

MASTERBATCHES



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## Masterbatch Selection Guide for Agricultural Film Applications



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# Introduction

This “Masterbatch Selection Guide for Agricultural Film Applications” provides detailed information about our extensive range of black, white and additive masterbatches specifically designed for use in agricultural films.

The brochure provides performance information on each masterbatch with regard to important application parameters such as opacity, weathering resistance, tensile strength, puncture resistance, tack properties and chemical resistance.

It also provides information on the requirements of end users, industry test standards and other matters relevant to the production and use of agricultural film.



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# Mulch Film

## ■ Definition

Mulch film is loose film laid at ground level around crops to suppress weed growth, maintain humidity and protect roots from climatic extremes.

The end result is a much improved crop yield with the following advantages:

- Increased soil temperature and humidity
- More roots
- Labour saving
- Fewer chemicals required for plant protection
- Higher germination rates

Mulch films are laid on an enormous area of land world-wide, totalling about 4 million hectares.

Mulch films are generally based on LDPE, LLDPE or a blend and vary in thickness from 10 to 80 microns depending on the crop and the required service life. They are mainly transparent or black, but can also be white, black/white or coloured (mainly to attract or repel certain insects).

Transparent films transmit most of the solar radiation to the soil. As this solar energy is absorbed by the soil and converted into heat, the result is a much quicker heating up of the soil than for pigmented mulch films. These types of film do not prevent weed growth.

Mulch film can be divided into 3 main categories:

### **Standard**

- 30 – 40 microns
- one season service life
- fruit and vegetables

### **Premium**

- 60 – 80 microns
- up to 5 year's service life
- vines and amenity plants

### **Special**

- 15 – 50 microns
- up to 3 year's service life
- specialist crops or for extended life

For black, white and black/white mulch films, the key performance requirements are the following:

- opacity (for weed control)
- weathering resistance appropriate to the service life
- mechanical properties

## Black Masterbatches

Cabot's range of black masterbatches provides the technical performance demanded by the film producer via a number of options. This is achieved by selection of the appropriate carbon black, additives and carrier systems together with use of state-of-the-art mixing technology.

Cabot's recommended PLASBLAK® masterbatches for mulch film are as follows:

Grade	Formulation	Mulch film
PE2642	40% small particle size carbon black	Premium grade with excellent opacity and weathering performance
PE2640	40% small particle size carbon black	Premium opacifying grade
PE2662	35% small particle size carbon black	Standard grade
PE2272	50% standard carbon black	Standard grade for specified carbon black content
PE1851	50% standard carbon black	Economy grade for specified carbon black content

### ■ Opacity

In order to ensure that weed growth does not occur, it is necessary for the film to have sufficient opacity. The opacity requirements for different films are defined in the European Standard EN13655, and currently correspond to a light transmission of 1 Lux for films below 20 µm thickness and 0.1 Lux for films of 20 µm thickness and above.

Table 1: MB addition rate (%) to achieve 1 Lux light transmission

Film thickness (µm)	15	30	40	50	60	80
PE2642	17	8	6	5	4	3
PE2640	17	9	7	5	4	3
PE2662	20	10	7	6	5	4
PE2272	22	11	8	7	6	4
PE1851	22	11	8	7	6	4

The masterbatch addition rates (%) required to achieve 1 Lux light transmission vary according to the masterbatch selected and are given in Table 1.

Table 2: MB addition rate (%) to achieve 0.1 Lux light transmission

Film thickness (µm)	30	40	50	60	80
PE2642	9.9	7.4	6.0	5.0	3.7
PE2640	10.3	7.7	6.2	5.2	3.9
PE2662	12.2	9.1	7.3	6.1	4.6
PE2272	13.3	10.0	7.9	6.6	4.9
PE1851	13.3	10.0	7.9	6.6	4.9

The masterbatch addition rates (%) required to achieve 0.1 Lux light transmission are shown in Table 2.

