - 3		8 (10kg/190°C)	1.23
EG3807	2 - 4		7 (21.6kg/200°C)	1.22
PA3785	1 - 3		23 (5kg/250°C)	1.28
PT4778	1 - 2		3.5 (5kg/275°C)	1.42
SA3176	2		57 (21.6kg/230°C)	1.20
PP2631	2 - 4		4.5 (5kg/230°C)	1.10
PP3585	2 - 7		9 (10kg/230°C)	1.12
PP3393	2 - 4		10 (5kg/230°C)	1.06
PS0469	2		68 (21.6kg/200°C)	1.20
PS4255	1 - 3		7 (10kg/200°C)	1.28
PS4256	2 - 4		37 (10kg/200°C)	1.48
PS3294	1 - 3		24 (21.6kg/200°C)	1.33
LL2633	1 - 3		23 (21.6kg/190°C)	1.50
PE4884	1 - 3		4 (10kg/190°C)	1.64
PE2272	1 - 3		13 (10kg/190°C)	1.23
PE2813	1 - 3		11 (10kg/190°C)	1.05

Dispersion is an inherent property of the pigment and process used to produce the masterbatch. Good dispersion characteristics are particularly important when the end application requires maximum mechanical properties and/or weathering performance.

It is important to have excellent **compatibility** between the masterbatch carrier resin and fabricator's polymer resin particularly in critical applications. Ideally, the carrier resin and polymer resin should be the same but where this is not practical due to the range of resins processed, Cabot's universal masterbatches offer good compatibility with a wide range of polymers.

Temperature stability must be considered when choosing the grade of masterbatch to be used. Figure 4 indicates the typical temperature ranges over which Cabot's black masterbatches for injection moulding should be processed. It may be possible to use processing temperatures outside of the indicated range depending on the masterbatch addition rate and residence time in the injection moulding machine.

Fig. 4: Typical Range of Processing Temperatures (°C)

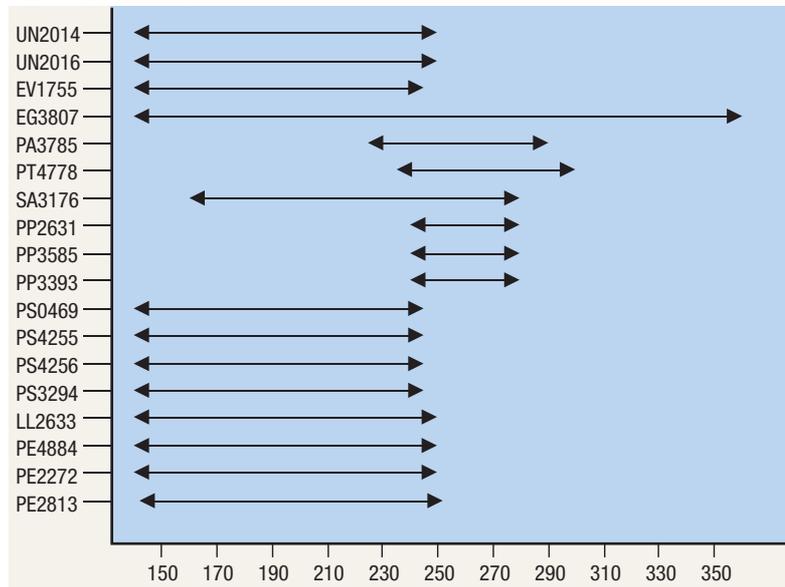


Fig. 5: Effect of Masterbatch on IZOD Notched Impact Strength of HIPS (kJ/m²)

