Formulating High Performance LLDPE Blown Films With Optibloc® High Clarity Antiblocks

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World LLDPE Film Market Trends

Around the world, LLDPE blown film resin, masterbatch and compound producers see a number of trends in the marketplace, as film producers vie to gain market share.

These trends are:

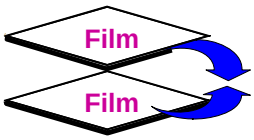
- Higher clarity films
- Lower costs
- Higher film strength
- Thinner films.

What can you do to make sure your products for LLDPE films meet the changing needs of your customers?

Key to coping with these market trends is choosing the right high performance antiblock additive for the films.

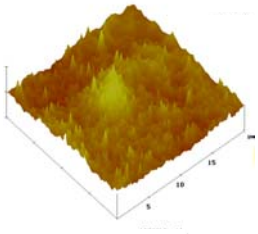
Antiblocks: A Quick Primer

Antiblocks are additives used to overcome the tendency of films to block – for two film layers to adhere to each other when in contact under moderate pressure. Blocking causes problems in opening up a bag or when unwinding film rolls during processing and conversion.



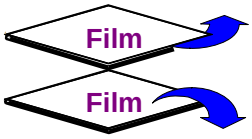
Antiblocking additives work by creating a surface roughness that keeps the films apart enough to make separation easy.

Using Atomic Force Microscopy, one can see the surface roughness induced in a LLDPE film that contains 3,000 ppm of Optibloc® high clarity antiblock. It is these peaks in the surface of the film which help prevent the two films from strongly adhering.



The efficiency of an antiblock additive is evaluated using an instrument that measures the blocking or the force, in grams, required to pull the two films apart. The more efficient the antiblock is, the lower the force will be to separate the films.

Blocking can be measured on films fresh off a roll, but more reproducible results are obtained using the Induced Reblock test. Here the films are separated, put back together and stored under mild pressure, 6.9 kPa or 1 psi, at a specified temperature, usually either 40° or 60° C, for 24 hours before testing.

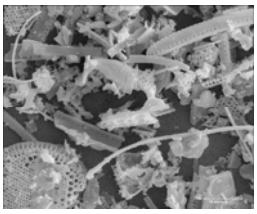


Antiblock Additives

While many compounds can be used as antiblocks, the most common in high performance polyethylene films are diatomaceous earth, synthetic silica and talc or talc-based minerals.

• Diatomaceous Earth (DE)

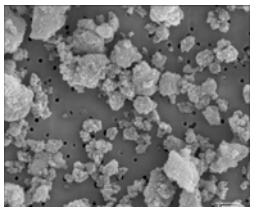
One of the earliest minerals adopted as an antiblock is calcined diatomaceous earth (DE), a natural silica, but its use is declining. A positive for DE is its low absorption of the other additives in the film formulation.



However, diatomaceous earth does absorb moisture, which limits its shelf life and that of the masterbatches containing it. Masterbatch addition is the normal incorporation method, but DE masterbatches are limited to concentrations of only about 25%. Diatomaceous earth is high in price.

• Synthetic Silica

Synthetic silica has the advantage of maintaining high clarity in PE films. It is, however, hard to disperse, is highly abrasive, and absorbs slip agents, resulting in films with higher Coefficients of Friction (COF).



Like DE, synthetic silica absorbs moisture, limiting shelf life. It is also usually added as a masterbatch, but concentrations of synthetic silica masterbatches are usually limited to only 5 to 10%. Synthetic silicas are very high in price.

• Special Talc Antiblocks

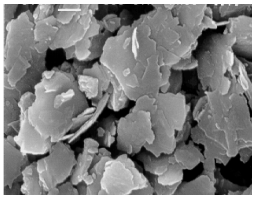
The technology of using talcs as antiblocks in polyethylene films was first developed in the 1980's by Specialty Minerals Inc. (SMI). Since then SMI has introduced a series of products of increasing performance for LDPE and LLDPE films:

- **ABT®-2500** talc, a highly efficient, uncoated talc antiblock,
- **Polybloc®** talc, coated for reduced additive absorption, and ideal when less-than-maximum clarity is required, and
- **Optibloc® 10 and 25** high clarity talc-based antiblocks, for high clarity and lowest additive absorption.

