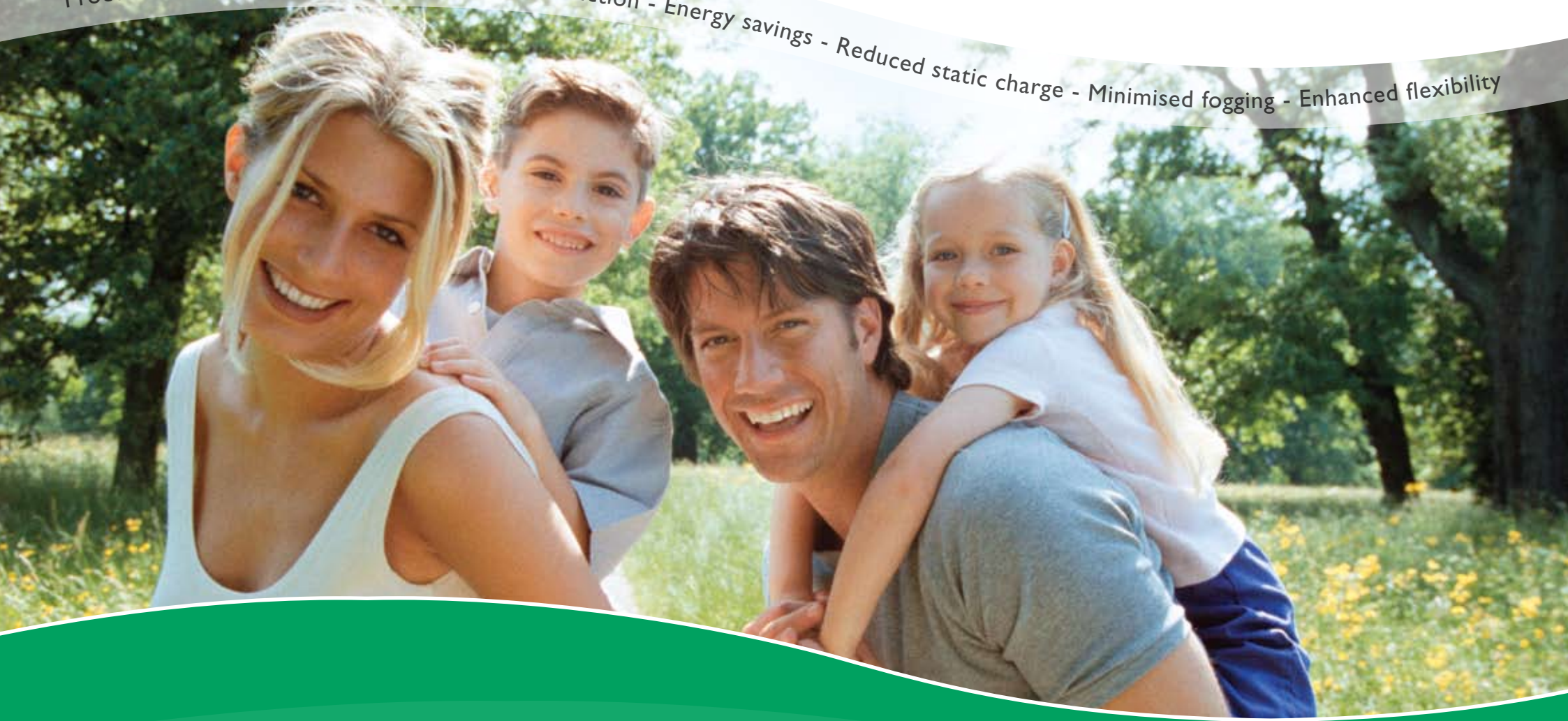


Better Together

Speciality Additives for Superior PET

Processing Improvements - Decreased surface friction - Energy savings - Reduced static charge - Minimised fogging - Enhanced flexibility



CRODA
Polymer Additives

At the heart of better plastics

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Croda – At the heart of better plastics

Croda is a world leader in natural based speciality chemicals which are offered into almost every industry type. Founded in 1925, Croda is a trusted name within the market and our vast experience allows us to offer extensive technical assistance to our customers. Both Croda Polymer Additives and Coatings and Polymers divisions offer products into the PET market. The products within the Polymer Additives range are added during processing to enhance the surface properties of the polymer, whereas the building blocks supplied by Coatings and Polymers are added during resin production to alter the mechanical properties of the polymer.

