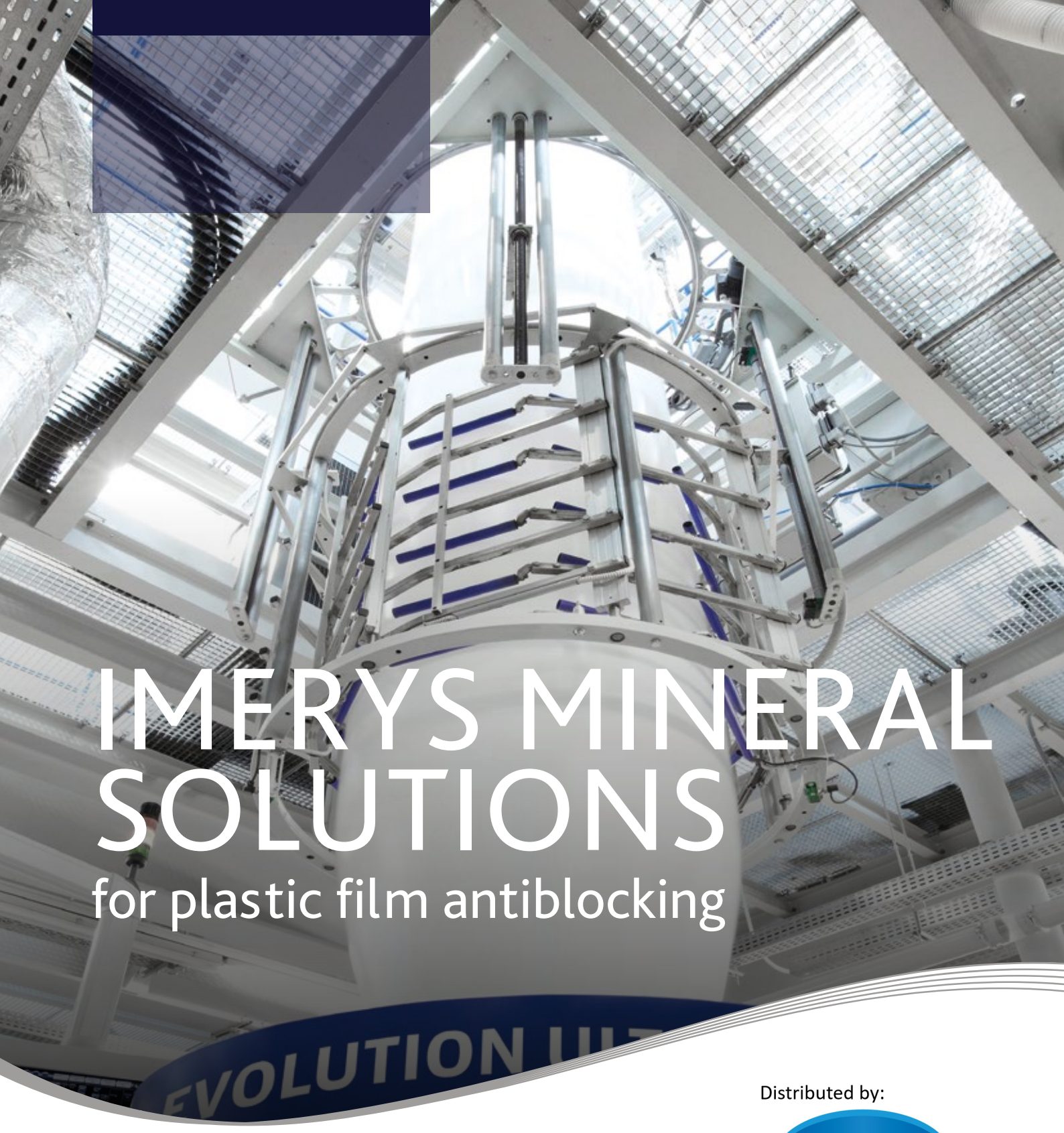

IMERYS MINERAL SOLUTIONS

for plastic film antiblocking

- Superior film clarity and haze
- Excellent antiblocking and COF
- Optimum mechanical and impact strength
- Good cost / performance balance
- Low abrasion mineral

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IMERYS

Performance Additives

INTRODUCTION

Plastic film blocking is a common occurrence during film production, converting and end use. It results in the adhesion of adjacent film layers to each other rendering their separation difficult.