Not every talc is useful as an antiblock. Talc ores must be carefully selected and processed to make efficient and effective antiblock additives. SMI leads in the technology to produce such high performance antiblocks.

Optibloc® Talc-Based Antiblocks

When high clarity and low haze are needed in polyethylene films, one of the Optibloc talc-based products is the best choice. They are used around the world by major resin and film producers.



Optibloc talcs are coated, which results in excellent dispersion in the film, reducing the presence of gel particles. Coating also gives low absorption of film additives.

Talc is the softest mineral, so the talc-based Optibloc products are low in abrasivity. Talc is also inherently hydrophobic, so there are no shelf life limitations due to moisture absorption either with the powder or the masterbatch.

Some polyethylene producers sell resins already formulated with antiblock. Unlike many other antiblocks, Optibloc talcs can be added directly to the resin melt – no masterbatch is required.

Manufacturers of masterbatches are able to produce very high concentration products, containing 50% Optibloc antiblock.

The talc-based antiblocks are moderately priced, making them very cost-effective. Diatomaceous earth is usually replaced with an equal weight of Optibloc. The replacement ratio of Optibloc for synthetic silica is normally between 1.0 and 1.6 to 1. Even at the higher ratio, costs are reduced.

• Optibloc® 10 and 25 Antiblocks

With the smaller particle size, 2.5 microns, and cleanest top size, 90% less than 10 microns, Optibloc 10 is the choice for highest clarity and lowest haze, or when thinner films are being produced.

Optibloc 25 is slightly larger, with a median particle size of 4.0 microns, and a top size of 25 microns. In some formulations it will give slightly less clarity, but provides better antiblocking. It is lower in cost than Optibloc 10.

You can choose the best balance of performance properties and cost for a particular formula.

Winning In The LLDPE Film Market

Using Optibloc 10 or 25 as the antiblock in your film formulation can help you develop products for today's changing LLDPE film market, with the demands for higher clarity, lower cost, stronger films and thinner films.

Film Clarity

The clarity and haze of a film is affected by two factors:

- The refractive indexes of the antiblock and the polymer
- The particle size distribution achieved for the antiblock in the film. This is determined by the antiblock's average particle size, its top size, or size of the largest particles, and how well it disperses in the film.

• Refractive Index and Film Clarity

Refractive Index is a measure of how much a ray of light is bent when it hits a material. The closer the refractive index of an antiblock matches the refractive index of the polymer, the better the clarity that can be achieved.

As can be seen in the following table, the Refractive Index of Optibloc antiblock closely matches that of base polyethylene resins.

Material	Refractive Index
Polyethylene	**1.51 – 1.54**
Talc	1.56
Optibloc®	**1.54**
Synthetic Silica	1.46
Diatomaceous Earth	1.45

This close match aids the development of high clarity and low haze in LLDPE films using Optibloc.

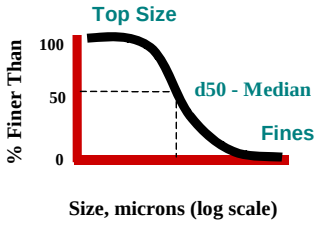
• Particle Size and Film Clarity

The second factor affecting film clarity is the size of the antiblock particles in the film.

When choosing the antiblock particle size to use, there can be a trade-off between clarity and antiblocking effectiveness. Very fine particles will give a very clear film, but if the particles are too small, the antiblocking will be poor. Very large particles will give very high blocking resistance, but the clarity will be poor.