Polyethylene terephthalate (PET)

Croda has created this product brochure as a guide to the products we can offer into the PET market. PET is a polyester commonly used in packaging applications owing to its clarity, strength and lightweight properties. The inclusion of additives and building blocks enables resin producers and processors to create premium PET products. As PET is increasingly used in more challenging applications, the inclusion of speciality additives is essential to enhance the polymer's physical properties to give superior PET compared with competitor products. PET and Croda Polymer Additives – Better Together.

For easier processing and handling of PET

PET naturally exhibits very high surface friction, especially immediately after processing. This can lead to production issues such as poor mold release, problems with line flow during filling, increased tendency to scratch and mark, difficulties with winding film rolls, as well as reduced packing density of parts in boxes. Slip additives can be used to overcome these difficult and costly problems.

IncroMax™ 100 and Atmer™ 7510

Croda Polymer Additives has developed a unique patented slip additive for PET processing. **IncroMax 100** is food approved and is suitable for use in resin, sheet and film. Key benefits the additive provides are listed below:

- Instantly reduces surface friction and mold release force by up to 60%
- Improves packing density of molded parts by up to 25%
- Increases scratch and scuff resistance to give an enhanced surface quality
- Easier processing and reduced manufacturing noise
- Energy required for extrusion reduced resulting in cost savings
- No detrimental effect on colour or clarity
- No negative effect on the physical properties of PET (such as acetaldehyde generation, injection pressure or intrinsic viscosity)
- Flow promotion of polyester during processing resulting in increased output
- Now available in an easy to use concentrate form as **Atmer 7510**

Reduced Surface Friction

IncroMax 100 acts as a slip agent, rapidly reducing friction on the surface of PET. Tests have shown a reduction of friction by up to 60%. This performance is long lasting and can be achieved by adding as little as 2000ppm additive.

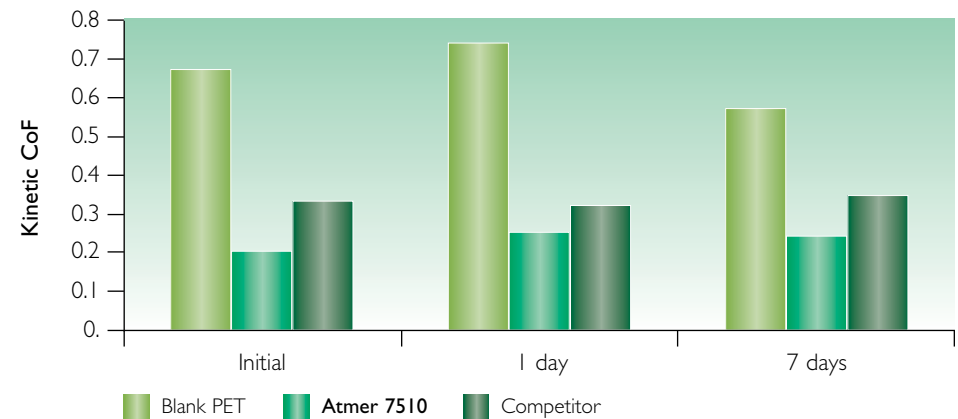


Figure 1: Kinetic CoF of blank PET, 3% Atmer 7510 and competitor slip additive. Testing was carried out according to the Standard Test Method for Static and Kinetic Coefficients of Friction (ASTM D1894)

Easier Mold Release

IncroMax 100 delivers a reduction in mold release force of up to 60%. By allowing molding at lower injection temperatures and/or mold release at higher ejection temperature, the cycle time of production is reduced and thus the number of shots per hour increased. **IncroMax 100** enables increased productivity and reduced waste in your business.