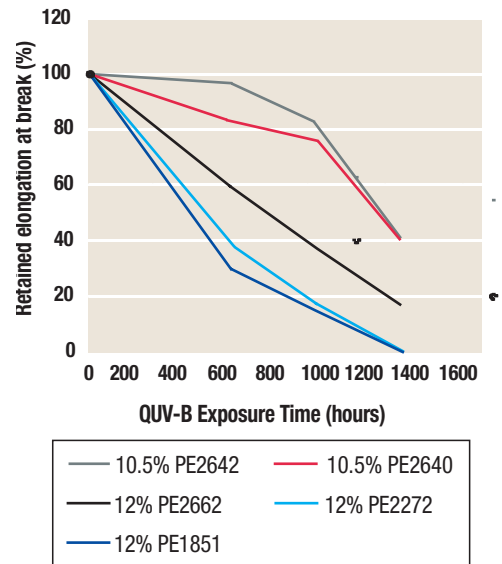
**Weathering resistance**

Mulch film is required to have a durability to match its service life. As previously mentioned, a weathering test is included in the EN13655 Standard. This is achieved, in the case of black masterbatches, by the use of carbon black.

For thinner films and films requiring longer service life, a small particle size weathering grade of carbon black is selected and, in some cases, the use of an antioxidant package is highly desirable to prevent degradation from occurring during processing as this can also adversely affect weathering performance of the film.

QUV weathering data for 30 µm film with addition rates of the masterbatches recommended for mulch film to achieve 0.5 Lux light transmission (“very high opacity”) is given in Fig. 1.

Fig. 1: QUV-B weathering of 30 µm LDPE/LLDPE film



**Mechanical properties**

Mechanical properties are another important consideration when choosing a masterbatch for mulch film. The film needs to remain intact during use, resisting damage during planting of the crops and environmental factors such as high winds, birds or animals.

Dart drop impact strength is a measure of the puncture resistance of the film and has been determined on 30 µm and 80 µm LDPE/LLDPE films with addition levels of the recommended masterbatches to achieve 0.5% Lux light transmission. The results are shown in the following graphs.

In the four following graphs, the “control” sample is natural polymer without any masterbatch added.

Fig. 2: Dart drop impact strength of 30 µm LDPE/LLDPE mulch film

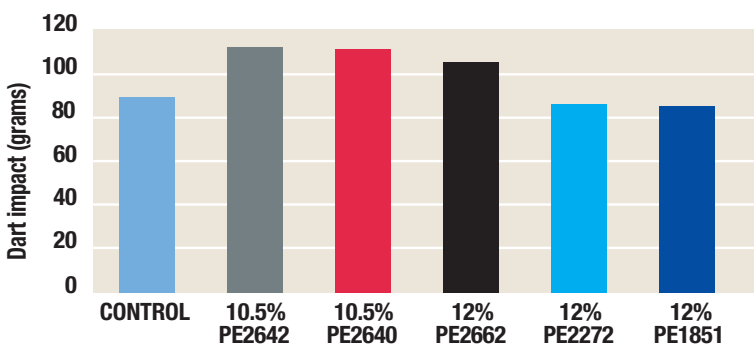
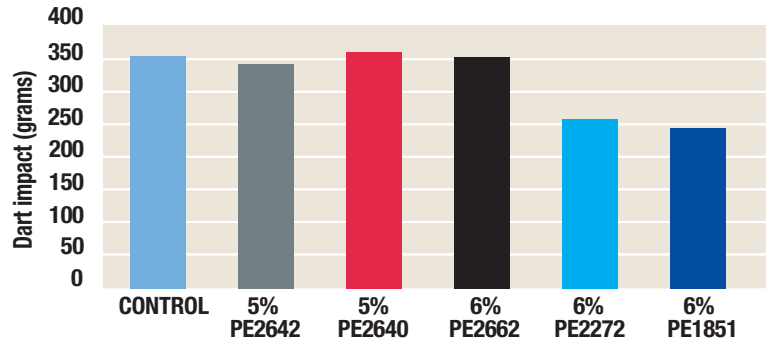


Fig. 3: Dart drop impact strength of 80 µm LDPE/LLDPE mulch film



Tensile properties are also an important measure of the resistance of the film to tearing and other mechanical stresses. The tensile strength and elongation at break have been determined on 30 µm LDPE/LLDPE films with addition levels of the recommended masterbatches to achieve 0.5% Lux light transmission. The results are shown in the following graphs for films tested in the machine direction and transverse direction respectively and expressed as a percentage of the control sample.