Polyethylene (PE) is one of the most widely used polymers and PE films are the most common in packaging applications. PE is relatively easy to process although thin films do have a tendency to stick to each other when pressed tightly together or wound onto a core.

This tendency to block increases with the presence of low molecular weight molecules on the surface of the film. Temperature, film winding pressure, and smoothness of the film surface also play a part.

Bright, finely ground minerals with an irregular particle shape are commonly used as anti-block additives to reduce blocking force, a measure of film-to-film adhesion. Anti-block minerals work by generating a micro-roughness that limits the contact between adjacent film surfaces, thereby reducing blocking force.

Anti-block minerals must also provide a good overall balance of optical and mechanical film properties. Other important properties are lowest possible plastic additives adsorption on the mineral surface, low hardness and low yellow index.
For high transparency films, the mineral's refractive index must closely match that of the polymer and particle size distribution is also key in minimising light scattering.

Table 1. Refractive index n_D^{20} of polyolefins and antiblocking additives

	n_D^{20}
HDPE	1.54
LDPE	1.51
LLDPE	1.51
PP isotactic	1.49
PP random copolymer	1.50
Talc	1.54-1.60*
Synthetic silica	1.46
Flux calcined DE	1.48
Calcined clay	1.56

* different room directions

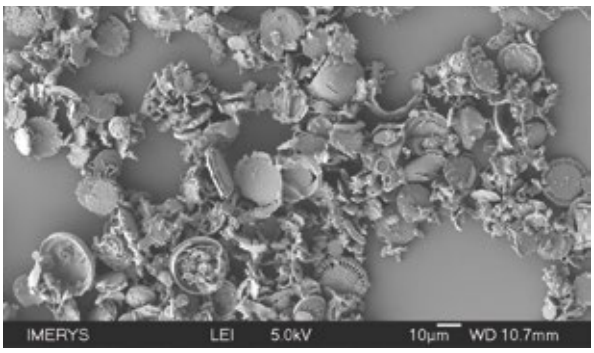
Different doses of anti-block additives, ranging from 500 to 10,000ppm addition rates, are required depending on film grade, the additives used, film thickness and extrusion conditions.

The anti-block agent is either introduced as a dry additive or in a chemical additive blend (Onepack) after resin polymerisation or in the form of a compound or master-batch by the film producer.

IMERYS MINERALS FOR ANTI-BLOCKING

Diatomaceous earth
Diatomaceous earth (DE) consists of fossilised remains of diatoms, a type of hard-shelled algae. It is a naturally occurring amorphous silica which is mined like a mineral.

Figure 1. SEM of diatomaceous earth



Best overall performance in plastic films is achieved with flux calcined DE. Calcination is heat treatment to above 1000°C which changes the mineralogy and morphology of the mineral and imparts excellent anti-block properties.

Flux calcined DE is used as an anti-block agent thanks to its very irregular shaped particles which provide fewer film surface contact points and, therefore, very low blocking force.

Talc

Talc is a naturally occurring hydrated magnesium silicate. Compared to other minerals, talc is very soft (Mohs hardness = 1) and therefore minimises abrasion on polymer processing equipment.

Mistroblock® talc is based on unique micro-lamellar talc ore which provides the film with better mechanical properties than any other anti-block mineral and better optical properties than conventional, lamellar talc ore. Unlike conventional talc morphology, special micro-lamellar talc is composed of conglomerates of block-like shaped particles with a high specific surface area.

