Black Masterbatch Application and Selection Guide for Agricultural Film
This Selection Guide provides detailed information about our extensive range of black 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.
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 mulch films, the key performance requirements are the following:

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

<table>
<thead>
<tr>
<th>Grade</th>
<th>Formulation</th>
<th>Mulch film</th>
</tr>
</thead>
<tbody>
<tr>
<td>PE2642</td>
<td>40% small particle size carbon black</td>
<td>Premium grade with excellent opacity and weathering performance</td>
</tr>
<tr>
<td>PE2640</td>
<td>40% small particle size carbon black</td>
<td>Premium opacifying grade</td>
</tr>
<tr>
<td>PE2824</td>
<td>Small particle size carbon black</td>
<td>Standard grade</td>
</tr>
<tr>
<td>PE2272/ PE2272R</td>
<td>50% standard carbon black</td>
<td>Standard grade for specified carbon black content</td>
</tr>
<tr>
<td>PE1851</td>
<td>50% standard carbon black</td>
<td>Economy grade for specified carbon black content</td>
</tr>
<tr>
<td>PE2605</td>
<td>50% standard carbon black</td>
<td>Low cost alternative to PE1851</td>
</tr>
</tbody>
</table>

### 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.

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

<table>
<thead>
<tr>
<th>Film thickness (µm)</th>
<th>15</th>
<th>30</th>
<th>40</th>
<th>50</th>
<th>60</th>
<th>80</th>
</tr>
</thead>
<tbody>
<tr>
<td>PE2642</td>
<td>20</td>
<td>10</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>PE2640</td>
<td>20</td>
<td>10</td>
<td>8</td>
<td>6</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>PE2824</td>
<td>31</td>
<td>16</td>
<td>12</td>
<td>9</td>
<td>8</td>
<td>6</td>
</tr>
<tr>
<td>PE2272/PE2272R</td>
<td>21</td>
<td>11</td>
<td>8</td>
<td>6</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>PE1851</td>
<td>21</td>
<td>11</td>
<td>8</td>
<td>6</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>PE2605</td>
<td>22</td>
<td>11</td>
<td>8</td>
<td>7</td>
<td>6</td>
<td>4</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Film thickness (µm)</th>
<th>30</th>
<th>40</th>
<th>50</th>
<th>60</th>
<th>80</th>
</tr>
</thead>
<tbody>
<tr>
<td>PE2642</td>
<td>12</td>
<td>9</td>
<td>7</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>PE2640</td>
<td>12</td>
<td>9</td>
<td>7</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>PE2824</td>
<td>19</td>
<td>14</td>
<td>11</td>
<td>9</td>
<td>7</td>
</tr>
<tr>
<td>PE2272/PE2272R</td>
<td>13</td>
<td>10</td>
<td>8</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>PE1851</td>
<td>13</td>
<td>10</td>
<td>8</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>PE2605</td>
<td>13</td>
<td>10</td>
<td>8</td>
<td>7</td>
<td>5</td>
</tr>
</tbody>
</table>
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 films, by the use of carbon black masterbatches.

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 adversely affect weathering performance.

QUV weathering date for 30µm film using addition rates of masterbatch to achieve 0.1 Lux light transmission is given in Fig. 1.

Mechanical properties

Mechanical properties are another important consideration when choosing a masterbatch for mulch film. The film must 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. Fig. 2 shows dart drop impact strength using addition rates of masterbatch to achieve 0.1 Lux light transmission in 30µm LDPE/LLDPE film.
Tensile properties are also an important measure of the resistance of the film to tearing and other mechanical stresses. Figs. 3 and 4 show the tensile strength and elongation at break using addition rates of masterbatch to achieve 0.1 Lux light transmission in 30μm LDPE/LLDPE film.

Fig. 3: Tensile strength of 30 μm LDPE/LLDPE film - Machine Direction (md) & Transverse Direction (td)

Fig. 4: Elongation at break of 30 μm LDPE/LLDPE film - Machine Direction (md) & Transverse Direction (td)
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 masterbatches offers the required properties by careful selection of fine particle size carbon blacks and a thermal stabilisation package to give excellent dispersion and weathering performance.