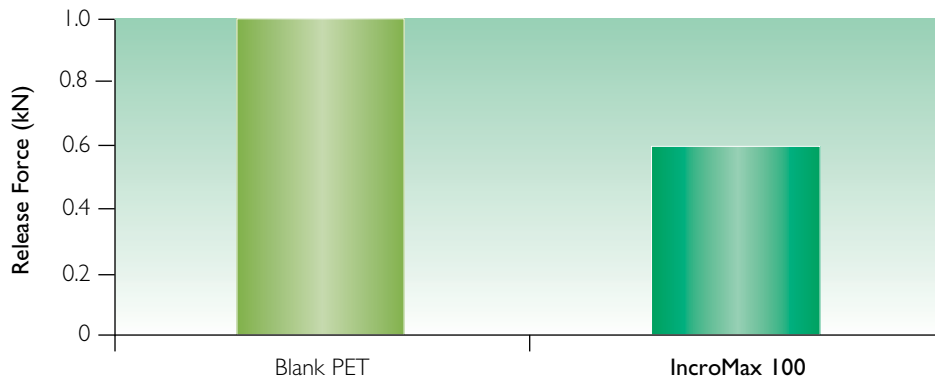


Figure 2: Mold release of blank PET vs. with the addition of 0.25% IncroMax 100

Excellent Colour and Clarity

The inclusion of additives directly into the polymer can often result in discolouration which increases exponentially with the thickness of the plastic. Transmission spectrophotometer readings show that there is no visible difference between the colour of blank PET and that containing **IncroMax 100**. Haze, which is the cloudiness of a product, also remained unaltered by the addition of **IncroMax 100** to PET. The colour and clarity are retained over the lifetime of the polymer.

	Time	L Value	a Value	B Value
Blank PET	Initial	94.6	-0.3	1.6
	4 Weeks	94.3	-0.3	1.5
PET + 0.5%	Initial	94.1	-0.3	1.8
	IncroMax 100	4 Weeks	94.0	-0.4

Figure 3: Colour of PET measured on Transmission Spectrophotometer



Figure 4: 2mm thick molded PET plaques containing 0.3% IncroMax 100 and 0.3% active ex. competitor masterbatch for colour comparison

Figure 5: Haze comparison of PET containing IncroMax 100 vs. competitor masterbatch

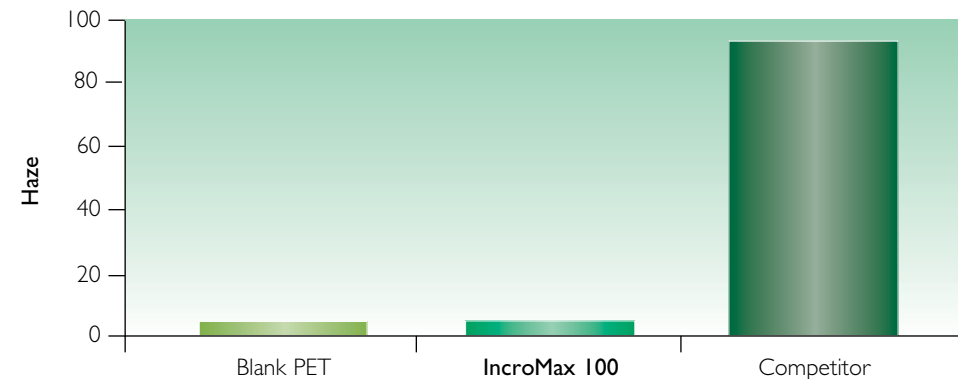


Figure 6: Haze measurements of blank PET vs. with the addition of 0.3% IncroMax 100 compared with a competitor product. Testing is in accordance with the Standard Test Method for Haze and Luminous Transmittance (ASTM D100395)



Processing Improvements

The addition of **IncroMax 100** provides significant benefits to the processing of PET; the output rate of the polymer is increased for a given extruder speed and allows the temperature of the extruder to be reduced.

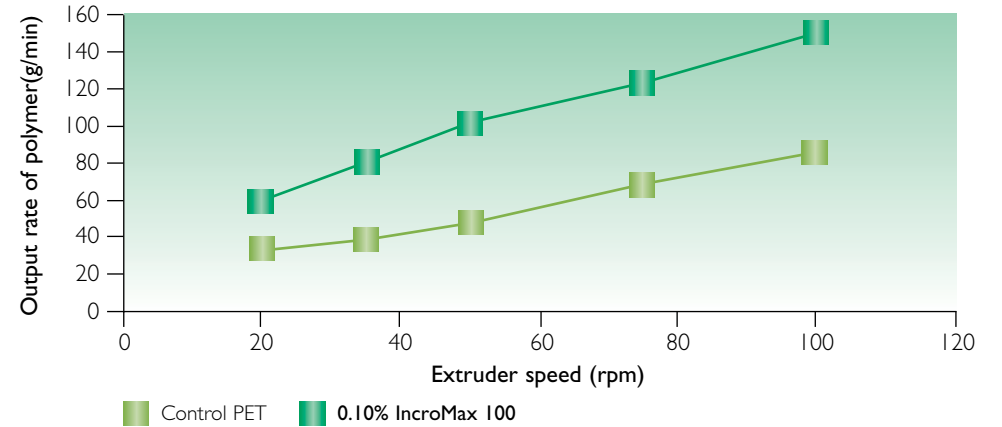


Figure 7: Output rate of PET at different extruder speeds with blank PET vs. the addition of 0.10% IncroMax 100

