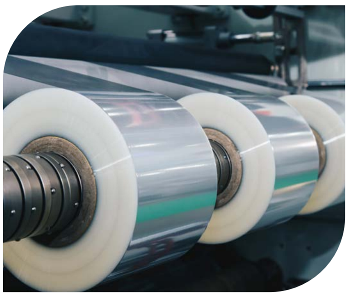
Optislip™ Slip and Anti-block Additives



Easier Processing & Handling of Polymers

Cargill™

Easier Processing & Handling of Polymers

A world leading range of slip and anti-block additives. Today's Optislip™ additives for polymers offer processors and end-users more flexibility, greater performance and better quality plastics than ever before. Cargill's polymer additives business is a world leading supplier of slip and anti-block additives, with over half a century of experience of production, applications and research in this area.

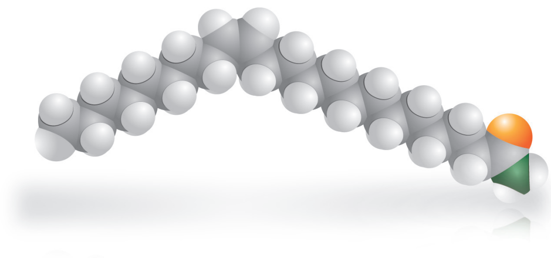
Understanding Our Additives at a Molecular Level

As a specialty polymer additives company, achieving tailored slip performance via the optimization of product combinations has become one of our technical strengths, and is an exciting area of development for the polymer additives team. By understanding additives at the molecular level, from the seed growing stage onwards, we can offer a superior range of primary amides, secondary amides and secondary bis-amides with precisely controlled functionality.

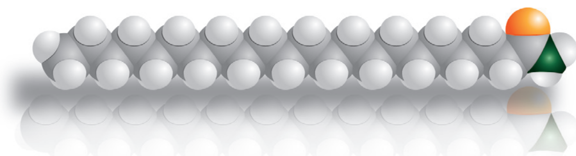
Rapeseed magnified

[†] *Image: Rapeseed at very high magnification – Our proprietary seed selection is specially grown for its particular fatty acid distribution & resulting slip properties*

Optislip ER Erucamide structure



Optislip BR Behenamide structure



Product Information

TRADE NAME	DESCRIPTION	PHYSICAL FORM AT 25°C	RAW MATERIAL ORIGIN	BIOBASED CARBON CONTENT*	KEY EFFECTS & RECOMMENDED USES
High slip*					
Optislip™ ER †	Erucamide	Bead/Powder/Microbead	Vegetable	100%	Slip/release in polyolefins, also PVC and many other polymers. Optislip OR is also used as a process aid in WPC
Optislip™ VRX	Oleamide	Bead/Powder	Vegetable	100%	
Optislip™ OR †	Oleamide	Powder/Pastille	Non-vegetable	100%	
Medium slip					
Optislip™ 203	Oleyl Palmitamide	Bead	Vegetable	100%	Medium or controlled slip in polyolefins, especially useful in laminated or co-extruded structures. Also slip in ionomers and other ethylene copolymers
Optislip™ 212	Stearyl Erucamide	Bead	Vegetable	100%	Medium or controlled slip in polyolefins, especially useful in laminated or co-extruded structures.
Low slip & anti-block					
Optislip™ BR	Behenamide	Bead	Vegetable	100%	Anti-block in polyolefins, also mold release.
Optislip™ SR †	Stearamide	Bead/Powder	Non-vegetable	100%	
Optislip™ SRV	Stearamide	Bead	Vegetable	100%	
Optislip™ EBO	Ethylene bis-oleamide	Bead	Vegetable	95%	Anti-block and medium slip/release in polyolefin polar copolymers. Especially useful as a pellet anti-tack in EVA hot melt adhesives. Process aid in WPC
Optislip™ EBS †	Ethylene bis-stearamide	Bead/Powder/Microbead	Non-vegetable	95%	Anti-block in polyolefins and process aid to improve dispersion of fillers. Also effective as a lubricant for PVC and process aid in WPC
Optislip™ EBSV	Ethylene bis-stearamide	Powder	Vegetable	95%	

* Specialty slip agents for specific applications are also available under the tradename Incroslip™ additives for caps and closures, and IncroMold™ additives for molding applications †Other technical grades are available. Please contact your local sales representative for more information.
*Tested according to ASTM D6866

Product Physical Forms

Optislip™ products are available in up to four physical forms. Please check with your local sales contact for availability in your region. Typical particle sizes are given below under product images.