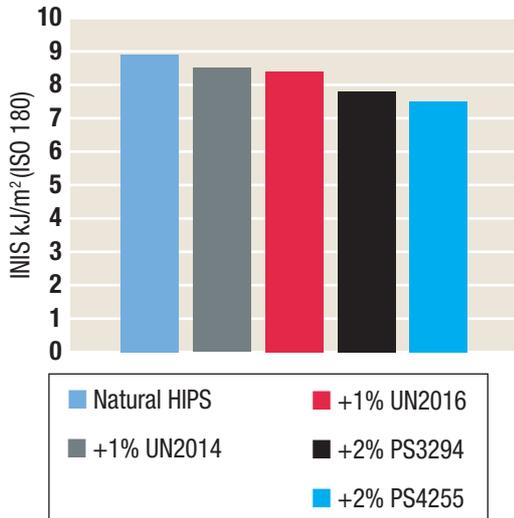
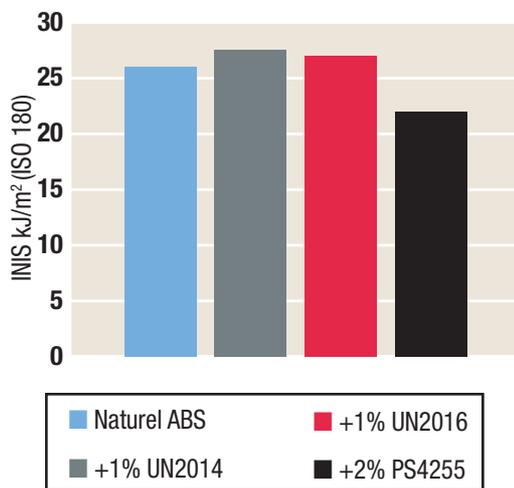


Fig. 6: Effect of Masterbatch on IZOD Notched Impact Strength of ABS (kJ/m²)



Physical properties

The use of black masterbatches to provide colouration during injection moulding can influence the physical properties of the end product. For example, impact strength of styrenics and engineering polymers can be reduced. The extent to which the physical properties are affected will depend on several factors including:

- Masterbatch addition rate
- Homogeneity of masterbatch in end product (i.e. dilution)
- Dispersion quality of the masterbatch
- Type and level of pigment
- Masterbatch carrier resin

A high quality, high colour strength masterbatch will normally be preferred in applications sensitive to loss of physical properties. Figures 5 and 6 show the effect of some PLASBLAK masterbatches on the impact strength of high impact polystyrene and ABS.



Black Masterbatches for Engineering Thermoplastics

Engineering thermoplastics are particularly important in applications such as automotive, electronics, business machines and domestic appliances due to their superior mechanical properties and high temperature performance. It is essential that the correct masterbatch is selected in order that the maximum performance from the polymer be obtained in the end-product.

It is usual to select a masterbatch, not only with high colouration properties, but with the most compatible carrier system. Often this will be polymer specific to the engineering thermoplastic being processed.

Figure 7 shows Cabot's currently available polymer specific masterbatches for engineering thermoplastics.

To complement this range of polymer specific masterbatches, Cabot has developed a high performance black masterbatch, **PLASBLAK EG3807**, designed for colouring a wide range of engineering thermoplastics, e.g. polycarbonate, polybutylene terephthalate, polyacetal and polyphenylene sulphide.

Processing properties of Cabot's masterbatches for engineering thermoplastics are summarised in figure 8 below.

Fig. 8: Summary of Properties Relevant to Processing

PRODUCT CODE	SUGGESTED ADDITION RATE	MELT FLOW INDEX	SPECIFIC GRAVITY
	%	g/10 min	
PA3785	1 - 3	23 (5kg/250°C)	1.28
PT4778	1 - 2	3.5 (5kg/275°C)	1.42
SA3176	2	57 (21.6kg/230°C)	1.20
EG3807	2 - 4	7 (21.6kg/200°C)	1.22

The use of PLASBLAK EG3807 offers certain performance benefits as follows in engineering thermoplastics:

