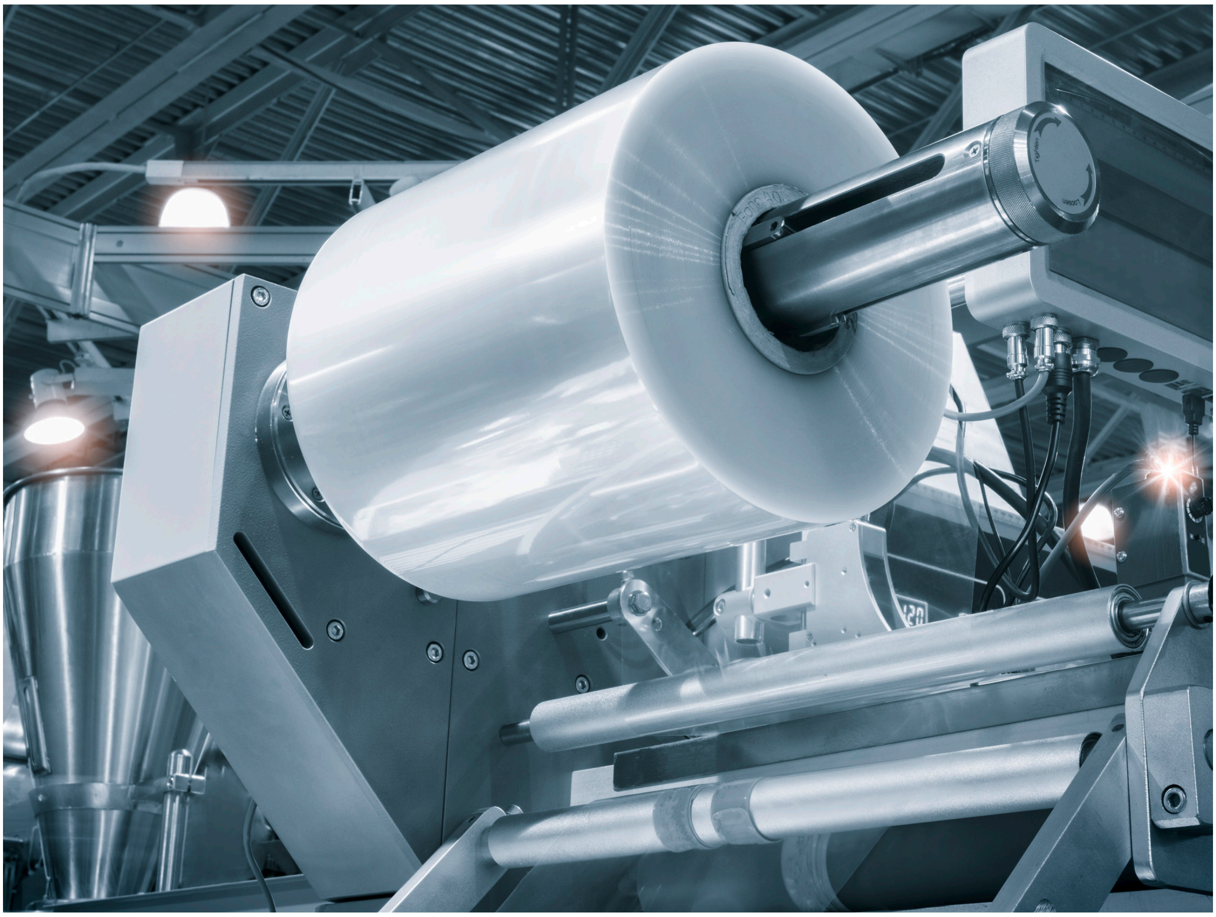
SIPERNAT® SPHERILEX® AEROSIL® AERODISP®

TECHNICAL INFORMATION TI1206

SILICA AS **ANTIBLOCKING AGENT** IN PLASTIC FILMS



Leading Beyond Chemistry

CONTENT

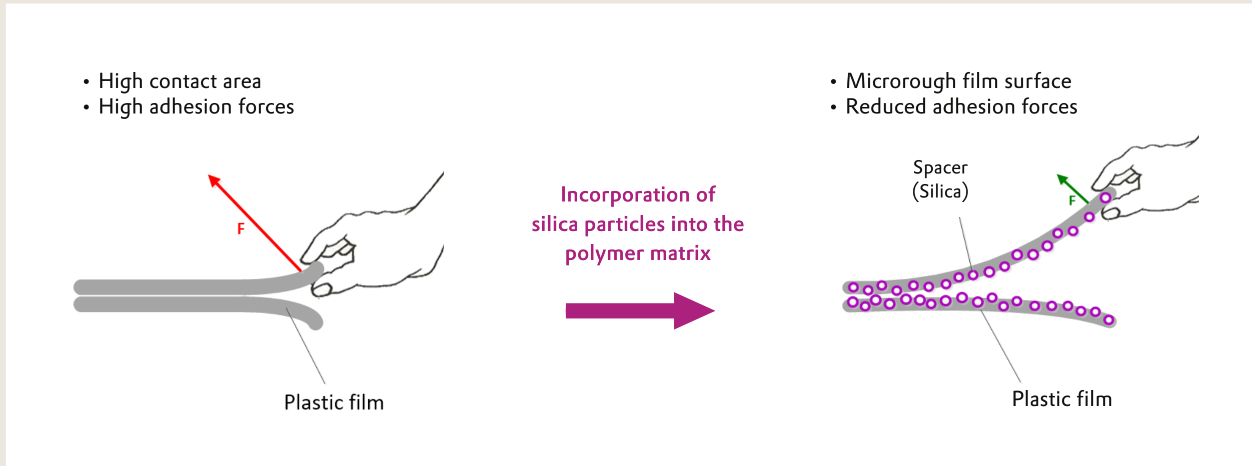
1. INTRODUCTION

Antiblocking agents are crucial additives used in the production and conversion of plastic films. They help facilitate smooth film winding operations, improve the handling properties of films during subsequent processing steps, and prevent films from sticking together during storage. As a result, they can also help to increase productivity on film processing and reduce the amount of waste generated.

Blocking of films is a common challenge in the plastics industry. It describes the adherence of two adjacent film layers, which arises from the appearance of strong van der Waals forces and electrostatic charging. Increased temperature and pressure during film processing further promote the blocking forces between the film layers.

By incorporating small amounts of fine-particle antiblocking silicas into the polymer, when they partially protrude from the film surface, causing a micro-rough surface and thus acting as spacers between different layers. This reduces the contact area and suppresses the adhesion of film layers. The principle of antiblocking agents is shown in **FIGURE 1**. The addition of antiblocking silicas to the polymer also reduces the friction of two film layers sliding on each other, which facilitates smoother winding processes during film production and minimizes blocking during film conversion processes. At the same time antiblocking agents should have little to no effect on other important film characteristics such as transparency, gloss and mechanical properties.

FIGURE 1: Principle of silica antiblocking agent



RESULT
- Improved winding process during film production
- Reduced blocking of films / film rolls after storage
- Reduced blocking during film conversion processes
- Improved handling of films during end use

2 MEASURING METHODS FOR **EVALUATION OF FILM BLOCKING**

2.1 Coefficient of Friction (COF)

The efficiency of antiblocking agents can be assessed by the determination of the Coefficient of Friction (COF) as the common test method in the industry. This method is easy to carry out and provides good reproducibility, which allows to uncover small differences in performance of antiblocking agents. The measurement procedure and a typical measuring device are shown in **FIGURE 2**. Two pieces of film are brought in contact and pressed to each other with a defined weight. One of the pieces of film is then moved and the frictional resistance to sliding is recorded. The COF is calculated as a ratio of the frictional force and the weight applied to the film. The value obtained gives an indication for the expected blocking behavior during film production, especially during film winding and converting processes.