Pastille

Size: 4 mm diameter x 1-2 mm
Ensures 100% dosing; reduced potential for agglomeration

Bead

Size: 1-2 mm
Good general purpose form suitable for the majority of feeders

Microbead

Size: 0.1-0.5 mm (100-500 μm)
Recommended for dry mixing with other granulates

Powder

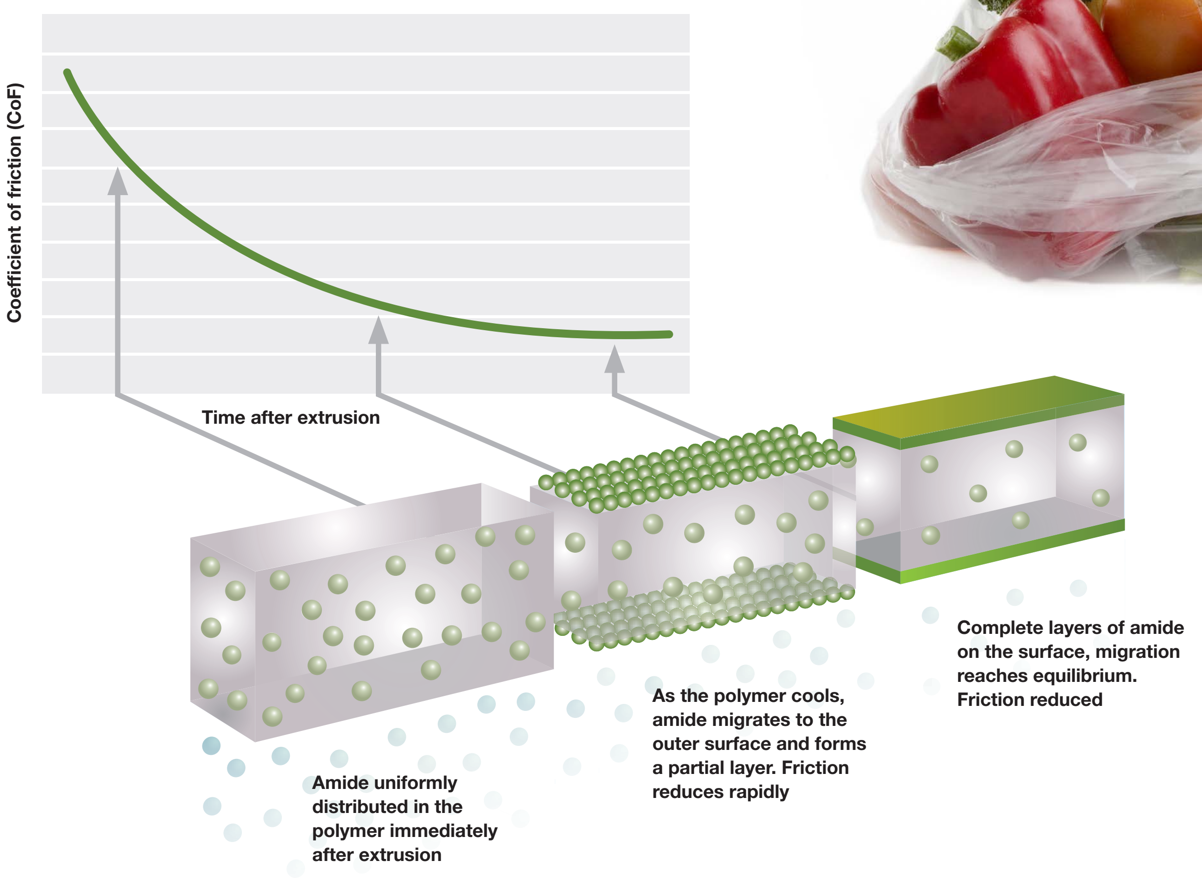
Size: 0.01-0.1mm average (10-100 μm)
Recommended for dispersion into liquids or other fine powders

Which Optislip™ Additive will Work Best in my Application?

Polymer surfaces often exhibit high friction leading to problems during manufacture, processing and use. High friction can result in difficulties with winding of film rolls, bag production and packaging operations. There are several factors affecting the development of friction including:

- Polymer type (nature, polarity, crystallinity)
- Process temperature
- Process type (film,blown/cast, co-extrusion,etc.)
- Film gauge & structure
- Other additives present (anti-fog, anti-static, pigment etc.)

Slip Development in Polymers



Optislip™ Slip & Anti-block Agents

Optislip specialty additives are incorporated directly into the polymer during the extrusion process. They work by migrating to the surface as the polymer cools forming a solid lubricating layer at the surface. This acts to lower the friction or adhesion between contacting polymer surfaces and the polymer and other materials.

When selecting the correct Optislip™ additive for your application you should consider a number of different formulating criteria, including:

Slip/blocking Performance Required

As a general guideline, unsaturated primary amides tend to have the best slip performance (CoF <0.2). Secondary amides are excellent for the control of medium slip (CoF 0.3 - 0.5). Saturated amides exhibit poorer slip properties but improved anti-blocking performance (CoF > 0.5).

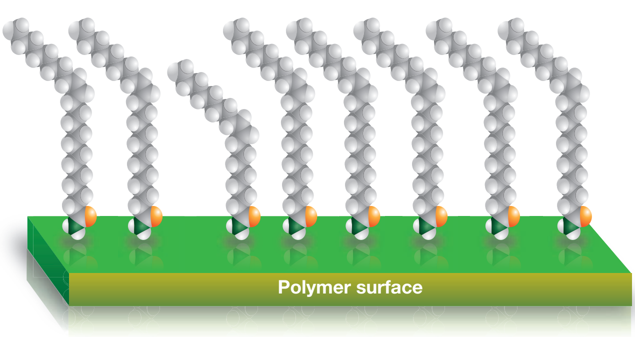
Rate of Slip Development

Generally the smaller the amide molecule, the faster it can migrate, especially in semi-crystalline polymers. Thus oleamide will cause a faster drop in CoF than erucamide. However, erucamide usually yields the lowest ultimate CoF.