Fig. 4: Tensile strength of 30 µm LDPE/LLDPE mulch film - Machine Direction (MD) & Transverse Direction (TD)

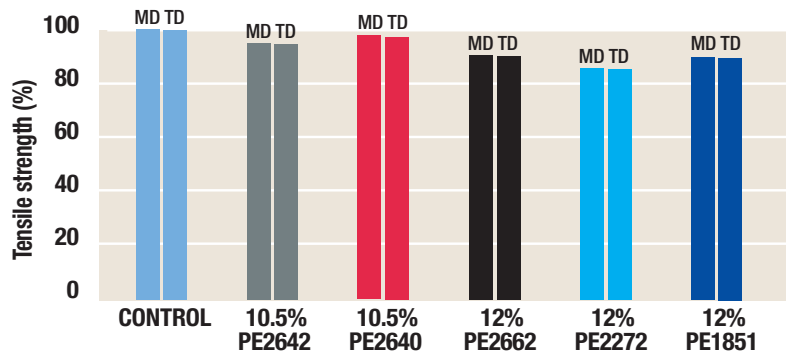
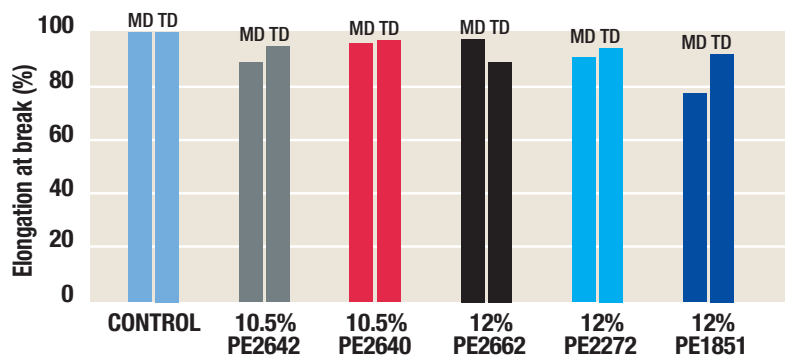


Fig. 5: Elongation at break of 30 µm LDPE/LLDPE mulch film - Machine Direction (MD) & Transverse Direction (TD)



## White Masterbatches

Cabot has a range of white masterbatches suitable for use in mulch film providing opacity together with durability appropriate to the service life of the film. Cabot's recommended PLASWITE® masterbatches for mulch film are as follows:

Grade	Formulation	Mulch film
LL7588	70% durable TiO <sub>2</sub>	High opacity, standard durability, use of a UV stabiliser masterbatch such as PE9365 is recommended
LL7014	70% durable TiO <sub>2</sub>	High opacity, good durability, use of a UV stabiliser masterbatch such as PE9365 is recommended

### ■ Opacity

Opacity of white films is normally measured by a contrast ratio method. This involves placing the film in front of a white background and then a black background and measuring the green light reflectance over each. The contrast ratio is the reflectance over the black background divided by the reflectance over the white background. Thus the more light that is reflected, the less light is absorbed by the black background behind the film and the higher the opacity. The opacity of any given film is directly proportional to the film thickness and the titanium dioxide (TiO<sub>2</sub>) pigment content of that film.

It should be noted that durable grades of TiO<sub>2</sub> have a more protective coating which does not contribute to opacity; therefore the pigment content of the film is effectively reduced. Fig. 6 shows the opacity for various thickness mulch films containing Cabot's recommended masterbatches at different addition rates.

### ■ Weathering performance

Generally a durable white TiO<sub>2</sub> pigment should be chosen for outdoor applications and it is advisable to use a hindered amine light stabiliser additive in addition. Fig. 7 compares the QUV-B weathering performance of Cabot's durable white grades, PLASWITE LL7014 and PLASWITE PE7344, with a standard 75% non-durable TiO<sub>2</sub> masterbatch, in 50 µm film containing 4.2% TiO<sub>2</sub>.

