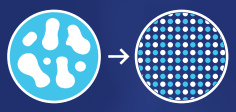
POLYSCOPE
fresh thinking, great products

XIBOND™ Blend Optimizers

At Polyscope, we offer a wide range of polymer additives for the compounding industry. These products are classified as our performance enhancers portfolio: XIRAN® heat boosters and XIBOND™ blend optimizers. In this brochure we focus on the XIBOND™ blend optimizers portfolio.

Many polymers are used within the compounding industry, each polymer has unique properties. Product developers are always looking to combine polymers to create new innovative blends, compounds or alloys with balanced properties. The XIBOND™ blend optimizers portfolio consists of different products which are suitable to enhance the properties of polymer blends that are used in industries such as automotive, building and construction, consumer goods, electrical and electronics, sports and leisure. The XIBOND™ portfolio consists of styrenics with functional Maleic Anhydride (MA) or Glycidyl methacrylate (GMA) groups. These functional styrenics affect the blend morphology or the surface characteristics of several polymer systems to fulfill the continuous needs to create new innovative blends.

The XIBOND™ portfolio



PAG 03

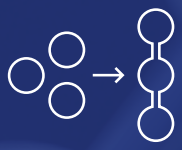
XIBOND™ Compatibilizers

The XIBOND™ portfolio offers a compatibilizers range enabling the compounding industry to create blends with different type of polymers. Compatibilizers are necessary to optimize the surface tension and achieve blends without delamination, resulting in optimized properties.

PAG 08

XIBOND™ Coupling Agents

Coupling agents are additives which enhance the chemical bonding in composite systems. The improved bonding between the polymer matrix and the filler surface is critical to achieve optimized properties in composite materials.



PAG 11

XIBOND™ Chain Extenders

The XIBOND™ chain extenders connect polymer chains together to raise the molecular weight, resulting in higher melt strength. This technique is especially suitable for polycondensates and polyamides and for upgrading recycled materials.

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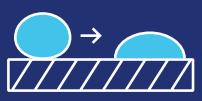
XIBOND™ Viscosity Modifiers

The addition of XIBOND™ influences the viscosity particularly of styrenics but also acrylics and PVC can be modified. The viscosity modification can act as processing aid for several processes such as blow molding or extrusion.



PAG 18

XIBOND™ Surface Modifiers

The addition of XIBOND™ enhances the surface properties of polymer matrices: the polarity of the surface is influenced due to the presence of polar maleic anhydride functionality. XIBOND™ can also improve the adhesion performance of several polymer matrices.

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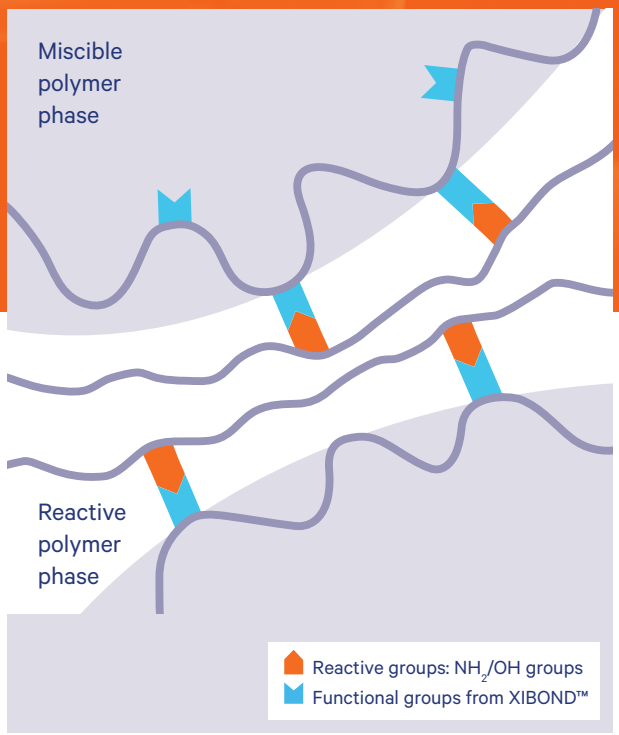
XIBOND™ product overview

XIBOND™ Compatibilizers

Most polymeric systems are immiscible and cannot be blended together without phase separation/delamination. Compatibilizers enable immiscible polymers to blend into a homogeneous compound.