Figure 2. Conventional lamellar talc

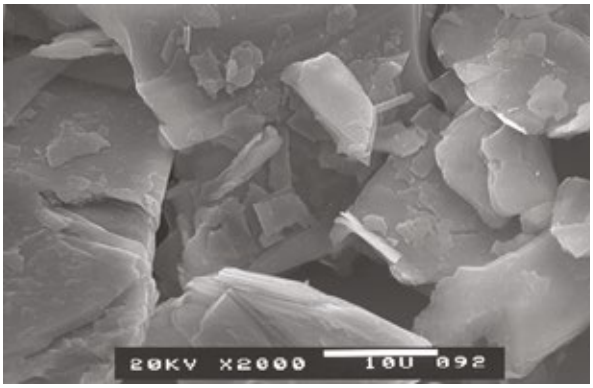
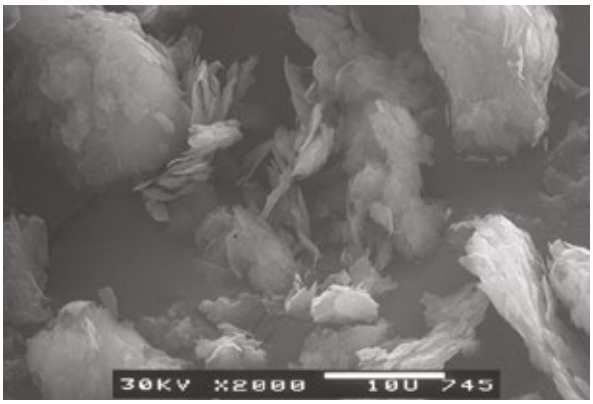


Figure 3. Micro-lamellar Mistroblock®



BALANCE OF OPTICAL PROPERTIES AND ANTI-BLOCKING PERFORMANCE

Whilst the film haze level is comparable to other anti-block minerals tested, at an equivalent addition rate, the calcined DE grade Celite® 263 LD provides much better anti-block properties in PE film. Consequently, the incorporation rate of Celite® 263 LD can be decreased from 4500 to 3000ppm in 30µm HAO LLDPE blown film, resulting in lower film haze and higher clarity whilst maintaining anti-block performance.

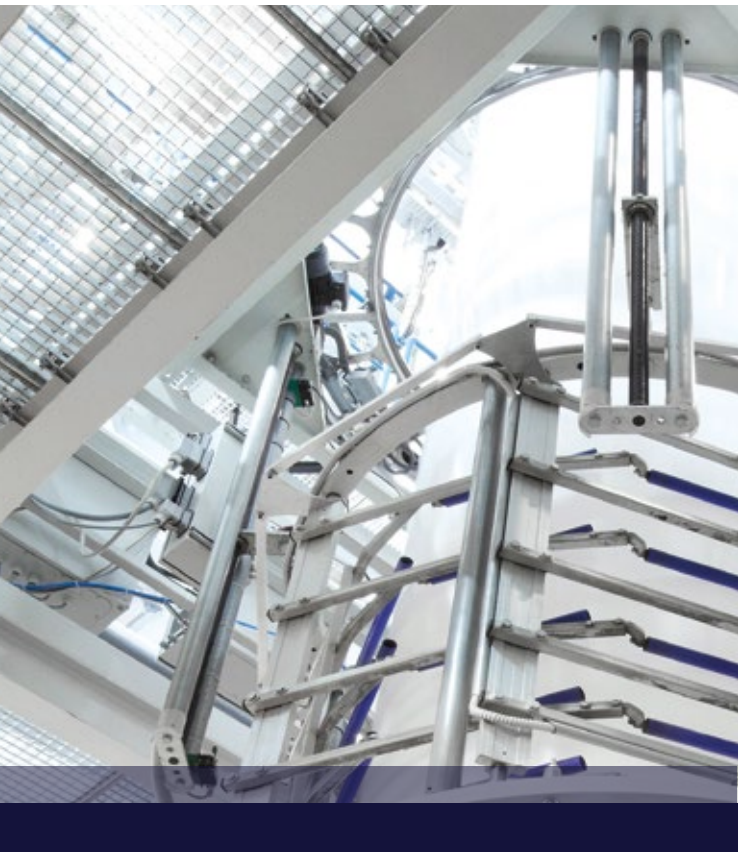
Table 2. Comparison of antiblocking minerals in LLDPE blown film