Fig. 6: Opacity vs MB addition rate for several film thicknesses

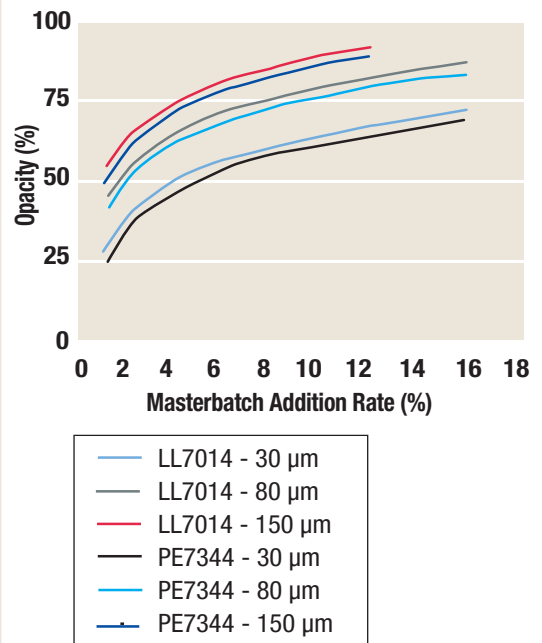
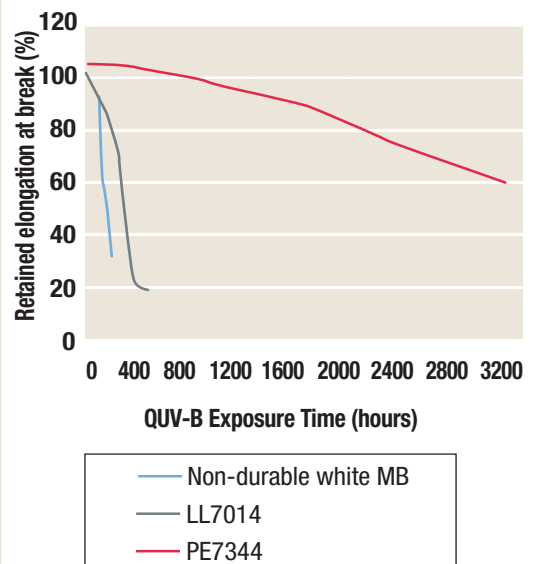


Fig. 7: QUV-B weathering of 50µm white LDPE films ISO 4892-3 and ISO 527-3



### ■ Mechanical properties

The relative effect of the recommended PLASWITE masterbatches on mechanical properties of mulch film is demonstrated in the following graphs of tensile strength, elongation at break and tear strength of 50 µm film with the masterbatch dosage calculated to give 4.2% TiO<sub>2</sub> in each film.

Fig. 8: Tensile strength of 50 µm LDPE white films

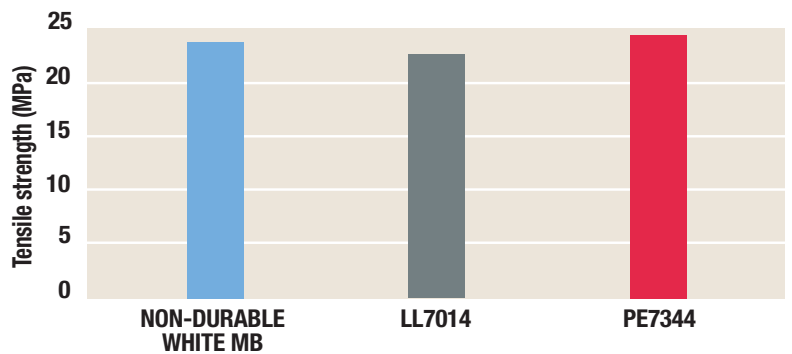


Fig. 9: Elongation at break of 50 µm LDPE white films

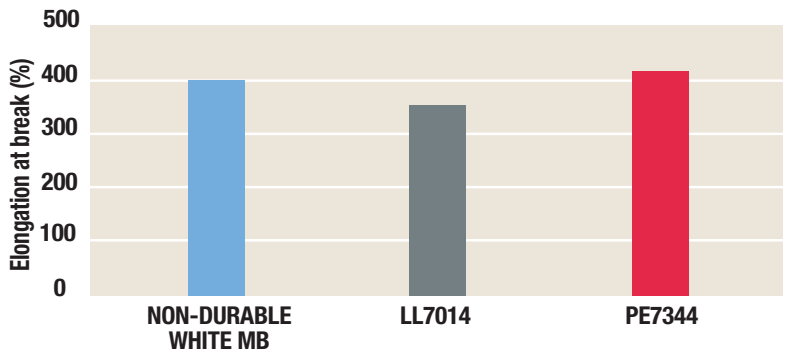
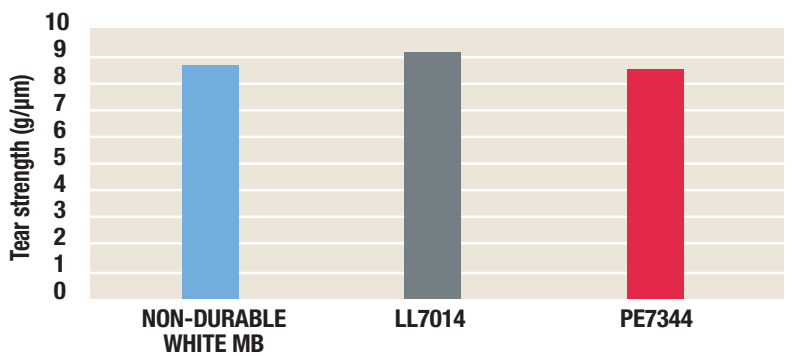