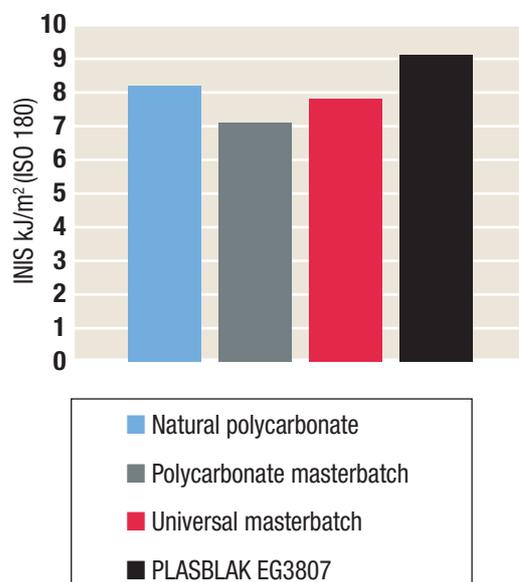
- Suitable for use in a wide range of engineering thermoplastics
- Improved colour generation
- Wide temperature stability
- Wide food contact approval
- Significant improvements in impact properties of some engineering thermoplastics e.g. polycarbonate when used in compounding

Figure 9 demonstrates the advantageous effect of EG3807 compounded into a polycarbonate resin system compared to the natural resin itself and the use of other masterbatches.

Fig. 7: Polymer Specific PLASBLAK Masterbatches for Engineering Thermoplastics

PRODUCT CODE	CARRIER RESIN	COMPATIBLE ENGINEERING THERMOPLASTICS
PA3785	Polyamide 6	Polyamide 6 et 66
PT4778	Polyethylene terephthalate	Polyethylene terephthalate
SA3176	SAN	SAN/ABS

Fig. 9: Effect of Masterbatch on IZOD Notched Impact Strength of Polycarbonate at 0.7% Carbon Black Versus Natural Polycarbonate (kJ/m²)



White Masterbatches

Cabot's PLASWITE masterbatches for injection moulding offer excellent pigmentation characteristics and easy processability across a wide range of polymers.

Basic processing properties of these grades are summarised in figure 10.

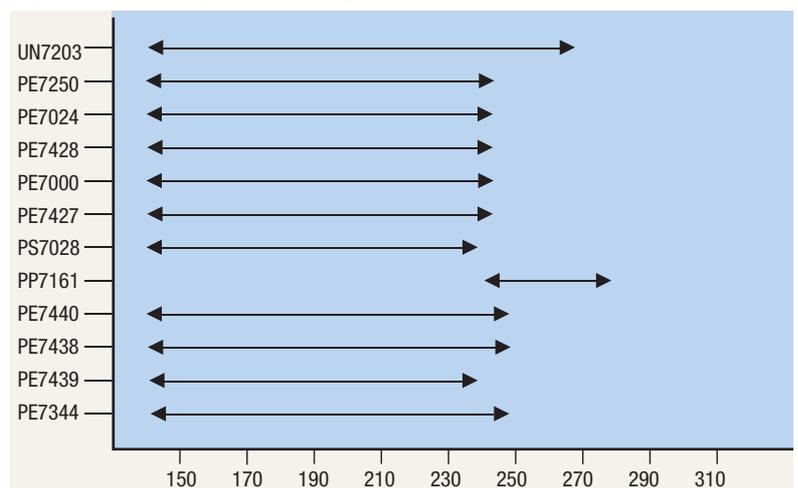
Fig. 10: Summary of Properties Relevant to Processing

PRODUCT CODE	SUGGESTED ADDITION RATE	MELT FLOW INDEX	SPECIFIC GRAVITY
	%	g/10 min	g/cm ³
UN7203	1 - 2	14 (2.16kg/190°C)	2.18
PE7250	1 - 2	45 (2.16kg/190°C)	2.00
PE7024	1 - 2	16 (2.16kg/190°C)	1.71
PE7428	1 - 2	28 (2.16kg/190°C)	2.26
PE7000	1 - 2	15 (2.16kg/190°C)	2.21
PE7427	2 - 4	18 (2.16kg/190°C)	2.15
PS7028	1 - 2	47 (5.0kg/200°C)	1.88
PP7161	2 - 4	15 (2.16kg/230°C)	1.48
PE7440	4 - 6	6 (2.16kg/190°C)	1.13
PE7438	1 - 3	53 (2.16kg/190°C)	1.71
PE7439	2 - 5	9 (2.16kg/190°C)	1.33
PE7344	3 - 5	1.5 (2.16kg/190°C)	1.72

Figure 11 shows the typical range of processing temperatures recommended for each PLASWITE masterbatch for injection moulding.