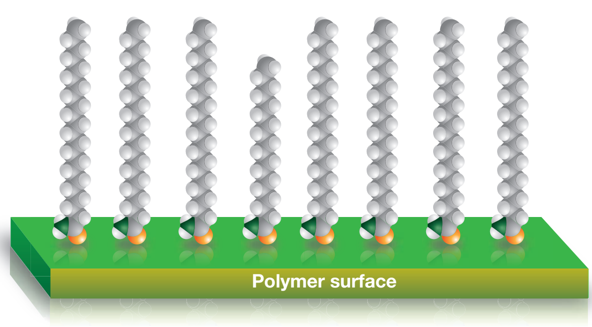
Volatility

Lower molecular weight additives are more volatile and prone to cause smoking, chill roll plate-out and die fouling. An indication of the relative volatility can be gained by Thermogravimetric Analysis (TGA), see page 10. Erucamide is less volatile than oleamide and is therefore recommended for polymers requiring higher processing temperatures. Secondary amides are recommended for engineering polymers.

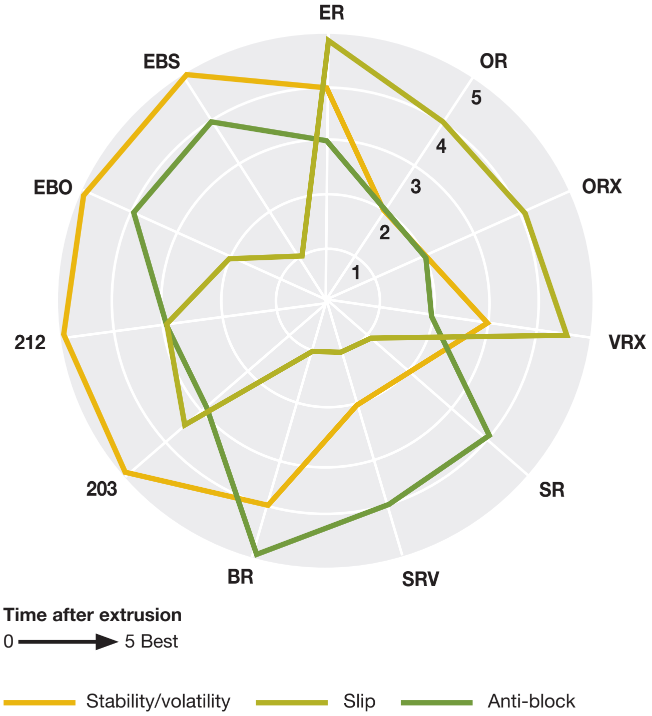
Mono-unsaturated amide



Saturated amide



Optislip™ Range - Comparison of Key Properties



Oxidative Stability

Unsaturated amides are more prone to oxidation due to the presence of the double bond. They may also have small amounts of polyunsaturates present which will significantly increase the rate of oxidation. The undesirable effects of oxidation include increased color, odor, and loss of slip properties/increased blocking.

Polymer Type

The performance and required inclusion level of the amide will vary depending on the type of polymer. Amide solubility is governed by the relative polarity of the polymer and the additive, and the crystallinity of the polymer. Slip molecules diffuse mainly through amorphous regions of a polyolefin, so with more crystalline polymers, such as PP and HDPE, migration of the amide to the polymer surface will be slower. In more polar polymers, e.g. PVC, amides exhibit greater solubility.

How are Optislip™ Products Incorporated?

Products can be added directly to the polymer at the processing stage, pre-compounded or included via masterbatch. Experience has shown that Optislip products can be easily incorporated into the polymer. Simple manual mixing prior to processing will normally give an acceptable dispersion, though mechanical means is preferable. The optimum dosage level depends on the polymer type and the degree of lubrication required. We recommend initial levels of around 500 – 2000 ppm in film.

Key Applications

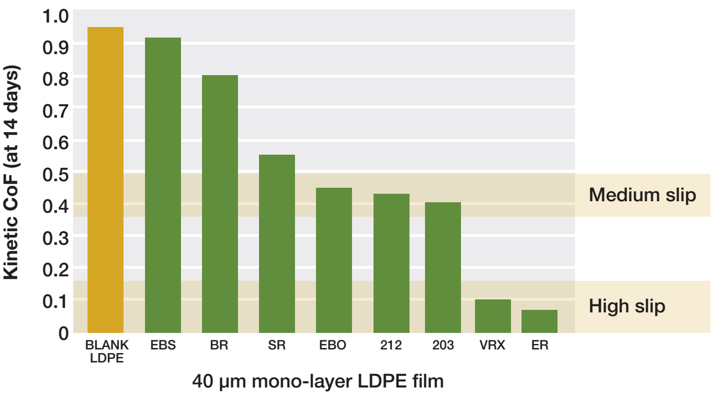
Slip

Optislip™ products are effective at low levels, providing a cost-effective solution to friction related constraints in film production and conversion applications. The range offers various levels of slip performance, both in the initial development of slip and in the final slip characteristics, depending upon the application requirements, as shown in figures 1 & 2.