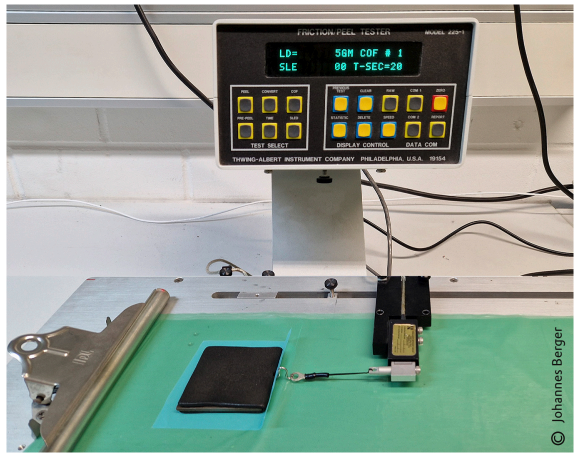


FIGURE 2: Measurement of the Coefficient of Friction of films

2.2 Blocking Force

Another test method to investigate the blocking behavior of films is the determination of the Blocking Force. In this case, two pieces of film that were pressed together are separated from each other in a vertical direction and the necessary maximum force is determined (illustrated in **FIGURE 3**). Before the measurement can be carried out, it is required to first precondition the film pieces by pressing them together for a certain time at defined pressure and temperature. The selection of appropriate parameters depends on the specific film polymer, film formulation and film thickness. Although this method provides useful insights, it is relatively complex and can suffer from poor reproducibility. That is why the determination of the coefficient of friction is the more commonly used measuring method in the film industry.

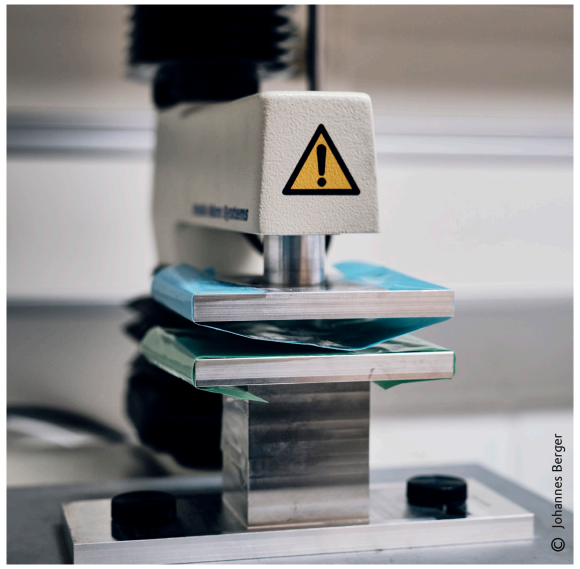


FIGURE 3: Measurement of the Blocking Force

3 **ANTIBLOCKING AGENTS** FROM EVONIK

Evonik is the only global producer offering both precipitated and fumed silicas as antiblocking agents for polymer film production. Precipitated antiblocking silicas are marketed under the brand names SIPERNAT® and SPHERILEX®, while fumed silicas are available under the AEROSIL® brand. Additionally, AERODISP® dispersions of fumed silicas can be used in specific film applications and can either be added in polymer synthesis or used to coat the final film surface. Our antiblocking agents have been successfully used in the film industry for decades, providing specific advantages across various of film types such as PE, PP, PET, PA and PVC films.

KEY BENEFITS OF SIPERNAT® AND SPHERILEX® ANTIBLOCKING AGENTS:

- Efficient antiblocking, enabling superior coefficients of friction (CoF)
- High film transparency (low Haze)
- Narrow particle size distribution of the silica and low wet sieve residues
- Favorable processibility through easy dispersibility in the polymer matrix
- High masterbatch loading capacity
- Excellent compatibility with other film additives, especially slip agents

3.1 SIPERNAT® antiblocking agents

In the family of the SIPERNAT® precipitated silica products as well as alumina and calcium silicates, SIPERNAT® 44 MS and SIPERNAT® 310 are well established antiblocking agents that have been successfully used in the film industry for a long time. Their main application is in cast and blown films of PE, PP and PVC. SIPERNAT® 44 MS is a synthetic zeolite of high purity. Due to its very small particle size and narrow particle size distribution, it is particularly suitable for thin and oriented film applications, where high transparency is the key. Its high bulk density enables easy handling during conveying and dosing in thermoplastic compounding processes, allowing for high loading of antiblocking masterbatches (up to concentrations of 30 - 40 wt-% in PE masterbatch). Based on its low specific surface area and compact particle structure, it exhibits very good wetting behavior with polymer melts and achieves superior dispersion quality that ensures high optical film quality. SIPERNAT® 310, on the other hand, is a precipitated silica which has larger particle size, higher specific surface area and higher oil absorption in comparison to SIPERNAT® 44 MS. The primary strength of SIPERNAT® 310 is its outstanding antiblocking efficiency, making it ideal for PE, PP and PVC films with medium to larger film thicknesses, where efficient antiblocking is the key. **FIGURE 4** and **FIGURE 5** illustrate a comparison of SIPERNAT® 44 MS and SIPERNAT® 310, highlighting their effects on the coefficient of friction and haze of polyolefin films containing the antiblocking silicas.