As with the PLASBLAK masterbatches, it may be possible to use processing temperatures outside of the indicated range depending on the masterbatch addition rate and residence time in the injection moulding machine.

Fig. 11: Typical Range of Processing Temperatures (°C)



Pharmaceutical White Masterbatches

Cabot manufactures 3 speciality white masterbatches for use in injection moulded articles for the pharmaceutical industry. PLASWITE PE7438, PE7439 and PE7440 are based on raw materials which not only meet food contact regulations in most countries but have been specially selected for their high chemical purity and compliance with the European Pharmacopoeia. Typical applications include bottles and containers for drugs and medicines as well as disposable syringes.

PLASWITE PE7438 contains 60% of a specially selected titanium dioxide pigment in a specially selected high flow LDPE carrier resin.

PLASWITE PE7439 contains 40% of a specially selected titanium dioxide pigment together with an amide type antistat in a specially selected LDPE carrier resin.

PLASWITE PE7440 contains 24% of a specially selected titanium dioxide pigment in a specially selected LDPE carrier resin.



Additive Masterbatches

Cabot's range of PLASADD masterbatches for injection moulding have different functions designed to enhance the performance characteristics of injection moulded articles and/or improve processing properties.

Basic processing properties of these grades are summarised in figure 12.

Fig. 12: Summary of Properties Relevant to Processing

PRODUCT CODE	SUGGESTED ADDITION RATE	MELT FLOW INDEX		SPECIFIC GRAVITY
		g/10 min		
	%			g/cm ³
PE9041	1 - 2	13	(2.16kg/190°C)	0.91
PE9247	0.5 - 2	39	(2.16kg/190°C)	0.94
PE9365	*	5	(2.16kg/190°C)	0.93
PP8738	*	25	(2.16kg/230°C)	0.92
PE8811	0.5 - 2	54	(2.16kg/190°C)	1.01
PE8999	1 - 3	16	(2.16kg/190°C)	1.29

* addition rate will depend on the specific application and requirements which should be discussed with a Cabot representative.

■ Mould release agent masterbatch: PLASADD PE9041

When moulding intricate plastic parts or articles with a large surface area, mouldings can fail to eject from the mould. To overcome this problem, mould release agents are used. They can be external additives such as silicone sprays or they can be internal additives such as those provided by PE9041.

Figures 13 and 14 demonstrate the benefits of adding PE9041 to polypropylene and high density polyethylene respectively at 1.25%. Reductions of approximately 20% in the cooling cycle were recorded during injection moulding of a PP wheel using a 4 cavity mould and approximately 20% in the second stage pressure holding time during injection moulding of an HDPE wheel.

■ Antioxidant masterbatch: PLASADD PE9247

Plastics are subject to degradation in the presence of heat and oxygen. This can occur during processing as well as any subsequent thermal ageing process, for example, if a part becomes warm during service.

Primary antioxidants rapidly react with peroxy radicals formed during degradation of the polymer thus preventing further degradation reactions. They are usually phenolics and provide long term thermal stability.

Secondary antioxidants react with hydroperoxides to yield stable products. They are usually phosphites and protect the polymer during processing, particularly at high temperatures.