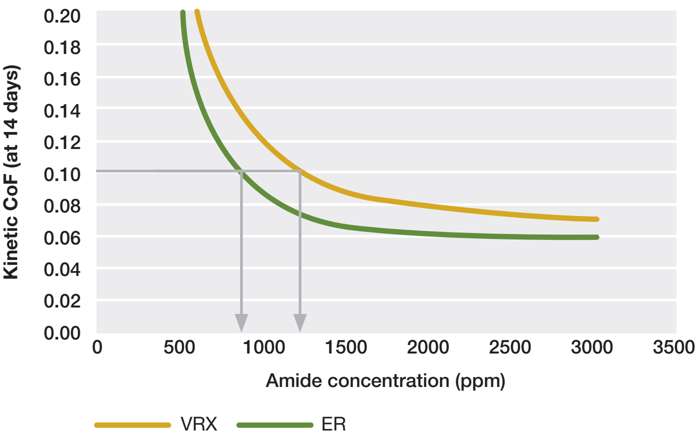
Slip - Polyethylene

At all concentrations, Optislip ER additives will give a lower ultimate CoF than Optislip VRX additive in LDPE. Therefore, less Optislip ER additive is required to give equivalent slip performance. To achieve an ultimate CoF of 0.1 only 850 ppm Optislip ER additive is required compared with 1200 ppm Optislip VRX additive, as shown in figure 3. A number of other processing variables and cost-performance benefits will also influence the final choice of slip additive.

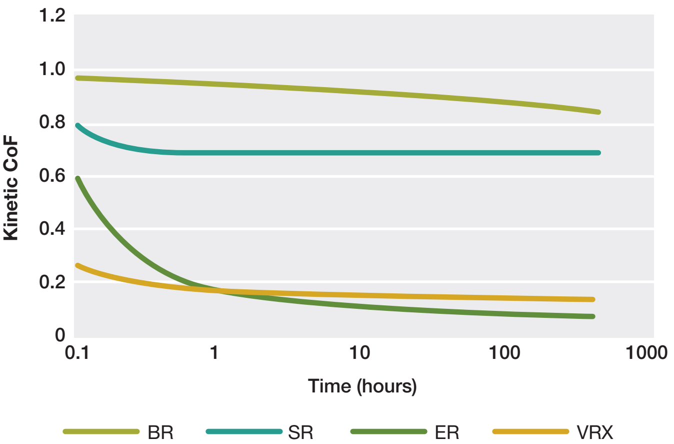
1. *Comparative effects of Optislip range on coefficient of friction in LDPE (40 µm blown film, all additives at 1000 ppm)*



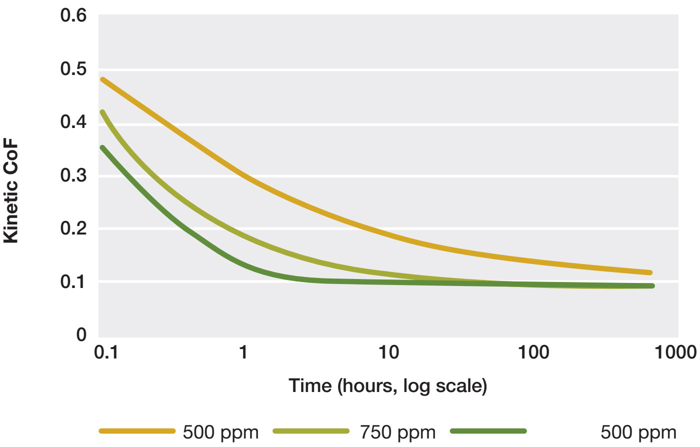
3. *Comparative effects of Optislip ER & Optislip VRX additive concentrations on the slip (CoF) of LDPE (35 µm blown film)*



2. *Comparative effects of primary amides on the slip (CoF) of LDPE vs time (35 µm blown film, all additives at 500 ppm)*



4. *Friction vs time for Optislip ER additive at 500, 750 & 1000 ppm in hexene LLDPE (40 µm blown film, 3000 ppm natural silica)*