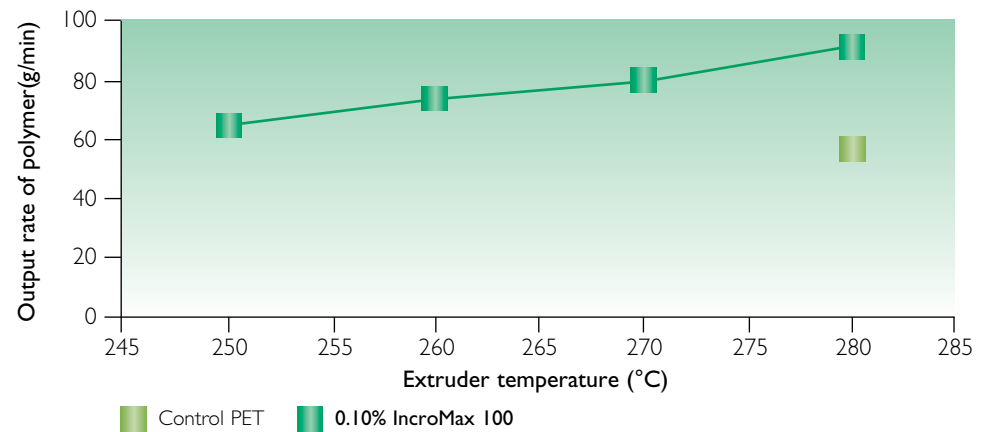


Figure 8: Output rate of PET at different extruder temperatures with blank PET and with the addition of 0.10% IncroMax 100

Addition

IncroMax 100 is available as white pastilles in 25kg bags. Recommended addition levels are typically 0.1-0.3%. The additive can be included directly to the throat of an injection molding machine or extruder using a cooled feeder.

Atmer 7510 is a solid pellet containing **IncroMax 100** at 10% in a PET carrier. It can be added directly to the polymer or alongside masterbatch in conventional dosing systems.

Applications

- Pre-forms
- Household & cosmetic bottles
- Injection molded trays & tubs
- Food packaging
- PET film & extruded sheet

Regulatory Information



Both **IncroMax 100** and **Atmer 7510** are pre-registered for REACH and are listed in EINECS and TSCA. They are also EU and FDA approved.

Further Information

Croda Polymer Additives can also offer **Atmer 7500**, a slip additive concentrate for PET, in the Asia Pacific region. The concentrate contains **IncroMax 100** at 12.5% in a PBT resin. Please contact Croda Singapore for further details.

For Greener Businesses

As **IncroMax 100** and its concentrate **Atmer 7510** function as slip additives they aid the processing of PET by reducing friction. They also provide an increased output rate of the polymer when processing at lower extruder speeds and lower temperatures. Such processing improvements result in lower energy required to extrude PET which in turn provide cost savings for your business.



Energy Saving

For a processor using 10,000 tonnes of PET resin a year, the inclusion of just 3% **Atmer 7510** can reduce the amount of energy required for extrusion by **60%** when processing at 275°C.

Annual energy for processing PET: 9.9 million MJ

Annual energy for processing PET + 3% **Atmer 7510**: 5.9 million MJ

Energy Saving = **4 million MJ**

Cost saving

The above energy savings which are the result of adding **Atmer 7510** to PET during processing translates to annual cost savings of over **€70,000***

Processing cost for PET = €179, 639

Processing cost for PET + **Atmer 7510** = €106, 915

Annual cost saving = **€72, 724**

*Assuming the cost of electricity to be €0.018/MJ

For performance you can clearly see

Fogging is a term used to describe the formation of small discrete droplets of water on the surface of transparent plastic films. Fogging most commonly occurs when there is a temperature differential between the inside and the outside of an enclosed atmosphere causing localised cooling at the interface. Fog formation in food wrapping film obscures the contents, significantly reducing the aesthetic quality of the packaged food.