Fig. 13: Mould Release Trials Using 1.25% PE9041 in Polypropylene

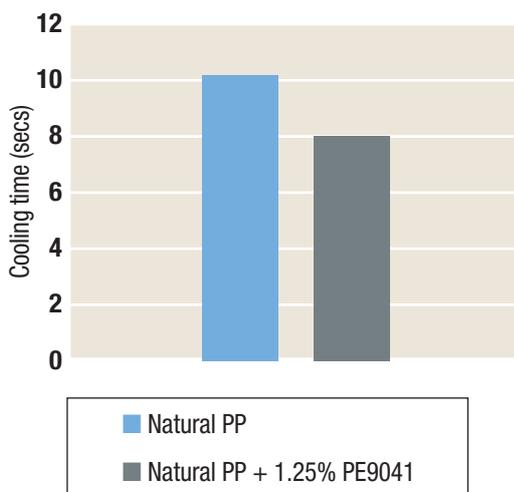
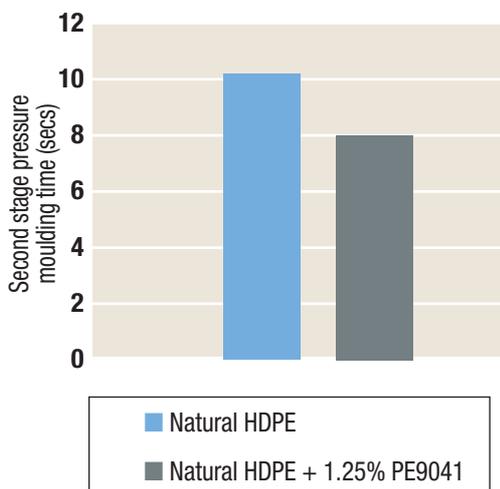


Fig. 14: Mould Release Trials Using 1.25% PE9041 in High Density Polyethylene



Cabot offers a phenolic antioxidant masterbatch for injection moulding of polyolefins as follows:

PLASADD PE9247 contains a phenolic which will offer protection during processing and will provide long term thermal stability enhancing the lifetime of the moulded part. PE9247 can also be used for shutdown stabilisation.

Figure 15 demonstrates the effect of thermal ageing on the IZOD Notched Impact Strength of black moulded parts, both with and without the addition of PE9247.

■ UV masterbatches: **PLASADD PE9365 and PP8738**

Injection moulded articles for outdoor applications require additional protection against UV degradation to prevent embrittlement and surface chalking effects during service life. Common outdoor applications for polyolefins include crates, seating, toys, rubbish bins and automotive trims.

The correct choice of masterbatch and addition level will depend on the exact application, composition, thickness, required lifetime and geographic area so should be discussed with the local Cabot representative.

Cabot offers 2 UV masterbatches for injection moulding as follows:

PLASADD PE9365 is based on a high molecular weight HALS making this grade highly recommended for the stabilisation against sunlight of polyethylene. This grade is widely suitable for plastics coming into contact with food.

PLASADD PP8738 is based on a synergistic combination of HALS and offers very good protection against light and heat designed for polypropylene applications. This grade is specially recommended when protection of the surface (thus avoiding “chalking” effects) is an important criterion in addition to maintaining the mechanical properties of the product. PP8738 is based on a polypropylene homopolymer carrier. This grade is not suitable for applications with a food contact requirement.