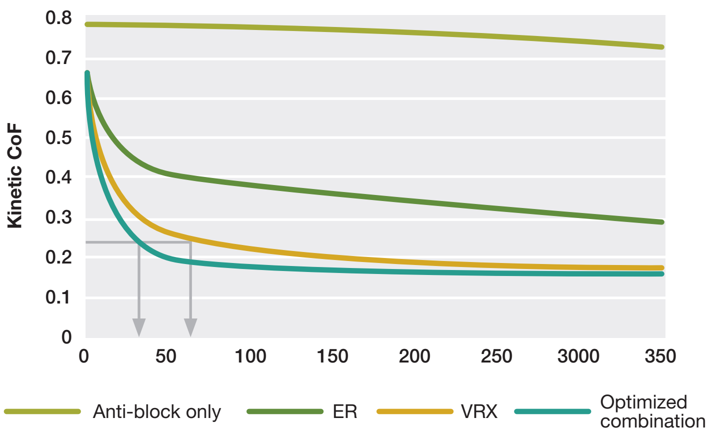


Slip - Polypropylene

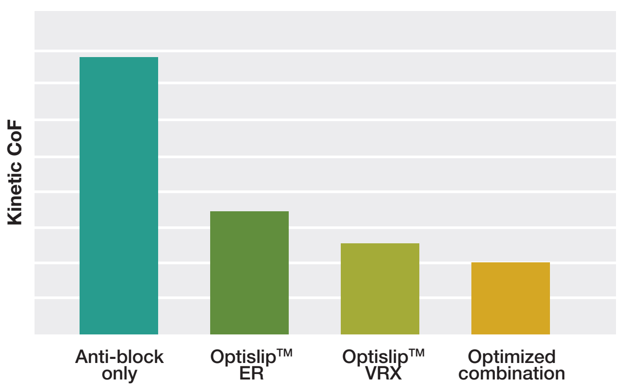
Optislip™ VRX additive is significantly faster migrating in hPP compared to Optislip ER additive. However, Optislip ER additive shows good migratory performance in coPP. Often blends of Optislip ER and VRX additives are used to optimize overall performance, but care must be taken to ensure blocking force is not increased. In our own research work on optimizing Optislip additive combinations, we have achieved very high slip in an impressively short time in polypropylene, as can be seen in figure 5. The optimized Optislip additive combination achieves a CoF of 0.25 after 35 hours approximately, whereas oleamide only reaches this CoF after 63 hours.

The effect of temperature when storing and/or transporting film can also significantly influence slip performance, and is a particular challenge in PP film. Whilst simulating cold weather conditions we tested the slip properties of PP film with various additives over seven days' cold storage. The best performing additive was an optimized Optislip additive combination which gave superior slip compared with both

5. *Optimized Optislip additive combination improves slip performance in hPP (30 µm cast film, 2000 ppm slip, 1500 ppm anti-block at 23° C)*



6. *Optimized Optislip additive combination gives reduced friction under low temperature storage in coPP (7 days at 4°C, 2000 ppm, 30 µm cast film)]*



Case Study

Optimizing Slip in LLDPE/LDPE Blend for Packaging Film

A customer processing a linear low/low density blend to produce packaging film encountered unexplained variability in blocking performance. It was noted that two different manufacturers' grades of LDPE were being used. Although the properties of the two resins were found to be equivalent, analysis showed that one manufacturer was using oleamide as a slip agent and the other erucamide. The LLDPE contained only erucamide, such that some films had a mixture of oleamide and erucamide coming from the base polymer. When erucamide and oleamide are used in combination, the slip material on the polymer surface is softer than either of the two additives individually, resulting in a greater tendency to block. It was also noted that the slip performance was slightly poorer than erucamide alone.

It was recommended that both the LDPE and LLDPE should contain Optislip ER additive only to eliminate this problem. No further blocking problems were experienced after this change was implemented. Statistical analysis of the CoF post-change showed that less Optislip ER additive could be used whilst still maintaining the desired CoF, resulting in further cost savings.

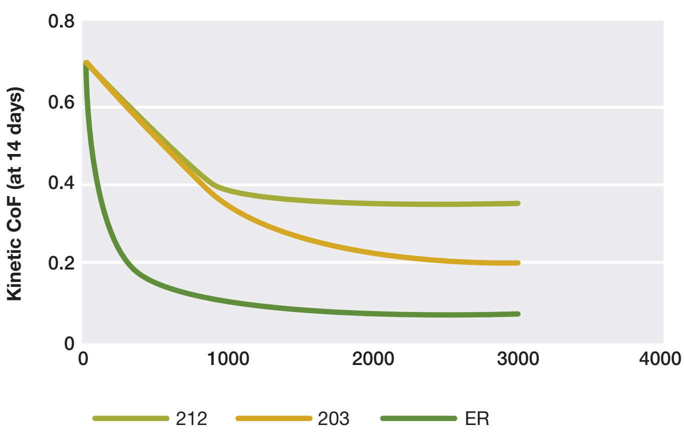
A project was initiated to look at the properties of erucamide and oleamide blends, and it was discovered that blending the two slip agents resulted in a softer, more greasy material than either additive on its own. Analysis showed that the blends had a lower melting point. This suggested that the blocking problem was related to the physical properties of the mixture of slip additives on the polymer surface. Blocking force was 20% higher where the two additives were blended, which was enough to cause serious problems during packaging.

Key Applications

Medium Slip/Control of Slip

Secondary amides have a higher molecular weight than primary amides, and are less polar, allowing greater control over the slip properties of the film. For polyolefins medium slip of 0.3-0.5 CoF can be achieved with far lower variability than with primary amides. The use of a secondary amide such as Optislip™ 203 or Optislip™ 212 additives can also enhance the printability of film surfaces due to the lower level of slip additives present at the surface. In multilayer/laminated films stable CoF levels may be achieved with secondary amides as they are far less likely to migrate into adjacent polar layers.

7. *Comparative performance of Optislip 203 & Optislip 212 medium slip additives in LDPE (35 μm blown film, various concentrations)*



Case Study

Medium Slip Solution for Multilayer Packaging Film

A customer making a five-layer co-extruded packaging film required a stable CoF between 0.25-0.30 on the outside skin layer of the film structure. The customer had attempted to achieve this by adding 150 ppm erucamide. Although the average CoF achieved was within the specification, there was unacceptable deviation throughout batches, typically between 0.1-0.4 CoF. The other layers consisted of two tie layers and a central barrier layer; the inner skin layer was LDPE.