	Pure LLDPE	Celite® 263 LD	Celite® 263 LD	Mistroblock®	Polestar® 200R
Mineral content [ppm]	0	4500	3000	4500	4500
Reblocking force [gf]	104	35.6	75.2	86.5	81.8
Haze [%]	3.87	8.94	7.03	8.52	9.04
Clarity [%]	99.5	90.3	96.9	94.8	95.4

Due to their intrinsically higher film surface roughness and resin crystallinity, certain metallocene LLDPE resin grades perform better mechanically and show less tendency to block at higher film haze values. Talc or talc blends with other minerals are often used with these resins. Trials with 25µm blown films produced from metallocene hexene copolymer LLDPE film containing 2000ppm anti-block mineral showed that Mistroblock® talc provides better overall optical properties than any other commercially available talc grade tested and gave higher film clarity than precipitated silica.

Table 3. Talc performance in metallocene LLDPE copolymer containing 2000ppm of antiblock mineral

	Pure LLDPE	Talc A	Talc B	Talc C	Talc D	Talc E	Mistroblock®	Precipitated silica
Haze [%]	12.0	13.3	13.7	14.2	13.3	12.9	12.3	12.1
Clarity [%]	98	94	91	94	95	95	95	92



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MECHANICAL FILM PROPERTIES

Current trends are towards thinner films and faster production cycles. This means producers have to ensure that their film grades maintain required tensile strength and impact properties at lower film gauge. Furthermore, surface friction has to be as low as possible for easy processing and film end-use.

Coefficient of friction

The extent of film surface friction can be expressed by dimensionless coefficient of friction (CoF). Long chain, linear fatty acid amides, such as erucamide or oleamide, are usually added as slip additives to the film formulation in order to reduce friction force. Imerys antiblocking minerals show low interaction with slip additives and allow their unhindered migration to the film surface.

Table 4. Coefficient of friction of 30µm LLDPE blown film containing 4500ppm of antiblock mineral and 2250ppm of slip additive

Coefficient of friction	Pure LLDPE + slip addtive	Celite® 263 LD	Talc/feldspar mineral	Mistroblock®	Polestar® 200R
Static	0.77	0.69	0.69	0.64	0.67
Dynamic	0.41	0.42	0.42	0.42	0.41

Compared to other anti-block minerals, Mistroblock® provides the best mechanical properties in high performing polyethylene film, such as dart drop impact and puncture resistance, as well as tensile strength.

Figure 4. Dart drop impact resistance of 25µm m-LLDPE film containing 750ppm of erucamide and 2000ppm of different antiblocking minerals