Atmer™ external anti-fogging agents

Croda Polymer Additives offers anti-fogging agents which can be externally applied to the surface of PET to change the interfacial tension between water and the polymer surface, allowing the condensed water droplets to spread into a continuous and uniform transparent layer on the fabricated film. **Atmer 116** and **Atmer 110** anti-fogging agents can be added to PET food wrap film and food packaging to improve the transparency of the polymer and the durability of the contents.

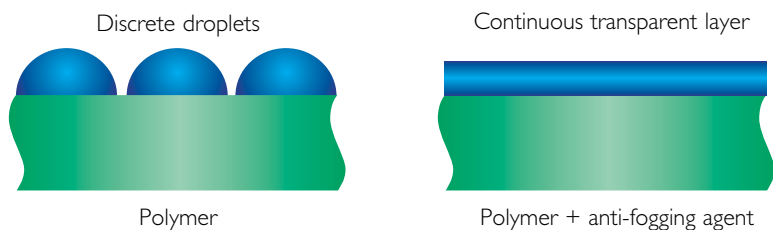


Figure 9: PET with and without anti-fogging agent

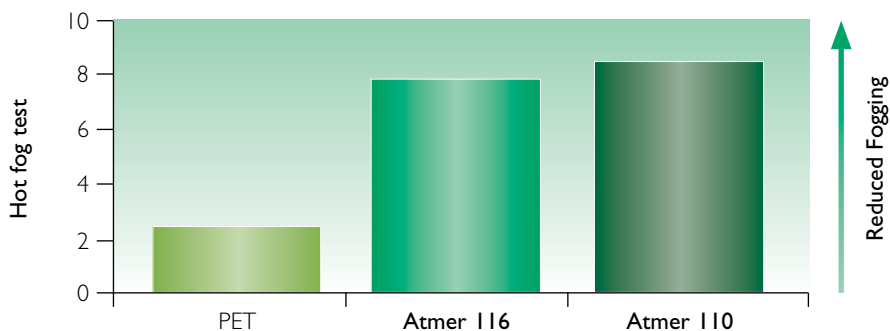


Figure 10: Blank PET and with the addition of 200mg/m² Atmer 116 and Atmer 110. (1= Very poor, 9= Excellent)

Addition

Both **Atmer 116** and **110** should initially be dissolved in a solvent (such as iso-propyl alcohol) at low concentrations before surface coating the PET using spray, roll or dip coating. Typical addition levels are between 1 – 2%. The shelf life of these temporary additives is dependent on the environment they are used in, however the anti-fogging effect can be replenished by reapplication.

Applications

- Food packaging
- Food wrap

Regulatory Information



The listed **Atmer™** products are pre-registered for REACH and are listed in EINECS and TSCA. They are also food contact approved.



For easier processing and minimal dust pick up

Plastic materials are good insulators and as such can support the build-up of high static charges. Static electricity is produced by charge separation caused by the movement of one material over another e.g. the passage of film over rollers, by high velocity cooling air passing over surfaces, or by incidental contact between plastic parts during transport or storage. The build-up of static charges can result in the following processing difficulties:

- Increased handling problems during transport, storage and packing
- Dust contamination, affecting both appearance and performance of end-products
- Risk of electrical shocks to employees working at the machines
- Risk of electrical discharge causing fire or explosion

Atmer™ external anti-static agents

Croda can supply **Atmer 110** and **Atmer 116** anti-static agents that can be applied directly to the surface of PET. These additives interact with atmospheric moisture reducing the surface resistivity and hence dissipating high electric charge densities, to provide an anti-static effect to the plastic part. The key benefits these additives provide are listed below:

- Immediate anti-static effect
- Can be directly applied to surfaces from a solution
- Easy application by spraying, wet coating or dipping
- Can be re-applied as required