Fig. 15: Effect of Thermal Ageing on IZOD Notched Impact Strength

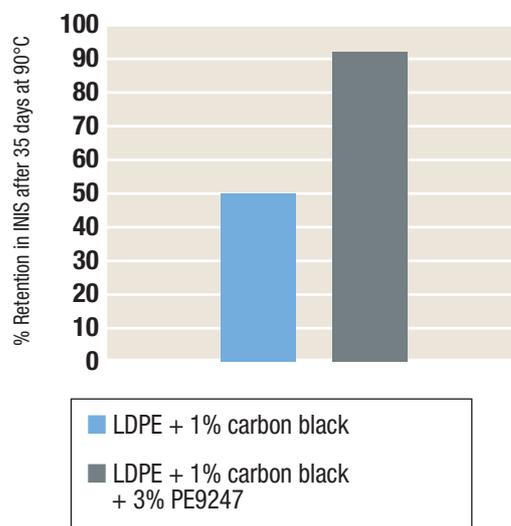
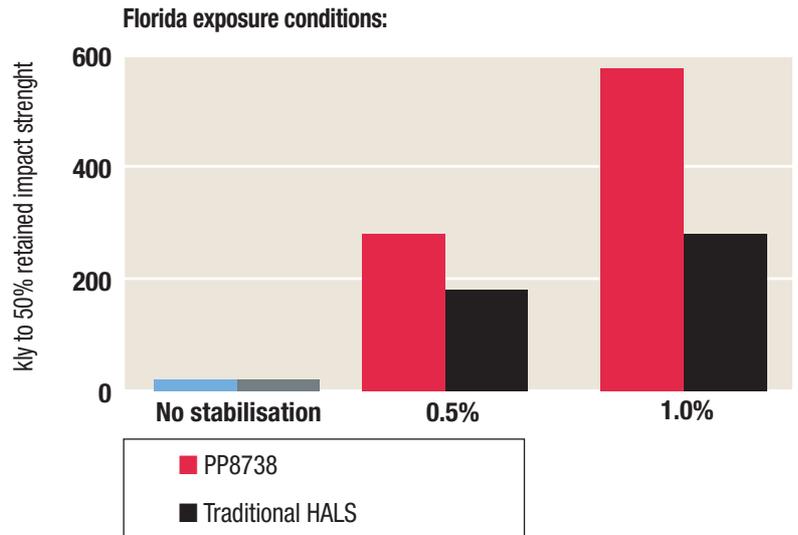


Figure 16 demonstrates the beneficial effect on impact strength of using PP8738 versus a traditional HALS when PP parts are exposed to UV light.

Fig. 16: Comparison of PP8738 with a Traditional Hals in 2mm Unpigmented PP Homopolymer Injected Plaques



■ **Antistatic masterbatch: PLASADD PE8811**

The accumulation of charge arising from the build-up of static electricity on injection moulded parts can have adverse effects during production, conversion processes and service life.

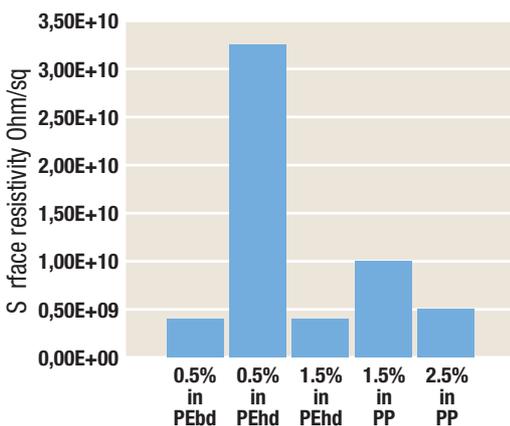
These include:

- Production delays due to clinging of adjacent moulded parts
- Dust attraction during storage and service
- Electric shocks due to static discharge
- Increased risk of fire and/or explosion, particularly in applications in contact with powders

PLASADD PE8811 gives a long duration antistatic effect and shows good antistatic performance, even at low relative humidity levels. It is widely suitable for use in plastics coming into contact with food.

The required addition level of antistatic masterbatch and the ultimate surface resistivity of the finished article will vary significantly depending on the type of polyolefin, time and relative humidity. Figure 17 demonstrates the antistatic performance of PE8811 at different levels and in different polyolefins.

Fig. 17: Effect of polymer type and masterbatch addition level on antistatic properties



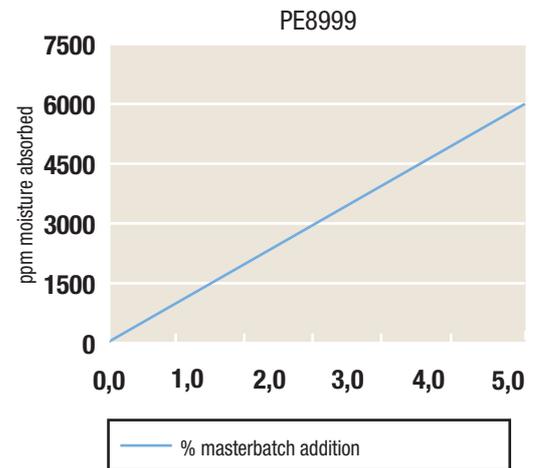
■ Desiccant masterbatch: PLASADD PE8999

The presence of moisture in raw materials can have a number of undesirable effects that can lead to increased scrap levels and loss of production. Common effects during injection moulding include porosity and surface imperfections as well as the emission of excessive amounts of volatiles from the nozzle of the moulding machine. The use of desiccants is therefore an important consideration for processors using recycled materials in ensuring that production efficiency and product quality are maintained.