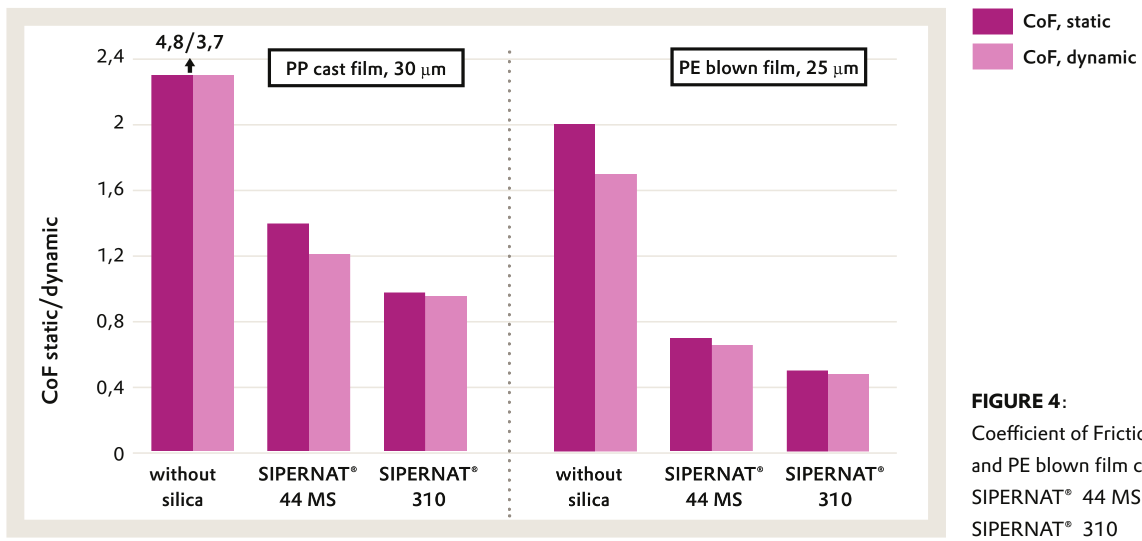


FIGURE 4: Coefficient of Friction of PP cast film and PE blown film containing 0,1 % SIPERNAT® 44 MS and SIPERNAT® 310