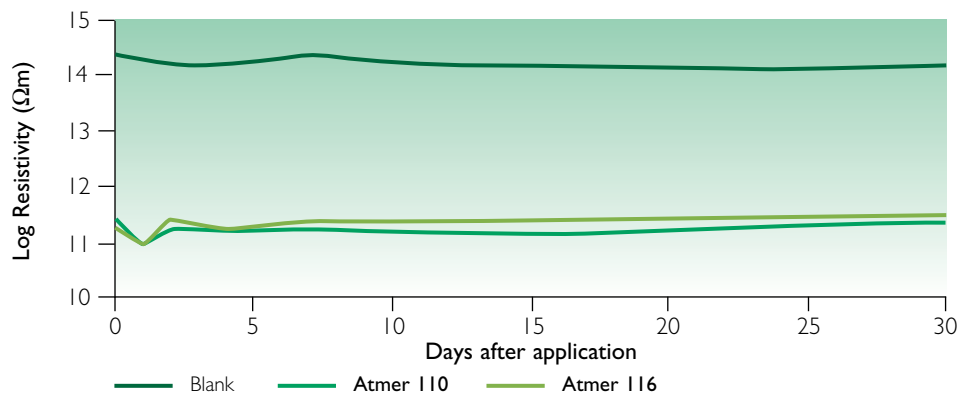


Figure 11: The anti-static effect of Atmer 110 and Atmer 116 in 50µm PET film (100 mg/m² additive)



Addition

Both **Atmer 116** and **Atmer 110** should first be dissolved in an appropriate solvent, such as water or alcohol, at typical levels of between 2% and 5%. Application can be by spraying, wet coating or dipping depending on the product and the manufacturing process, to give an immediate effect. Quantities used depend upon surface area, typical requirements range from 50 – 100 mg/m² of active **Atmer™** additive.

Applications

- Pre-forms
- Finished bottles
- Household & cosmetic bottles
- Injection molded trays & tubs
- Food packaging
- PET film & extruded sheet

Regulatory Information



The listed **Atmer™** products are pre-registered for REACH and are listed in EINECS and TSCA. They are also food contact approved.

For enhanced flexibility and water resistance in PET

Pripol™ for water resistance

The **Pripol** technology offered by Croda Coatings and Polymers can provide water resistance and flexibility for PET applications. When this branched C₃₆ di-carboxylic acid is incorporated into the polymer, its large hydrocarbon nature brings excellent hydrophobicity to the PET. Such technology can also be supplied in the diol form – both of which are made from natural fatty acids resulting in a 100% renewable carbon content.

The **Pripol** dimer acid and dimer diol provide the following benefits to PET modification:

- Enhanced hydrophobicity and thus reduced drying time which can translate to cost savings
- Reduced melt viscosity allows lower processing temperatures meaning savings in energy and by-product formation
- Improved stability and chemical resistance
- Enhanced adhesion to low polarity plastics
- Low temperature flexibility reducing stress after moulding or casting
- Superior barrier properties
- Improved melt flow properties and substrate wetting

Applications

- PET laminates with other polymers
- Food packaging films
- Molding
- Casting
- Film stretching
- Modification of PET adhesives and coatings

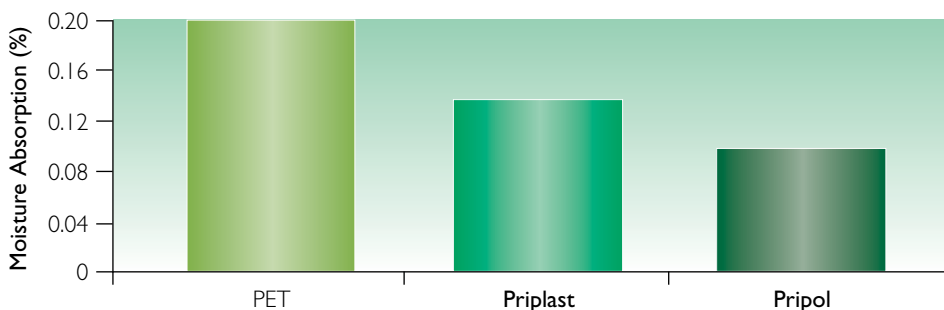


Figure 12: Hydrophobicity demonstrated by low moisture absorption of PET modified with Pripol and Pripol at 5% wt

Note: Unmodified PET absorbs approximately 0.2% moisture. Prior to processing the polymer must be dried to ensure it contains less than ~0.005% moisture.

Priplast™ for maintaining hardness

Croda Coatings and Polymers can also provide a range of **Priplast** products which are made from dimer fatty acids and are ideal as larger soft segments to modify PET. As with the **Pripol** range, these bio-based building blocks also provide excellent hydrophobicity. When care is taken in the manufacturing process to prevent trans-esterification (and hence randomisation), the low polarity **Priplast** can be built in as an elongated soft segment. This results in a two-phase structure with soft, rubbery **Priplast** segments distributed through the hard PET matrix.