Fig. 10: Elmendorf tear strength of 50 µm LDPE white films



## Natural Masterbatches

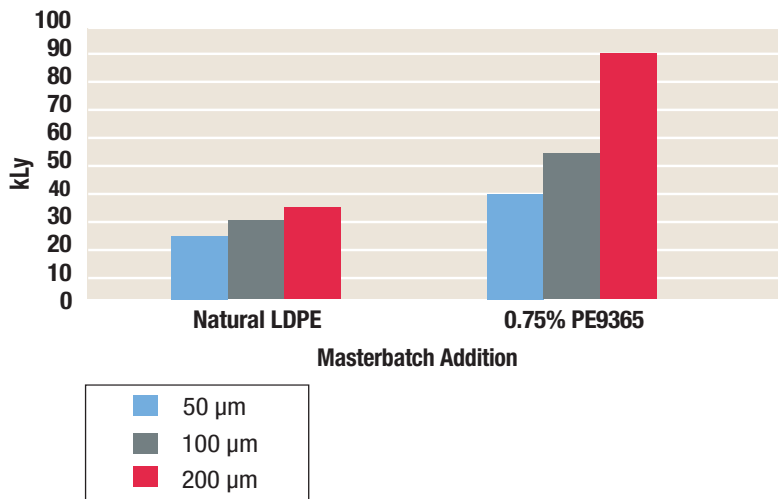
Transparent mulch films are designed to heat up the soil more quickly and prevent moisture loss. The types of masterbatches required are mainly UV and antifog.

CABOT offers some PLASADD® UV masterbatches for use in mulch film as follows, which can be used in coloured or transparent film:

Grade	Formulation	Mulch film
PE9365	20% high molecular weight HALS	For film up to 100 µm
PE9373	10% high molecular weight HALS	Recommended in black pigmented film

Fig. 11 compares the UV performance of PLASADD® PE9365 in LDPE film with natural LDPE when exposed in Florida at 45° facing south without backing. No pesticide has been applied.

Fig. 11: kLy exposure to 50% retained elongation



# Silage Film

## ■ Definition

Silage film is used by farmers to produce nutritional winter feed for livestock by anaerobic fermentation.

Silage is the process by which fodder is produced and stored. It is normally produced during spring and late summer in temperate climates and in the rainy season in the tropics. The process of anaerobic fermentation is designed to preserve green fodder, such as maize and grass, and other agricultural produce in a moist state to maximise its nutritional value without harmful formation of fermentation by-products.

The mechanism is as follows:

### **Respiration activity (plants)**

- Degradation of sugars, heat production
- Loss in nutrient value

### **Acidification**

- Coli bacteria  
Acid (mainly lactic) formation, decrease in pH  
Active to pH 4.5
- Lactic bacteria  
Continuing lactic acid formation  
Stabilisation at pH 3.5 – 4.2

### **Undesirable fermentation**

- Fodder putrefaction (butyric and rot inducing bacteria)

Silage films can be produced in one of 3 forms:

### **Silage stretch wrap for bales**

- 15 – 25 microns
- black, white or green mono- or co-extruded
- produced from LLDPE and /or metallocene blends

### **Silage sheet**

- 125 – 200 microns
- black, white or black/white co-extruded
- produced in large widths from recycled polyethylene, LDPE, LLDPE or EVA/EBA

### **Silage bags**

- 90 – 150 microns
- black or white
- produced from recycled polyethylene, LDPE, LLDPE or EVA/EBA

The key characteristics of a good silage film are:

- A certain degree of opacity
- Excellent weathering resistance to preserve the original mechanical and gas barrier properties thus ensuring the protective role of the film throughout the duration of its outdoor exposure
- Excellent puncture and tear resistance to ensure low oxygen permeability
- Excellent tack and one side cling properties (for bale wrap)

## Silage Stretch Wrap for Bales

Cabot's range of black, white and additive masterbatches offers the required properties by careful selection of fine particle size carbon blacks or highly durable TiO<sub>2</sub> and an appropriate HALS or thermal stabilisation package to give excellent dispersion and weathering performance.