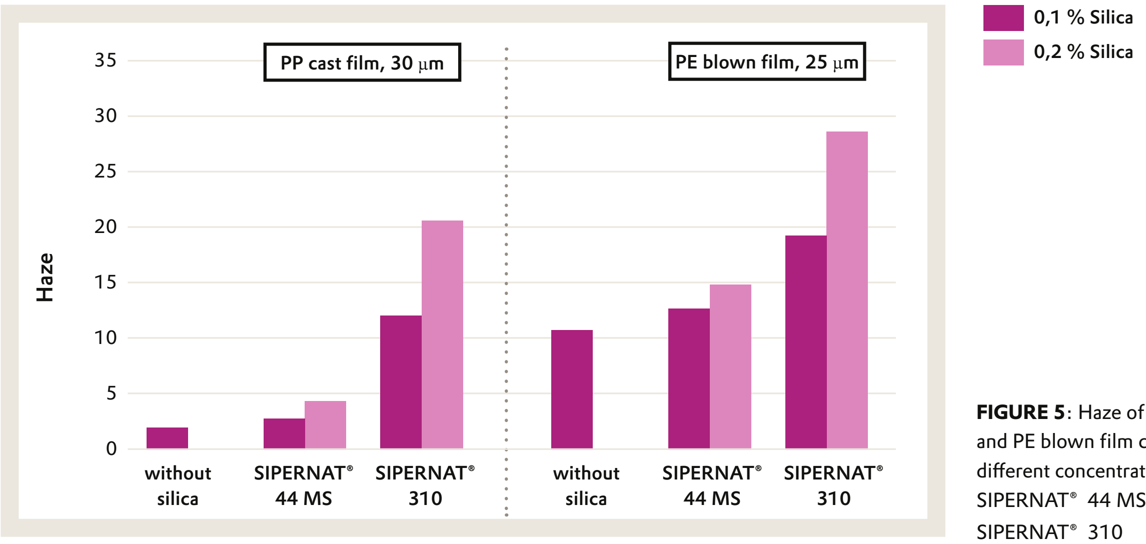


FIGURE 5: Haze of PP cast film and PE blown film containing different concentrations of SIPERNAT® 44 MS and SIPERNAT® 310

3.2 SPHERILEX® antiblocking agents

The SPHERILEX® brand features antiblocking agents developed through an innovative precipitation process, characterized by an almost ideal spherical particle shape and tight particle size distribution. Evonik offers two standout products: SPHERILEX® 30 AB and SPHERILEX® 60 AB which are characterized by a high powder density and favorably low oil absorption properties.
This unique combination of product features offers significant benefits, especially when used as antiblocking agent in blown and cast films made from materials such as polyethylene (PE), polypropylene (PP), polyethylene terephthalate (PET), and polyamide (PA). **FIGURE 6** shows SEM micrographs that illustrate the particle morphology of SPHERILEX® 60 AB.

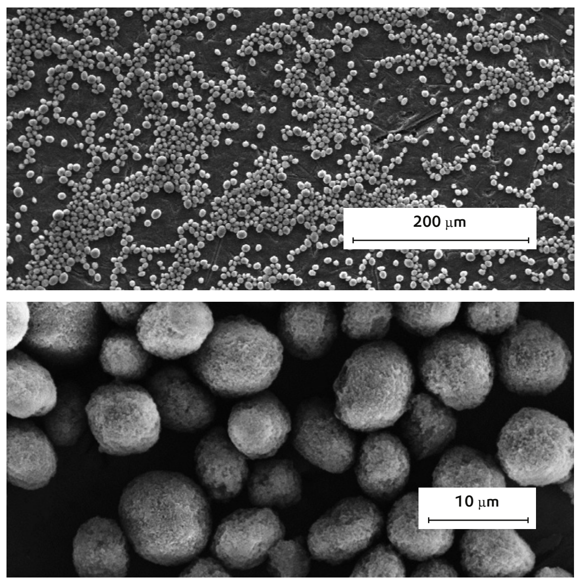
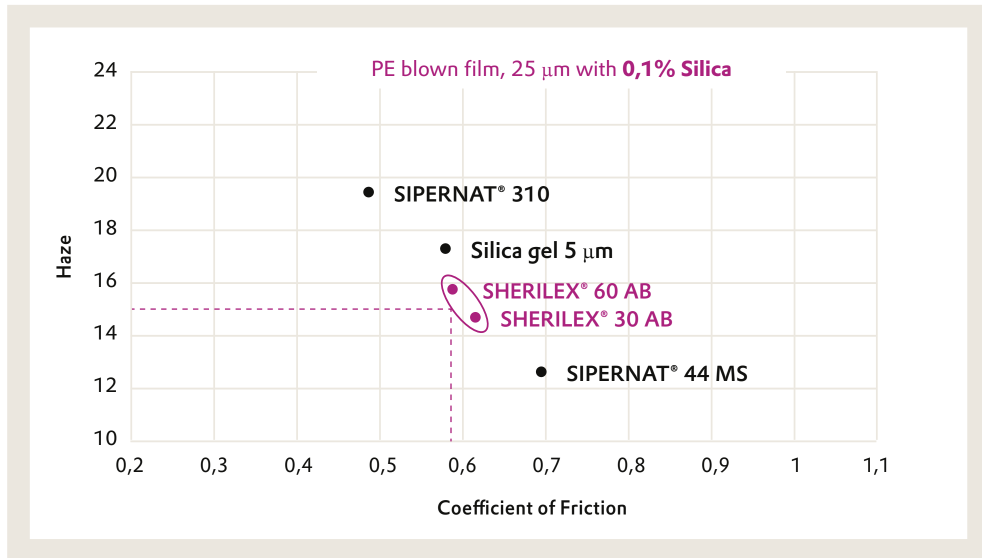
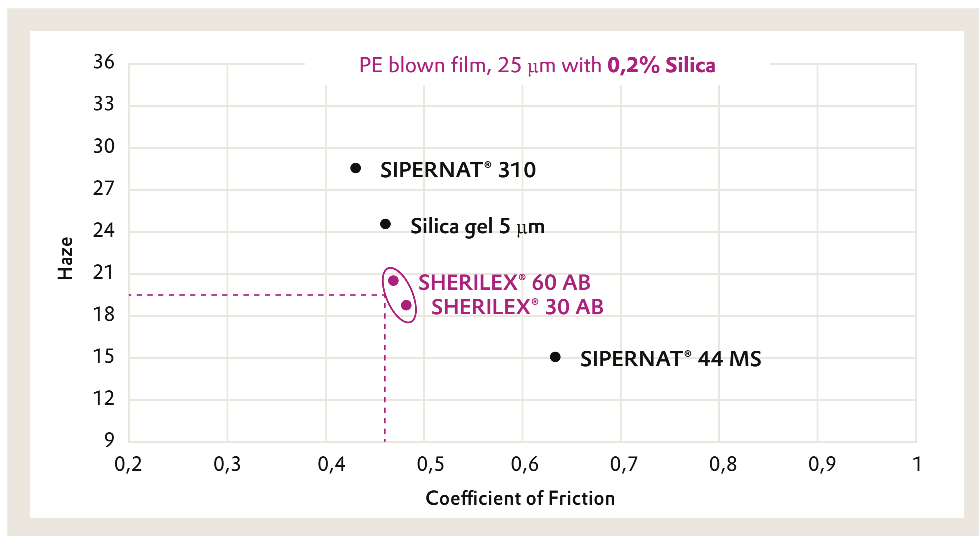