The variability in slip performance was thought to be caused by the difficulty in dosing such a low level of additive accurately, and the tendency of erucamide to migrate into adjacent layers, especially if they are of high polarity, such as tie layers and adhesives. It was suggested to the customer to replace the erucamide with Optislip 203 medium slip additive, and produce a trial batch using 750, 1000, and 1500 ppm of Optislip 203 additive. The skin layer also contained 1500 ppm of an inorganic anti-block. The CoF performance of the films produced was measured over 21 days. Within three days of production a stable CoF was achieved at all levels of Optislip 203 additive, with 1000 ppm achieving the required level 0.25-0.3 CoF, with a variability of +/-0.05.

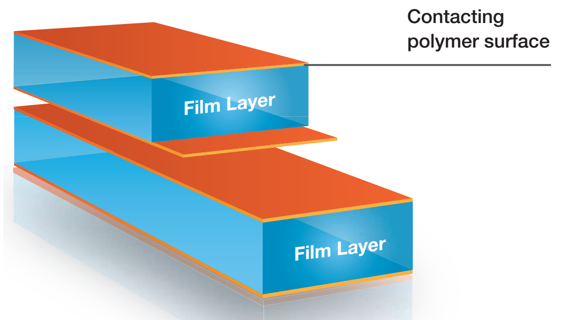
Over the same period erucamide at 500 ppm achieved a CoF of 0.1 within one day, which remained stable for two weeks with a slight upward trend in the third week. Erucamide at 150 ppm achieved the required CoF during the first week but with a larger variability in excess of +/-0.1. After the first week the CoF steadily rose up to 0.5 in the third week.

Anti-block

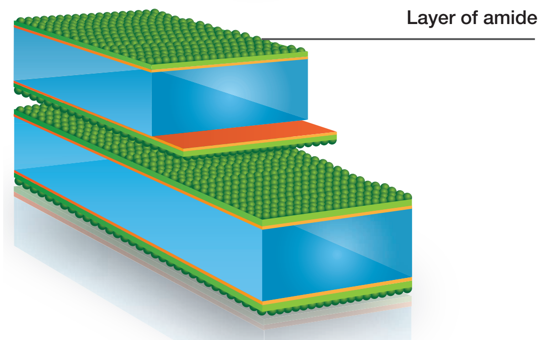
Most Optislip™ additives will improve blocking when used in combination with inorganic materials. Optislip BR additive is the most effective, migrating to form a continuous non-sticking layer. This allows lower levels of inorganic anti-blocking agent to be used, resulting in improved clarity. Optislip BR additive can be used in combination with Optislip ER additive, without increasing the total amide level, to give combined slip and anti-block performance.

Benefits

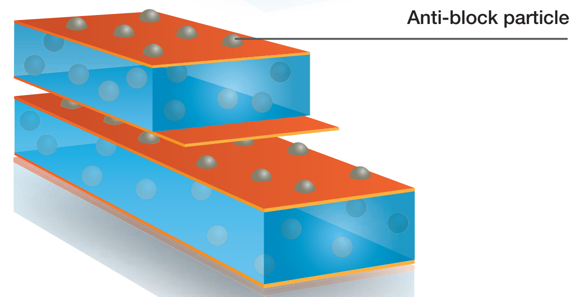
- High film clarity
- Low use levels (500 - 2000 ppm)
- Slipping or non-slipping solutions
- Synergy with inorganic anti-block additives



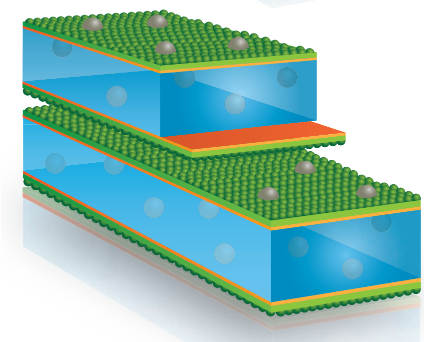
Film with low molecular weight polymer at the surface. Surface layer may comprise polymer and low molecular weight oligomers.



Low molecular weight material covered by a layer of amide.



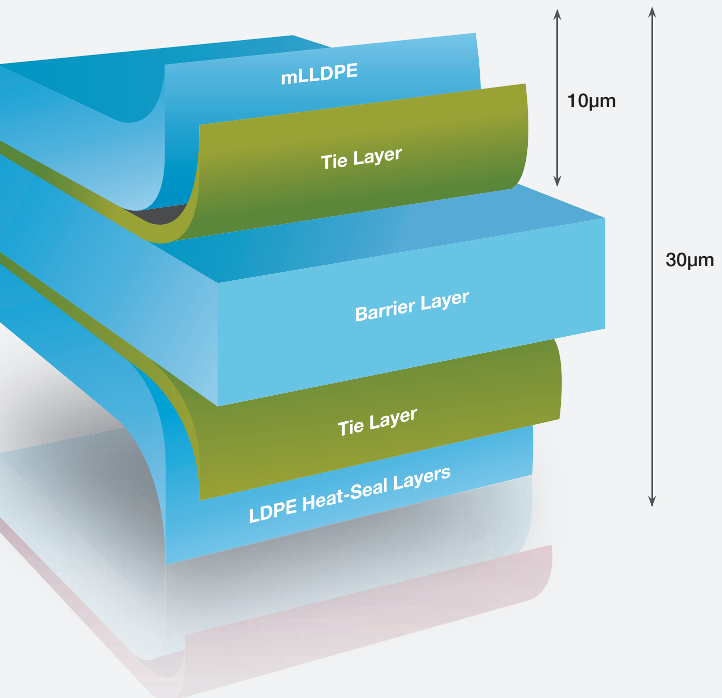
Film surfaces separated by inorganic anti-block.