Cabot's recommended PLASBLAK, PLASWITE and PLASADD masterbatches for silage stretch wrap are the following:

Grade	Formulation	Silage stretch wrap
PE4441	38% small particle size carbon black + antioxidant	Premium grade with high dispersion quality
LL4897	39% small particle size carbon black + antioxidant	Standard grade
PE2642	40% small particle size carbon black	Premium weathering grade
PE4780	40% small particle size carbon black	Standard grade based on LDPE
PE7344	60% durable TiO <sub>2</sub> + HALS	Fully formulated grade for premium weathering performance
LL7014	70% durable TiO <sub>2</sub>	High opacity, good durability, use of a UV stabiliser masterbatch such as PE9365 is recommended
LL7588	70% durable TiO <sub>2</sub>	High opacity, standard durability, use of a UV stabiliser masterbatch such as PE9365 is recommended
PE9373	10% high molecular weight HALS	UV masterbatch recommended for use in conjunction with PE4441, LL4897 or PE2642 in areas of high UV
PE9365	20% high molecular weight HALS	UV masterbatch recommended for use in conjunction with LL7014

### ■ Opacity

High levels of opacity are desirable in silage stretch wrap film although it is not essential for the film to be totally opaque since film is normally wrapped 3 or 4 times around each bale. Table 3 shows the level of light transmission through 15µm and 25µm films containing CABOT's PLASBLAK silage stretch wrap grades used at the recommended addition levels. The incident light is 100,000 Lux.

### ■ Weathering

Excellent weathering resistance appropriate to the service life of the film and region in which the film is to be used, is an essential requisite of silage stretch wrap film. The lifetime would usually be expected to be a minimum of 12 months. Black silage bales are normally used in the UK, Ireland, Scandinavia, France and Spain. For the latter 2 regions, it is recommended that PLASADD PE9373 is used in conjunction with one of the PLASBLAK masterbatches.

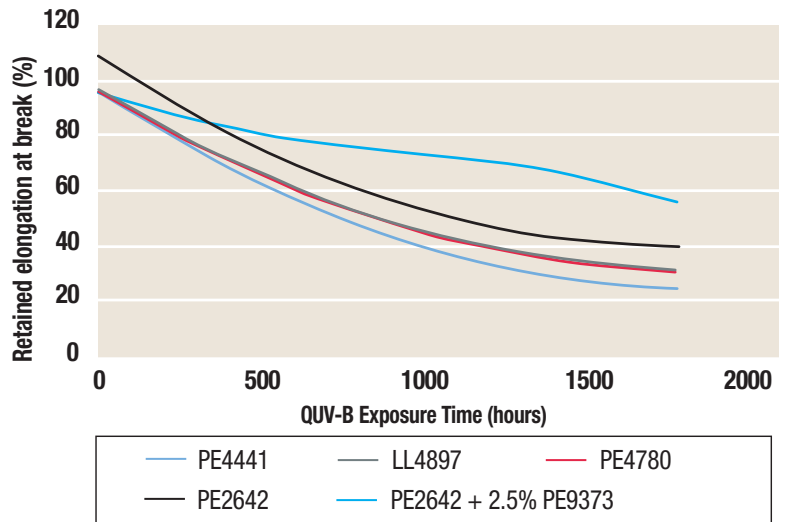
Comparative QUV weathering performance for Cabot's silage stretch wrap PLASBLAK masterbatches at their recommended addition rates is shown in Fig. 12:



Table 3:

Film thickness	15 µm	25 µm
6.5% PE4441	3330 Lux	345 Lux
6.0% PE2642	1257 Lux	68 Lux
6.0% LL4897	2010 Lux	149 Lux
6.0% PE4780	1818 Lux	126 Lux

Fig. 12: QUV-B weathering of 25 µm black LDPE films ISO 4892 and ISO 527-3



### ■ Mechanical properties

Silage stretch wrap films need to withstand the baling process and use in the field without puncturing or tearing, otherwise oxygen will be present in the fermentation process causing spoilage of the crop.