FIGURE 6: SEM micrographs of SPHERILEX® 60 AB at different magnifications

3 **ANTIBLOCKING AGENTS** FROM EVONIK

The main difference between the two SPHERILEX® antiblocking grades is their average particle size, whereas their other characteristics remain very similar.
SPHERILEX® 60 AB (particle size about 6 µm) was developed for standard cast and blown film based on PE and PP, whereas SPHERILEX® 30 AB (particle size about 4 µm) is specially designed for thin film and biaxially oriented film applications of PP, PET and PA. Both grades offer an excellent combination of low coefficient of friction and high film clarity (low haze). The good balance between these two key properties in antiblocking application is shown in **FIGURE 7** and **FIGURE 8**.





FIGURES 7 AND 8: Balance of antiblocking performance (Coefficient of Friction) and Haze for SPHERILEX® and SIPERNAT® antiblocking agent and a competitor silica gel

3 **ANTIBLOCKING AGENTS** FROM EVONIK

3.3 Typical physicochemical data of SIPERNAT® and SPHERILEX® antiblocking silicas

TABLE 1 provides an overview of SIPERNAT® and SPHERILEX® antiblocking silicas, which Evonik offers to the film industry. It lists important physicochemical properties of the silicas for this application. The influence of these properties on their effectiveness in antiblocking masterbatches and film applications has already been described earlier.

3.4 Product recommendations for different polymer grades and film systems:

Product recommendations for the use of Evonik antiblocking agents in specific film applications are provided in **TABLE 2**. These specifications highlight the preferred areas of application for each silica grade in film applications, but are not limited to the areas of application mentioned. For tailored recommendations of our products suited to your specific film application, our application technology experts are available to assist you.