Film with amide and inorganic anti-block. Used in combination the level of inorganic anti-block can be reduced, thus improving film clarity.

The customer selected 950 ppm of Optislip 203 additive for all future production, and over the following year achieved almost 50% reduction in out of spec film, and almost 100% reduction in film considered unsuitable for sale. An added benefit was the ability to formulate differential slip on the inside and outside of the film structure. It was also noted that Optislip 203 additive showed less tendency to off-set from one side to the other when the film was wound up on reels. A similar approach was taken when formulating a multilayer laminate film, and in this case Optislip 212 additive was found to give the most stable CoF.

Cross-section of multilayer co-extruded film

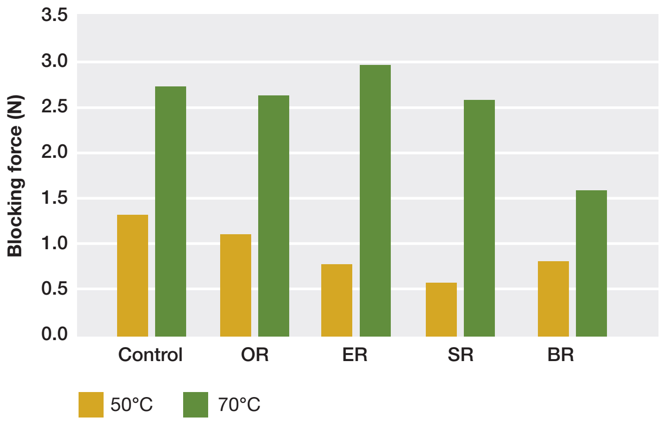


Key Applications

Blocking in Film

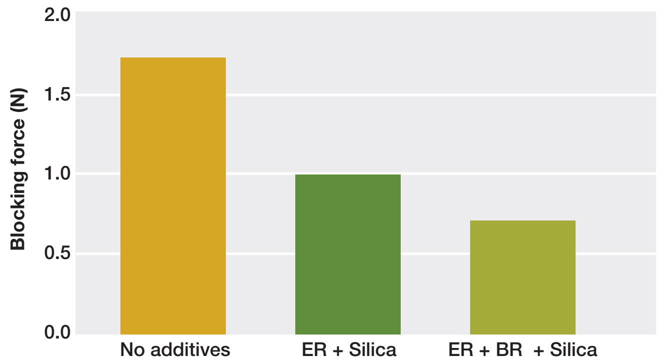
Figure 8 shows induced blocking whereby two pieces of film are placed together between two pieces of glass (100 x 100 mm) with a load of 7 kg. The samples are held at 50°C or 70°C for 24 hrs, cooled to room temperature for 24 hrs, and the force required to separate the two layers tested according to ASTM D3354. It can be seen that at 50°C Optislip™ ER additive gives quite a good anti-block performance, but Optislip SR additive is best overall. However, when the temperature is increased to 70°C, only Optislip BR additive gives a good result. Whilst good performance is seen with amides alone in film, we recommend that organic anti-blocking agents should be used to reduce the level of inorganic anti-block, rather than replace it entirely. The inclusion of an inorganic anti-block gives time for the organic anti-block to migrate to the surface.

8. *Comparative blocking performance of primary amides in LDPE at high temperature (40 μm blown film, 1000 ppm amide)*



Optislip BR additive can be used in combination with Optislip ER additive, without increasing the total amide level, to give combined slip and anti-block performance (figure 9).

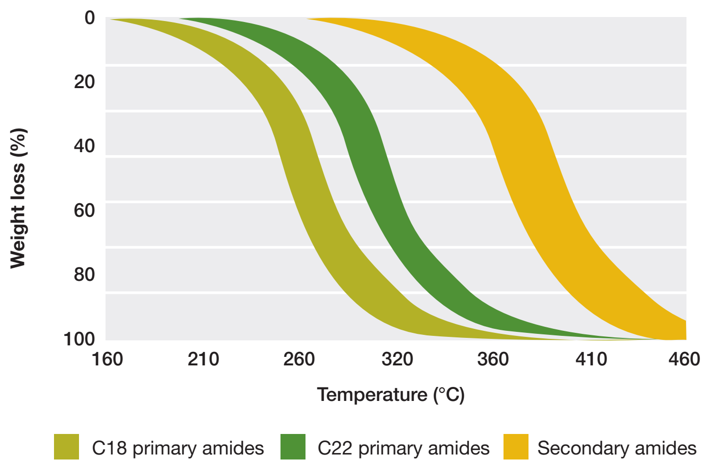
9. *Performance of Optislip ER & Optislip BR additives in combination with inorganic anti-block additive in coPP (30 μm cast film, 2000 ppm total amide content & 1000 ppm silica)*