Tensile strength, elongation at break and dart drop impact strength tests have been carried out on films produced using Cabot's silage stretch wrap PLASBLAK masterbatches at their recommended addition rates in 25µm LDPE film as follows:

Fig. 13: Tensile strength of 25 µm black LDPE films

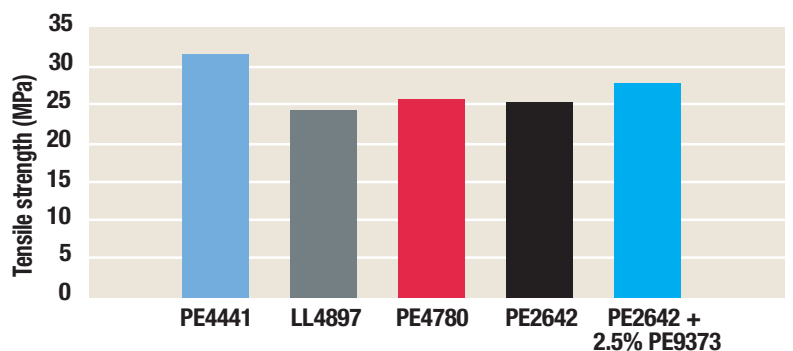


Fig. 14: Elongation at break of 25 µm black LDPE films

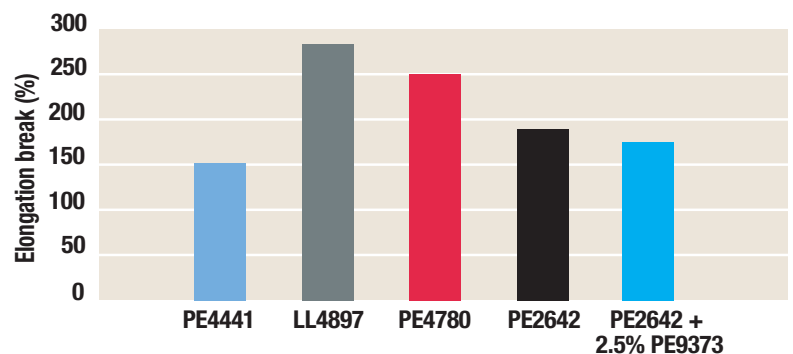
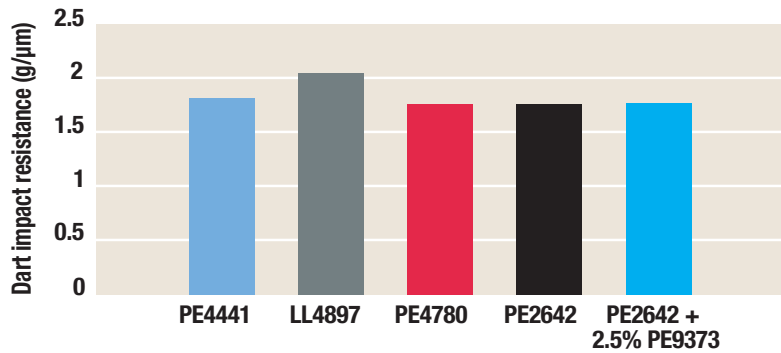


Fig. 15: Dart impact resistance of 25 µm black LDPE films



### ■ Tack properties

Tack properties of silage stretch wrap film are normally achieved by the use of polyisobutylene (PIB) which can be combined with other tackifier additives such as ethylene vinyl acetate (EVA), very low density polyethylene (VLDPE), atactic polypropylene (a-PP) or metallocenes. The final tack properties of the film are affected by many factors including the extrusion technique, film thickness, film structure, cooling rate, blow-up ratio and so on. In order to determine whether, in coloured films, the pigment type also has an influence, Cabot made a study of the tack properties of black and white films produced under controlled conditions incorporating 2 types of PIB and a number of very different grades of carbon black and titanium dioxide.

Within the scope of this study, it was concluded that the type and level of carbon black or titanium dioxide present in silage stretch wrap film did not influence the tack performance of the film given by PIB. The biggest influence was found to be that due to the molecular weight of the PIB used. A higher molecular weight PIB should be chosen if greater tack performance is required.