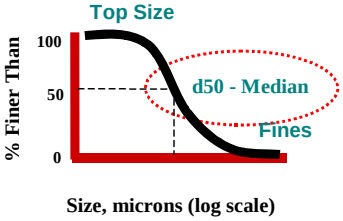
The right particle size and particle size distribution is necessary to give the right balance of clarity and antiblock effectiveness. The ability to achieve this balance by careful processing and control is what distinguishes Specialty Minerals talc-based antiblocks from standard types of talcs that are not effective antiblocks.

The particle size distribution of minerals like talc are plotted on a graph such as this, where the cumulative percent of particles that are finer than a given size is plotted against the particle size.

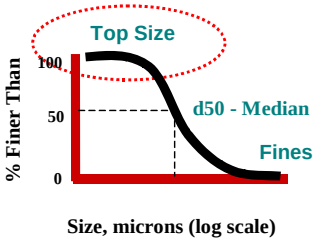


Particle size is plotted on a log scale.

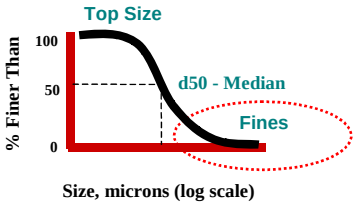
The median particle size is the particle diameter where 50% of the particles are larger and 50% are smaller. It is denoted as the d50 or D_{50}. In modern LLDPE films, a median particle size of 2 to 4 microns is usually best for maximum antiblock efficiency.



Important for both clarity and film strength is minimizing the presence of large, oversized particles – known as having a clean top size. SMI's advanced talc grinding technology allows tight control of this top size in its talc-based antiblock products such as Optibloc.



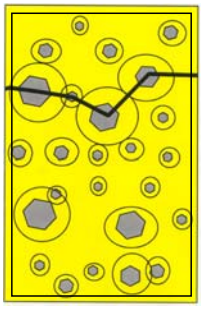
Lastly, minimizing the presence of very small particles is important. Very small particles get buried in the film, and cannot contribute to the surface roughness, so do not contribute to antiblocking effects. The portion they represent is just wasted weight. Again, Specialty Minerals' expertise in mineral grinding produces the desired particle size distribution, with reduced fines, for best efficiency.



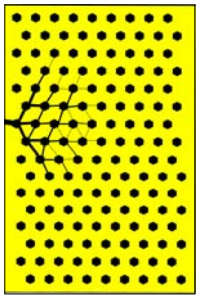
High Film Strength

Antiblock particle top size is also important to maximizing the strength of films. As is true for all plastics, the presence of large, oversized particles is detrimental to strength. These particles can either be in the antiblock to begin with, or can result when the antiblock is not well dispersed in the formulation.

Very large particles form points of weakness in plastics. When a stress is applied – the piece is hit – the large particles concentrate the stress, and form a path for failure. When the break occurs, it is often brittle.



Failure Mechanism



Toughening Mechanism

In contrast, small particles can dissipate the applied stress through localized deformation, and either prevent failure, or if the impact is high enough to cause breakage, the break is more likely to be of the desirable ductile type.

- **Aspect Ratio and Film Strength**

Another advantage to using talc-based antiblocks has to do with the platy nature of the talc particles, which can be seen in the photograph on page 2.

If the length of one of the plates is divided by the thickness of that plate, the plate's aspect ratio is obtained. For spherical particles like synthetic silica, the aspect ratio is 1:1. For platy talc, the aspect ratio is in the range of 20:1.
High aspect ratio minerals are reinforcing minerals, and add better tensile and impact strengths to polyethylene films.

Thinner Films

The combination of small particle size, controlled top size and high aspect ratio of Optibloc antiblocks can produce high clarity films with higher strength. This allows the "down gauging" – the production of thinner films with the strength of the original, thicker film.

Lower Costs

In addition to the lower cost in use, Optibloc talcs can produce additional savings from their lower abrasivity and low additive interactions.