TABLE 1: Characteristic physicochemical data

Product	Particle size(1 (d_{50})	Sieve residue(2 > 25 µm Mocker	Sieve residue(3 > 45 µm spray	Specific surface area(4 (N_2)	DOA absorption(5	Tamped density(6
Units	[µm]	[%]	[%]	[m^2/g]	[ml/100g]	[g/l]
SPHERILEX® 30 AB	4.0	< 0.01 %	-	100	85	490
SPHERILEX® 60 AB	5.7	< 0.01 %	-	100	85	510
SIPERNAT® 44 MS	3.0	-	≤ 0.01	5	55	550
SIPERNAT® 310	8.5	-	≤ 0.02	700	265	95
SIPERNAT® 500 LS	10.5	-	≤ 0,1	500	270	100

The given data are typical values. Product Specifications are available on request.

(1 Laser diffraction, following ISO 13320
(2 following ISO 787-18
(3 following ISO 3262-19
(4 Multipoint, following ISO 9277
(5 Dioctyl adipate absorption, following ISO CD 19246
(6 following ISO 787-11

TABLE 2: SIPERNAT® and SPHERILEX® antiblocking silica for polymer films

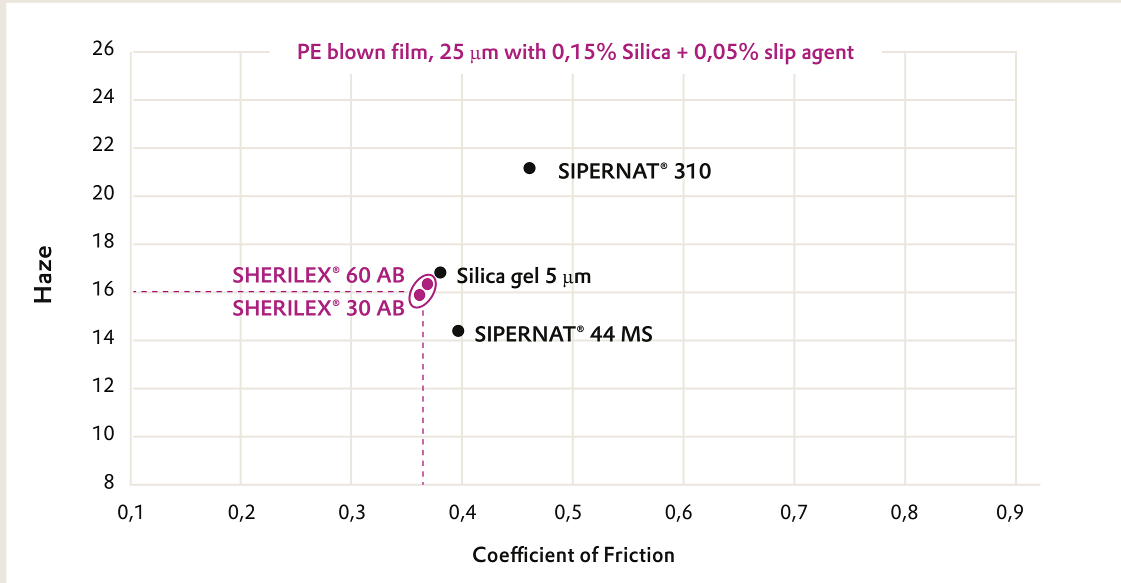
Film systems	SPHERILEX® 30 AB	SPHERILEX® 60 AB	SIPERNAT® 44 MS	SIPERNAT® 310	SIPERNAT® 500 LS
PE film, standard		X		X	X
PE film, high clarity	X		X		
PP film (CPP, IPP)	X	X	X	X	
BOPP film	X		X		
PET film	X	X			
PA film	X				
BOPET, BOPA	X				
PVC, calendered		X		X	X

4 COMBINATION OF **ANTIBLOCKING AGENTS** AND OTHER **FILM ADDITIVES**

Depending on the specific application and requirements for plastic films, different additives can be used alongside antiblocking agents. These include processing stabilizers, UV stabilizers or slip agents. Slip agents help to further reduce the coefficient of friction and can be used in combination with antiblocking silicas. Typically slip agents are based on fatty acid amides, which are incorporated into the film matrix and gradually migrate to the film surface in a time-dependent manner. It is therefore important that these agents are minimally absorbed by the antiblocking agent to ensure they can perform effectively and develop their desired effect. SPHERILEX® 30 AB, SPHERILEX® 60 AB, and SIPERNAT® 44 MS are designed to minimally absorb other film additives, thanks to their low specific surface area and oil absorption, enhancing their compatibility and performance in film applications.