For optimum masterbatch dilution, it is recommended that PIB is pumped into the extruder after the masterbatch and polymer have melted and are well mixed or homogenised in order to allow efficient mixing before the viscosity is greatly reduced due to the presence of the PIB.

Further information can be found in the Cabot Technical Tool “Influence of Black and White Masterbatches on the Tack Performance of PIB Used in Silage Stretchwrap Films”, which can be obtained from your Cabot representative.



## Silage Sheet and Silage Bags

Cabot's recommended PLASBLAK and PLASWITE masterbatches for silage sheet and silage bags are the following:

Grade	Formulation	Sheet and silage bags
PE7344	60% durable TiO <sub>2</sub> plus HALS	Fully formulated grade for premium weathering performance
LL7014	70% durable TiO <sub>2</sub>	High opacity grade which should be used in conjunction with a UV masterbatch such as PLASADD PE9365
LL7588	70% durable TiO <sub>2</sub>	High opacity, standard durability, use of a UV stabiliser masterbatch such as PE9365 is recommended
PE7002	75% non-durable TiO <sub>2</sub>	Excellent opacity grade, but limited service life; must be used in conjunction with a UV masterbatch such as PE9365
PE2642	40% small particle size carbon black	Premium opacifying weathering grade
PE4780	40% small particle size carbon black	Premium weathering grade
PE2640	40% small particle size carbon black	Premium grade for co-extrusion applications
PE2662	35% small particle size carbon black	Standard grade
PE2605	50% standard carbon black	Cost effective grade for specified carbon black content
PE1851	50% standard carbon black	Standard grade for specified carbon black content

### ■ Opacity

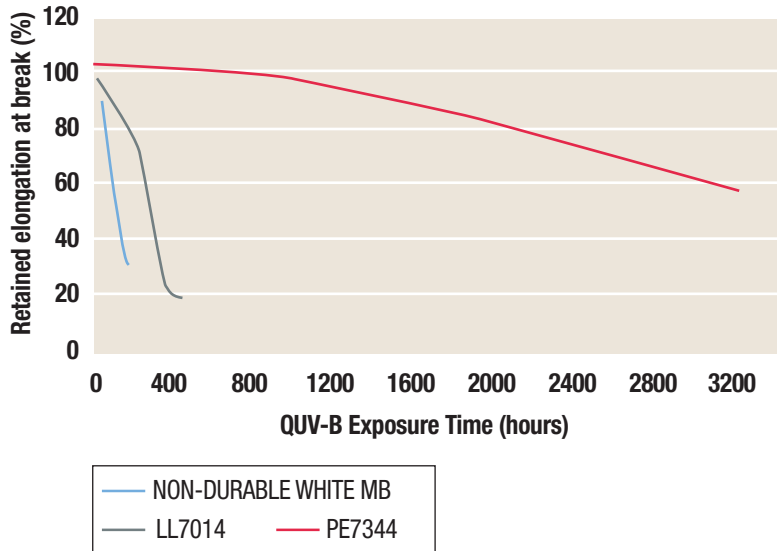
Highly opaque film is desirable for silage sheet and silage bags. However this is relatively easy to achieve since the film is of a greater thickness than silage stretch wrap film and the minimum masterbatch addition level to give the desired weathering performance will almost certainly be more than enough to give the film sufficient opacity.

### ■ Weathering

Weathering resistance of silage sheet and silage bags is easier to achieve than that of silage stretch wrap film, the films being of a thicker gauge. Masterbatches of a lower weathering performance quality can be used provided that masterbatch is added to ensure sufficient carbon black to give the required weathering protection (normally a minimum of 2% carbon black).

The advantage of using a durable grade of TiO<sub>2</sub> as opposed to a non-durable grade is demonstrated in Fig. 16. Furthermore the importance of using a HALS for applications requiring high weathering performance is shown.

Fig. 16: QUV-B weathering of 50 µm white LDPE films ISO 4892-3 and ISO 527-3



### ■ Mechanical properties

Silage sheet and bags need to have adequate mechanical properties to be able to be used in the field without puncturing or tearing, otherwise oxygen will be present in the fermentation process causing spoilage of the crop. Again, this is easier to achieve as the thickness of the films already ensures a reasonable level of mechanical performance.



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