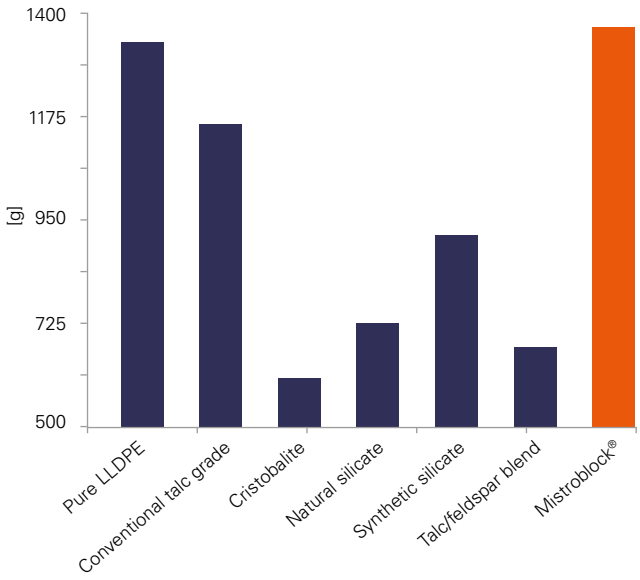

Table 5. Puncture and tensile tests performed at low test speed

	Pure LLDPE	Mistroblock®		Talc / feldspar		Commercial reference 1	Commercial reference 2
Mineral addition rate [ppm]	0.77	2500	5000	2500	5000	2500	5000
Max. puncture force [N]	67	72.6	60.5	59.8	54.1	54.7	48
Total puncture energy [J]	6.1	6.04	4.3	4.0	3.5	3.7	3.0
Elongation at max. puncture force [mm]	150	146	122	117	109	116	107
Tensile strength MD [MPa]	49.8	52.9	53.7	45.4	44.9	46.8	49.7
Elongation at break MD [%]	546	546	563	532	542	546	570

CONCLUSION

Imerys flux calcined diatomite Celite® 263 LD provides outstanding film anti-block performance compared to the other minerals tested. By virtue of the low blocking force it generates in plastic films, the addition rate of Celite® 263 LD for an equivalent anti-blocking force can be reduced, thereby increasing film clarity and reducing haze.

Imerys Mistroblock® talc provides best mechanical properties in high-performing polyethylene film together with good anti-block performance. The optical film properties it imparts are much better than those of other talc grades at comparable fineness of grind. Mistroblock® talc is the least abrasive of all anti-block minerals.

All Imerys anti-block minerals are approved without limitation for food-contact approved plastics formulations.

RECOMMENDED PRODUCTS

Celite® 263LD flux calcined diatomaceous earth: best anti-blocking performance for low haze LDPE and LLDPE films.
Mistroblock® and compacted **Mistroblock® C** talcs: best mechanical film properties together with good clarity and low abrasiveness for high performing metallocene LLDPE films.

MATERIALS AND METHODS

Materials used

- Exceed 1018CA: metallocene hexane copolymer LLDPE from Exxon Mobil, MI = 1 (190°C, 2.16kg), density = 0.918 g/cm^3
- LDPE LD 150 BW from Exxon Mobil, MI = 0.75 (190°C, 2.16kg), density = 0.923 g/cm^3
- A mixture of Exceed 1018CA/LD150BW = 9/1 was used, ground on a Powder King pulveriser mill
- Dowlex NG 5056G: HAO LLDPE, MI = 1.1 (190°C, 2.16kg), density = 0.919 g/cm^3
- Armoslip E: high quality erucamide from AkzoNobel
- Irganox 1076 and Irgafos 168 from BASF/CIBA

Methods

Preparation of recipes

- Exceed 1018CA/LD 150BW: Powder blends of LLDPE/LDPE = 9/1, slip additive, anti-block mineral, antioxidant and phosphite were prepared in a 6 liter twin shaft paddle lab mixer.
- Dowlex NG 5056G was used in commercially available granule form; other ingredients were added as a 10% masterbatch.

Compounding
The Exceed 1018 CA powder blend recipes were compounded under nitrogen atmosphere on a super-cleaned Prism TS 24 twin screw compounding extruder (L/D 28) employing a flat temperature profile of 200°C, 300rpm screw speed and an output of 4kg/h.
20% mineral containing Dowlex NG 5056 compounds were produced and consecutively diluted down to 10% mineral content on a super cleaned Coperion ZSK 18 ML twin screw extruder with a temperature profile of 160-205°C, 900rpm screw speed and an output rate of 7.2 kg/h.