Cabot’s recommended PLASBLAK masterbatches for silage stretch wrap are the following:

<table>
<thead>
<tr>
<th>Grade</th>
<th>Formulation</th>
<th>Silage stretch wrap</th>
</tr>
</thead>
<tbody>
<tr>
<td>PE4441</td>
<td>38% small particle size carbon black + antioxidant</td>
<td>Premium grade with high dispersion quality</td>
</tr>
<tr>
<td>LL4897</td>
<td>39% small particle size carbon black + antioxidant</td>
<td>Standard grade</td>
</tr>
<tr>
<td>PE4780</td>
<td>40% small particle size carbon black + antioxidant</td>
<td>Standard grade based on LDPE</td>
</tr>
</tbody>
</table>

■ **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.

<table>
<thead>
<tr>
<th>Film thickness</th>
<th>15 µm</th>
<th>25 µm</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.5% PE4441</td>
<td>3330 Lux</td>
<td>345 Lux</td>
</tr>
<tr>
<td>6.0% LL4897</td>
<td>2010 Lux</td>
<td>149 Lux</td>
</tr>
<tr>
<td>6.0% PE4780</td>
<td>1818 Lux</td>
<td>126 Lux</td>
</tr>
</tbody>
</table>

■ **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 to use a UV stabiliser masterbatch 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. 5:

Fig. 5: 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. 6: Tensile strength of 25 µm black LDPE films](image)

![Fig. 7: Elongation at break of 25 µm black LDPE films](image)

![Fig. 8: Dart impact resistance of 25 µm black LDPE films](image)
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 films produced under controlled conditions incorporating 2 types of PIB and a number of very different grades of carbon black.

Within the scope of this study, it was concluded that the type and level of carbon black 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 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 masterbatches for silage sheet and silage bags are the following:

<table>
<thead>
<tr>
<th>Grade</th>
<th>Formulation</th>
<th>Sheet and silage bags</th>
</tr>
</thead>
<tbody>
<tr>
<td>PE2642</td>
<td>40% small particle size</td>
<td>Premium opacifying weathering grade</td>
</tr>
<tr>
<td></td>
<td>carbon black</td>
<td></td>
</tr>
<tr>
<td>PE4780</td>
<td>40% small particle size</td>
<td>Premium weathering grade</td>
</tr>
<tr>
<td></td>
<td>carbon black</td>
<td></td>
</tr>
<tr>
<td>PE2640</td>
<td>40% small particle size</td>
<td>Premium grade for co-extrusion applications</td>
</tr>
<tr>
<td></td>
<td>carbon black</td>
<td></td>
</tr>
<tr>
<td>PE2824</td>
<td>35% small particle size</td>
<td>Standard grade</td>
</tr>
<tr>
<td></td>
<td>carbon black</td>
<td></td>
</tr>
<tr>
<td>PE2605</td>
<td>50% standard carbon black</td>
<td>Cost effective grade for specified carbon</td>
</tr>
<tr>
<td></td>
<td></td>
<td>black content</td>
</tr>
<tr>
<td>PE1851</td>
<td>50% standard carbon black</td>
<td>Standard grade for specified carbon black</td>
</tr>
<tr>
<td></td>
<td></td>
<td>content</td>
</tr>
</tbody>
</table>

■ **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).

■ **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.
EMEA
Cabot
Interleuvenlaan 15 i
3001 Leuven
BELGIUM
Tel.: +32 16 39 24 00
Fax: +32 16 39 24 44

ASIA PACIFIC
Cabot China Ltd.
558 Shuangbai Road
Shanghai 201108
China
Tel: +86 21 5175 8800
Fax: +86 21 6434 5532

SOUTH AMERICA
Cabot Brasil Industria e Comercio Ltda.
Rua do Paraiso 148 - 5 andar
04103-000 Sao Paolo,
SP Brazil
Tel: +55 11 2144 6400
Tel: 0800 19 59 59 (Customer service)
Fax: +55 11 3253 0051

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