FIGURE 9 shows the resulting properties of a PE blown film when using different antiblocking silicas in combination with a slip agent. Notably, the SPHERILEX® products achieve both low coefficient of friction and high film transparency (low haze value).

FIGURE 9: SPHERILEX® 30 AB and SPHERILEX® 60 AB provide excellent balance of low Haze and low CoF in PE blown film containing additionally slip agent



5 INCORPORATION AND DISPERSION OF **ANTIBLOCKING SILICAS** IN THE **POLYMER RESIN**

Antiblocking silicas can be added to the film polymer by using different technologies, which can depend on the specific polymer grade and the processing step when the antiblocking silica is incorporated into the polymer matrix. The most common way is to prepare an antiblocking masterbatch with higher silica concentration and to subsequently dilute the masterbatch during the film manufacture to the required silica amount. The quality of silica dispersion in the polymer matrix is a crucial factor. It does not only influence the resulting antiblocking performance, but also affect the optical properties of the final plastic film. Insufficiently dispersed silica particles can lead to undesirable film defects such as speck formation. They can also cause clogging of filter screens applied during masterbatch production or final film production. Regardless how the antiblocking agent is introduced into the polymer matrix (e.g. masterbatch/compound manufacture, use of powder mixtures or incorporation before the polymer synthesis), the compounding equipment and applied shear energy affect the achievable dispersion quality. Generally speaking, high shear mixing processes are required to achieve good dispersion quality of the antiblocking silica in the polymer matrix and final plastic film. Suitable processing equipment includes twin screw extruders, Banbury kneaders or other thermoplastic kneading systems. Additionally the physicochemical characteristics and dispersion behavior of the silica have an important influence on the achievable dispersion quality. A low or moderate specific surface area and oil absorption of the silica are favorable to achieve high dispersion quality by enhancing the wettability of the particle surface with the polymer melt and by lowering the impact on the rheology. High bulk density of the silica help achieving high loading concentrations of silica during masterbatch production. SPHERILEX® 30 AB, SPHERILEX® 60 AB and SIPERNAT® 44 MS offer exactly these physicochemical characteristics and are therefore easy to disperse and can be used in high masterbatch concentrations. Another important attribute of antiblocking agents for achieving high optical film quality is a very low coarse material content in the starting product. One measure of this is the wet sieve residue of the silica (> 25 µm / > 45 µm). In this respect, SPHERILEX® 30 AB, SPHERILEX® 60 AB and SIPERNAT® 44 MS exhibit extremely low values.

6 **AEROSIL®** AND **AERODISP®** PRODUCTS FOR THE USE AS **ANTIBLOCKING AGENTS**

In specific film applications requiring outstanding transparency of the film or very high purity of the silica, our customers benefit by the specific product features of AEROSIL® fumed silica products. Typical areas of application are very thin biaxially oriented PET or PA films (BOPET, BOPA), commonly used in the packaging industry as well as in optical, electrical and electronic applications. Here the fumed silica particles are incorporated into extremely thin outer film layers with a thickness of only a few microns. When well dispersed into the polymer matrix, AEROSIL® particles are predominantly present in the submicron range, reducing their impact on film transparency to a minimum. Best performing products in those applications are AEROSIL® OX 50 and AEROSIL® TT 600. Additionally, both products are also available as ethylene glycol based dispersions AERODISP® G 1220 and VP Disp. G 6020 X , which contain the silica particles already in a well dispersed form using high-shear mixing equipment. These AEROSIL® and AERODISP® products can be incorporated into antiblocking masterbatches or added during the polycondensation process of the PET film polymer. In specific cases, our AEROSIL® and AERODISP® products are also used in coating formulations, which are applied to the film surface to achieve an antiblocking effect.

7 **REGULATORY**

SIPERNAT®, SPHERILEX® and **AEROSIL®** products mentioned in this technical information are compliant for use in food contact articles under EU Regulation 10/2011 and as indirect food additive in accordance to U.S. regulations 21 CFR, part 175 – 177. More detailed information regarding food contact suitability and further regulatory information, please refer to the Product Safety Information (PSI) of the respective Evonik product.

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