Film extrusion
Blown 25µm Exceed 1018 CA monolayer film was produced on a super-cleaned Dr. Collins laboratory blown film extrusion line. Screw diameter was 25mm; screw speed 70 rpm. The die diameter was 50mm and the die gap 1.5mm. A temperature profile from 205-210°C was used; take off speed was 4.5m/min, output 3.4kg/h.
30µm blown monolayer Dowlex NG 5056 film was produced at a screw speed of 75 rpm. The die diameter was 60mm and the die gap 0.8 mm. A temperature profile from 190-235°C was used; take off speed was 7m/min, output 6kg/h.

Film evaluation
Tensile test ASTM D-882
- Test speed: 500mm/min
- Sample width: 25mm
- Grip distance: 50mm
- Hounsfield tensile test machine

Dart drop ASTM D-1709
- Staircase technique method A
- Davenpost Model C

Reblocking force ASTM D-3354
- Artificial blocking 50°C/5kg/24h
- Kayness D-9046 block tester

Coefficient of friction ASTM D-1894
- Test speed 150mm/min
- Inside/outside
- Hounsfield tensile test machine

Haze, transmittance ASTM D-1003, clarity ASTM D-1746
- BYK Gardner, Haze-gard Plus

Puncture test ASTM D-5748
- Test speed 250mm/min
- Hounsfield tensile test machine

ABOUT IMERYS

Imerys is the world leader in mineral-based specialty solutions for industry. We transform a unique range of minerals to deliver functional specialty solutions that are essential to customers' products and manufacturing processes. With 300 scientists, eight research and technology centres, 21 market-focused regional laboratories and close ties with renowned research institutes, we lead the way in engineering minerals for industry.

ABOUT PERFORMANCE ADDITIVES

Performance Additives is a division of Imerys. With over a hundred years' experience in the minerals business, we offer customers engineered solutions derived from our portfolio of diatomite, mica, perlite, talc and wollastonite. We refine and engineer these minerals through various—often proprietary—processes that influence their concentration, size, shape, structure and surface chemistry to obtain the exact properties our customers require. Each year, we process thousands of tons of materials to the highest standards of quality, consistency and reliability.

Our polymers team has in-depth knowledge of polymer processing and of how minerals interact in polymers and a proven track record for developing new, value-added solutions for customers. Our product and applications laboratories are equipped with a full range of analytical and polymer-specific equipment enabling us to spearhead applications innovation as well as to provide customers with bespoke formulation services and technical support.

DELIVERING THE GOODS

With production sites in Australia, Belgium, Canada, France, Italy, Japan, Mexico, Spain and USA we are able to provide customers with optimised logistics and costs. Our sales administrators organise the optimum transport, warehousing and product delivery form to meet our customers' specific needs.

MEETING TODAY'S NEEDS, SECURING TOMORROW'S

We believe that running a successful business and sustaining quality of life and the environment go hand in hand. From implementing behaviour-based safety training to rehabilitating the land, we think it's important that future generations' needs are not compromised by our actions today.

OUR FUNDAMENTAL SUSTAINABILITY PRINCIPLES

- SAFETY - We promote the health and safety of employees, contractors, customers, neighbours and consumers through active caring.
- PARTNERSHIP - We seek to understand the issues that are important to our neighbours, and to make a lasting contribution to the communities in which we operate.
- ENVIRONMENTAL PROTECTION - We work to minimise our environmental footprint by using natural resources efficiently, preventing pollution, complying with applicable laws and regulations and continually improving our performance.
- ACCOUNTABILITY - We conduct business in an accountable and transparent manner, relying on external auditing and reporting to understand and reflect our stakeholders' interests.
- PRODUCT STEWARDSHIP - We are committed to ensuring that our products are safe for people and the environment, employing best available technology and following best-in-class procedures to ensure that our standards and practices meet or exceed safety requirements everywhere we do business.

We conduct life cycle assessments (LCA) at all our operations to quantify the environmental effects associated with producing our products from the mine to factory gate, and to identify areas for improvement. Likewise, we compile life cycle inventories (LCI) of the energy consumption, materials used and emissions generated by each of our product ranges. These LCI can be made available to customers and research institutions on request.

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