- **Low Abrasivity**

Abrasion caused by the antiblock can be a "hidden cost" factor in masterbatch and film production. Abrasive additives cause wear of expensive dies, screw elements, barrels, cutting blades, and other equipment that comes in contact with the mixture.

Abrasion can be correlated to the hardness of the particles. Hardness is described using the Moh's Hardness scale, where talc is defined as a hardness of 1 and diamond, a hardness of 10. It is a logarithmic, not a linear scale; minerals with higher Moh's values are much more abrasive than the simple numbers might imply.

Antiblock	Moh's Hardness
Talc	1
Optibloc®	3
Synthetic Silica	5
Diatomaceous Earth	6

Diatomaceous Earth, with a Moh's value of 6 is four times more abrasive than Optibloc.

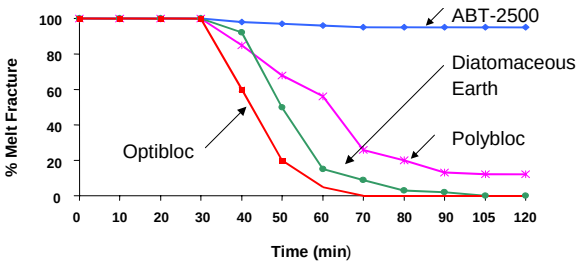
- **Low Additive Interaction & Fast Melt Fracture Elimination**

Another cost factor can be the tendency of an antiblock to absorb some of the additives used in the film formulation, such as the slip aids, and especially the PPA, the Polymeric Processing Additive. PPA is an expensive fluoroelastomer used to improve melt flow properties and lubricate the metal surfaces.

When some of the PPA is absorbed by the antiblock, the extruded film can show melt fracture, producing an uneven surface, often termed "shark skin". Either additional PPA needs to be added, or excessive amounts of waste film are produced until the melt fracture is eliminated.

Experiments were run in Specialty Minerals' blown film laboratory, comparing the effectiveness of different antiblocks in melt fracture elimination. All antiblocks were used at a 7,000 ppm level, with 500 ppm of PPA fluoroelastomer in a 1.0 MI LLDPE Hexene copolymer. The percent melt fracture remaining is plotted against the test time.

Melt Fracture Elimination



A standard in the industry is diatomaceous earth, the green line, which is considered to have low additive interaction, and to be very good at melt fracture elimination.

With the standard, untreated talcs, such as ABT® -2500, the blue line at the top, much of the PPA is absorbed, so melt fracture continues.

The purple line, which is the coated talc, Polybloc®, shows much less PPA is absorbed, and the melt fracture is reduced, but not completely eliminated by the end of the test time.

Best is the Optibloc, which reduced melt fracture even faster than the diatomaceous earth.

Optibloc Talc's High Performance in LLDPE

Three examples of the use of Optibloc talc-based antiblocks will demonstrate these products' high performance:

- Replacing Diatomaceous Earth with Optibloc 25 in a 1.0 MI Hexene LLDPE copolymer.
- Replacing Synthetic Silica with Optibloc 10 in a 1.0 MI Butene LLDPE copolymer.
- Replacing Synthetic Silica with Optibloc 10 or Optibloc 25 in a 0.5 MI Hexene LLDPE copolymer.

While all of the data shown here is in LLDPE, Optibloc products are also useful in LDPE blown films.

• Replacing Diatomaceous Earth With Optibloc® 25

Diatomaceous earth is replaced by an equal weight of Optibloc 25, the larger particle sized of the two Optibloc antiblocks.

The test system is a 1.0 MI Hexene LLDPE copolymer, blown as a 25 micron / 1 mil film. Equal weights, 6,300 ppm, of each antiblock are used.