The additional benefits this technology provides are listed below:

- Hardness maintained
- Improved impact strength, also at low temperatures
- Resistance to heat, oxidation, UV, hydrolysis and chemicals
- Enhanced melt flow characteristics

Applications

- PET laminates with other polymers
- Refrigerated/frozen food packaging
- Engineering applications
- Molding
- Casting
- Film stretching

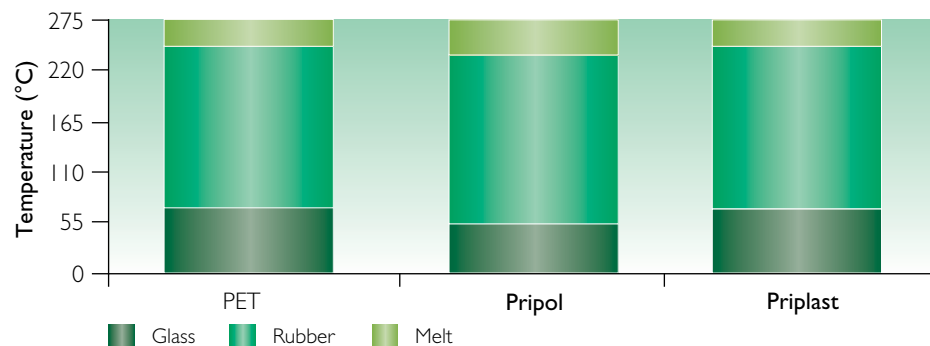


Figure 13: Maintaining the high melting point and glass transition temperature (T_g) of PET using Priplast, whereas Pripol has a softening effect. PET modified at 10% wt

Product	Product description	Additional product benefits	Renewable carbon (%)
Priplast 3199	MW 2000, amorphous	High purity product for very high MW polymers; hydrophobic	87
Priplast 1838	MW 2000, amorphous	Hydrophobic	82
Priplast 3196	MW 3000, amorphous	Very hydrophobic	83
Pripol 1009	High purity, UV stable dimer (>98%)	Hydrophobic, low colour, colour stability	100
Pripol 1006	High purity, UV stable dimer (95%)	Hydrophobic, low colour, colour stability	100
Pripol 2033	High purity dimer diol, fully amorphous	Hydrophobic, low colour, colour stability, lower viscosity for easy handling	100



Addition

It is recommended that **Priplast** is used at 5-15%, allowing a two-phase morphology. **Pripol** is usually added at 5-40%, depending on the properties desired.

Regulatory Information



These products are pre-registered for REACH and are listed in EINECS and TSCA. They are also food contact approved.

For Greener Businesses

PET is hygroscopic meaning that it naturally absorbs moisture from the atmosphere. PET resin must consequently be dried prior to processing in order to remove this water which can otherwise cause hydrolysis. The excellent hydrophobicity of the **Priplast** and **Pripol** products results in reduced drying efforts which can result in cost savings and improved throughput.



The typical residence time for drying PET is approximately 4 hours. With additions at 5% by weight, **Priplast** and **Pripol** modifiers reduce moisture content in PET by 25% and 50% respectively. This means that residence time in the dryer is reduced to 3 hours with the use of **Priplast** and 2 hours when **Pripol** is added.

Energy Saving

For a processor using 10,000 tonnes of PET resin a year the inclusion of just 5% wt Croda modifiers could save over **3.9 million MJ** of energy in reduced drying time*.

4 hours drying (blank PET) = 7.8 million MJ
 3 hours drying (+ **Priplast**) = 5.8 million MJ
 2 hours drying (+ **Pripol**) = **3.9 million MJ**

Cost saving

With the reduction of drying time necessary for PET with the inclusion of Croda modifiers, we can calculate cost savings based on the reduction of energy required. Again for a processor using 10,000 tonnes of PET resin, over **€70,000** can be saved in energy costs annually**.

Drying cost for blank PET = €140,909
 Drying cost for PET + **Priplast** = €105,686
 Drying cost for PET + **Pripol** = **€70,463**

*Using the Kenplas 'Hopper 1000T' drying system which uses 54.06 kW of power when drying 1000 kg of PET in an hour.

**These calculations assume the cost to be €0.018/MJ for electricity

Further information

Croda sales and distribution are coordinated through an extensive worldwide network of associates and agents. For details of your local representative please contact your nearest Croda regional office.

Visit our global website at www.croda.com/pa

For further details on any of the Coatings and Polymers products listed in this brochure please visit: www.croda.coatingsandpolymers.com

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