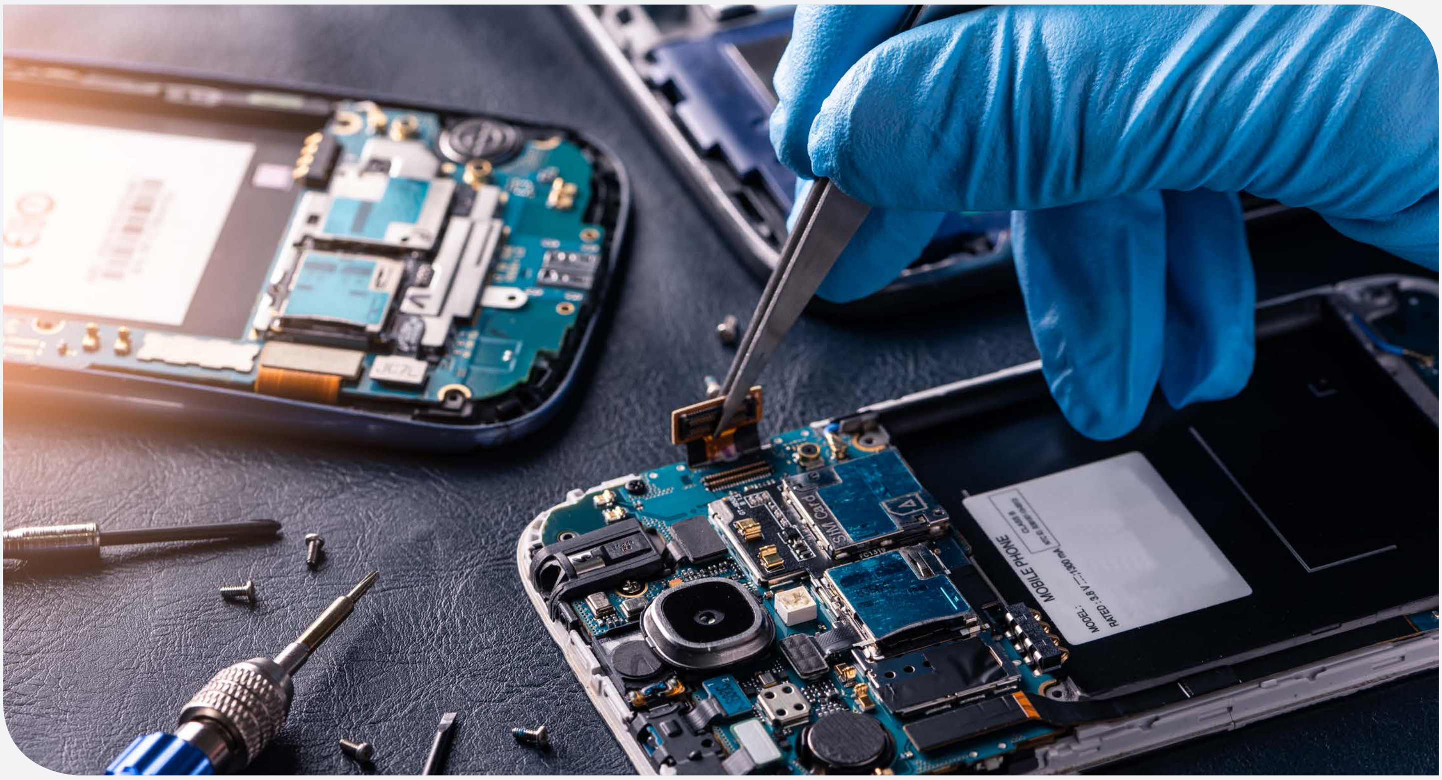


Thermal Stability of the Optislip Range

Based on the graph below we recommend that oleamides and stearamides are used up to 230°C, erucamides and behenamide are used up to 260-270°C and secondary amides may be used up to and in excess of 300°C. These recommended maximum processing temperatures are for guidance only and alterations may be necessary to compensate for residence time during processing.

10. *Thermogravimetric analysis: Weight loss ranges of Optislip product classes on heating*





Case Study

Pellet Anti-Tack Additive Solves Agglomeration Problem in Asia

A customer was using a combination of primary and secondary amides to improve the flowability of high vinyl acetate content EVA pellets (VA greater than 20%). The product worked well under normal conditions, however, at elevated temperatures in less temperate regions, such as Asia, they experienced numerous problems with polymers stored in silos or when transported in railcars. It became impossible to discharge the pellets due to excessive agglomeration. It was theorized that the amides resolubilized in the polymer surface and thus were rendered ineffective as surface lubricants.

The use of 0.2-0.5% Optislip™ EBO additive was recommended to enhance the flow of the pellets and reduce pellet blocking, under the widest range of conditions. This allowed continuous discharge from silos and railcars even after prolonged storage at temperatures in excess of 35°C. It was noted that there was no detrimental effect on the adhesive properties of the EVA in the end user application. The customer was able to optimize the additive level to use a lower quantity than in the original combination product. Optislip EBO additive can also be used in combinations with other additives to optimize pellet flow properties for polymers of differing compositions.

Optislip™ EBO additive acts as an effective pellet anti-tack for high VA content EVA. EVA uses include solar panel manufacture & hot melt adhesives.

Further Information

Cargill Bioindustrial sales and distribution are coordinated through an extensive worldwide network of technical and commercial experts. For further information or guidance please contact us:

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