- Optical properties are all better with Optibloc:

Optical Properties			
Antiblock	**Haze %**	**Clarity %**	**Gloss %**
Optibloc 25	9	92	65
Diatomaceous Earth	11	85	61

- Antiblocking effect was also better with Optibloc, and the COF is lower:

Antiblock Properties		
Antiblock	**Reblock @ 40°C, grams**	**Coefficient of Friction**
Optibloc 25	151	0.13
Diatomaceous Earth	156	0.16

- **Conclusion: Replacement of diatomaceous earth by Optibloc 25 produces a film with better properties at a lower cost.**

• Replacing Synthetic Silica With Optibloc® 10

Generally, the Optibloc talc-based antiblocks are not as efficient as the synthetic silicas on a weight basis. But even when replacing these silicas with a higher level of one of the Optibloc talcs, a lower cost formulation still results because of the significantly higher price of the silicas.

To match the optical properties of the synthetic silica in this formulation, 3,000 ppm of Optibloc 10 replaces 1,900 ppm of synthetic silica, and 400 ppm of additional euracamide slip is used in the Optibloc formula.

The test system is a 1.0 MI Butene LLDPE copolymer, blown as a 25 micron / 1 mil film.

Formulations		
Antiblock	**Antiblock, ppm**	**Slip, ppm**
Optibloc 10	3,000	1,600
Synthetic Silica	1,900	1,200

- Optical properties, haze, clarity and gloss with Optibloc 10 are equal to those of synthetic silica:

Optical Properties			
Antiblock	**Haze %**	**Clarity %**	**Gloss %**
Optibloc 10	14	94	50
Synthetic Silica	12	94	50

- Antiblocking effect was also a bit better with Optibloc, and the COF is lower:

Antiblock Properties		
Antiblock	**Reblock @ 40°C, grams**	**Coefficient of Friction**
Optibloc 10	12	0.094
Synthetic Silica	13	0.102

- **Conclusion: Replacement of synthetic silica by Optibloc at a 1.6 replacement ratio gives equal or better properties, with the total formulation cost still well below that of synthetic silica.**

- **Replacing Synthetic Silica With Optibloc 10 or 25 – Equal Weights**

There are some formulations where one of the Optibloc products can replace synthetic silica on a 1-for-1 basis, while giving the same high optical and antiblock performance.

The test system is a 0.5 MI Hexene LLDPE copolymer blown as a 25 micron / 1 mil film. Equal weights of all antiblocks are used, 5,000 ppm.

- Both of the Optibloc antiblocks give equal optical properties – haze, clarity and gloss:

Optical Properties			
Antiblock	**Haze %**	**Clarity %**	**Gloss %**
Optibloc 10	6	95	69
Optibloc 25	6	95	70
Synthetic Silica	6	95	69

- Antiblocking effect is better with both Optiblocs, and the COFs are lower:

Antiblock Properties		
Antiblock	**Reblock @ 40°C, grams**	**Coefficient of Friction**
Optibloc 10	22	0.09
Optibloc 25	22	0.09
Synthetic Silica	31	0.22

- **Conclusion: Replacement of Synthetic Silica by either of the Optibloc products in this fractional melt polymer results in equal opticals, better antiblock and substantially lower cost.**

Optibloc High Clarity Antiblocks Help -

- **Help you make higher clarity films**
  - Refractive Index closer to LLDPE's
  - Clean top size
  - Surface treated for best dispersion
- **Help you lower film costs**
  - Lower purchase price
  - High efficiency
    - Combining to give low cost in use
  - Low additive interaction, which reduces
    - Melt fracture film losses
    - Extra usage of PPA
  - Low abrasion of process equipment
  - Ability to add directly during resin manufacture
  - Ability to make higher concentration masterbatches
  - Masterbatch and powder shelf life not shortened by moisture absorption
    - Talc is inherently hydrophobic
- **Help you make stronger films**
  - Platy, high aspect ratio talc particles increase tensile strength
  - Clean top size improves impact strength
- **Help you make thinner films**
  - Get the tensile strength and impact strength of thicker films
- **Help you succeed in the challenging and changing Polyethylene Film Market.**

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