Cabot's desiccant masterbatch incorporates additives which chemically bond with the moisture, a process which is irreversible at all temperatures used in plastics processing. The masterbatch will absorb 1500 ppm of moisture for every 1% added.

PLASADD PE8999 contains a desiccant additive in an LDPE carrier and is suitable for use in the injection moulding of recycled polyethylene and polypropylene.

Fig. 18: Moisture Absorption versus Desiccant Masterbatch Addition Rate



It should be noted that high levels of desiccant masterbatch could have a detrimental effect on the surface smoothness of the moulded parts.

Grade Summary

PRODUCT CODE	DESCRIPTION	PE	PP	PS	ABS	SAN	PA	PC	PET	Other engineering polymers*
PLASBLAK MASTERBATCHES										
UN2014	Premium jet black universal	++	++	++	++	++	+	+		
UN2016	Medium colour universal	++	++	++	++	++	+	+		
EV1755	Universal black masterbatch	++	++	++	++	++	+	+		
EG3807	High performance jet black masterbatch for engineering polymers				+	+	++	++		++
PA3785	Black masterbatch for nylon						++			
PT4778	Black masterbatch for PET								++	
SA3176	Black masterbatch for ABS/SAN			++	++	++				
PP2631	Premium black masterbatch for PP weathering applications based on homopolymer		++							
PP3585	Premium black masterbatch for PP weathering applications based on copolymer		++							
PP3393	Black masterbatch for PP		++							
PS0469	Jet black pigmentation for styrenics			++	+	+				
PS4255	Premium black masterbatch for styrenics			++	+	+				
PS4256	Economy black masterbatch for styrenics			++	+	+				
PS3294	Economy black masterbatch for styrenics			++	+	+				
PE4884	Economy black masterbatch for polyolefins	++	++							
LL2633	General purpose economy black masterbatch	++	++							
PE2272	General purpose black masterbatch	++	++							
PE2813	FDA compliant black masterbatch	++	++							

Key:

++ suitable

+ limited suitability

* PBT, PMMA, POM, PPS

PRODUCT CODE	DESCRIPTION	PE	PP	PS	ABS	SAN	PA	PC	PET	Other engineering polymers*
PLASWITE MASTERBATCHES										
UN7203	Universal 75% white	++	++	++	++	++	+	+		
PE7250	Premium 70% white for polyolefins with outstanding pigmentation	++	++							
PE7024	Premium 60% white for polyolefins	++	++							
PE7428	Utility 60% white for polyolefins	++	++							
PE7000	Utility 50% white for polyolefins	++	++							
PE7427	Utility 40% white for polyolefins	++	++							
PS7028	60% white for styrenics			++	++	++				
PP7161	50% white for PP		++							
PE7440	Pharmaceutical 24% white	++	++							
PE7438	Pharmaceutical 60% white	++	++							
PE7439	Pharmaceutical 40% white with antistatic	++	++							
PE7344	60% white for UV weathering	++	++							
PLASADD MASTERBATCHES										
PE9041	Mould release agent	++	++							
PE9247	Antioxidant	++	++							
PE9365	UV stabiliser for polyolefins	++	++							
PP8738	UV stabiliser for PP		++							
PE8811	Slow migration, long duration antistatic for polyolefins	++	++							
PE8999	Desiccant for polyolefins	++	++							

Key:

++ suitable

+ limited suitability

* PBT, PMMA, POM, PPS

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