To create an optimal compound, we offer a range of reactive compatibilizers containing functional styrenics with Maleic Anhydride (MA) functionality and Glycidyl methacrylate (GMA) functionality. MA and GMA are reactive components that interact with functional end groups such as the –OH and $–NH_2$ end groups to obtain polymer blends with optimal properties.



Interaction of the functional end groups of the reactive polymer with the XIBOND™ compatibilizer to obtain an optimal polymer blend.

Benefits of XIBOND™ compatibilizers:

- They optimize the interfacial tension,
- They stabilize the morphology against high stresses and
- They enhance the adhesion between the phases in the solid state.

The compatibilization results in a large improvement of the mechanical properties of the polymer blend.

XIBOND™ compatibilizing opportunities for different blends

When creating polymer blend with different components, the blend always contains a continuous phase which is the main components of the polymer blend. This continuous phase is very critical to determine the correct XIBOND™ compatibilizer. Polyscope can advice you in selecting the correct XIBOND™ compatibilizer. Some solutions are shown in the table below.

	Polycarbonate	Polyesters	Polyamides
ABS/SAN	✔	✔	✔
ASA	✔	✔	✔
PS/HIPS	✔	✔	✔
SBC	✖	✔	✔
PPO	✖	✖	✔
PMMA	✖	✔	✖

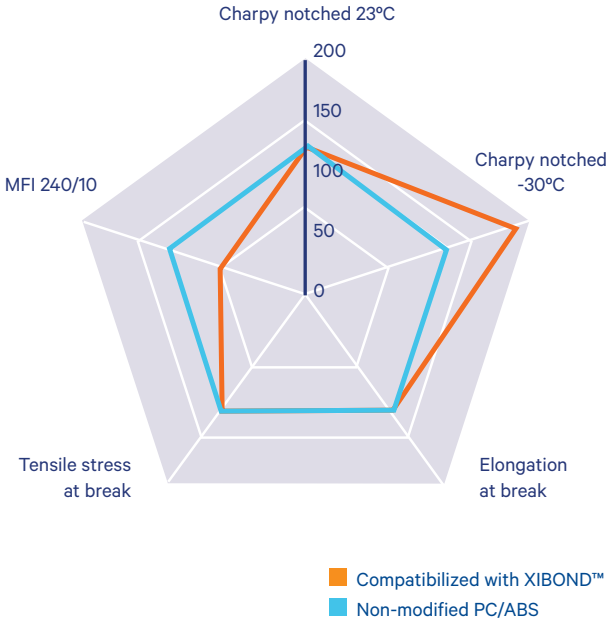
XIBOND™ Compatibilizer examples

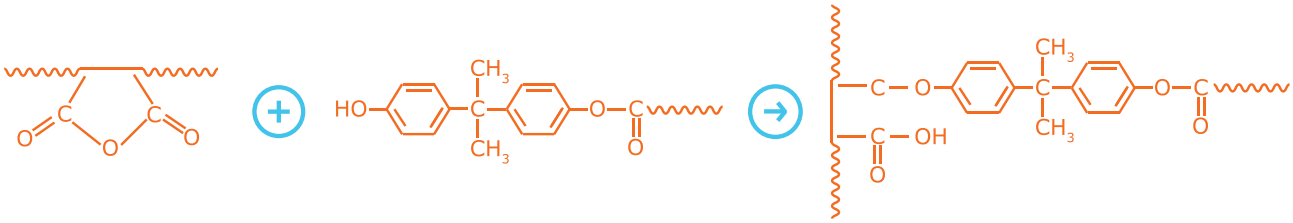
PC/ABS Blends

One of the most common blends within the plastics industry is a combination of polycarbonate and ABS. These blends are partially miscible and can be optimized with the addition of a compatibilizer. The property profile of PC/ABS blends is very dependent on the raw material selection of the ABS and PC types. The raw material selection can influence the room temperature impact (23°C). XIBOND™ on the other hand can improve the morphology and thus positively effect the low temperature impact (-30°C), which is impossible to influence by just raw material selection. The XIBOND™ portfolio contains compatibilizers for various blend ratios.

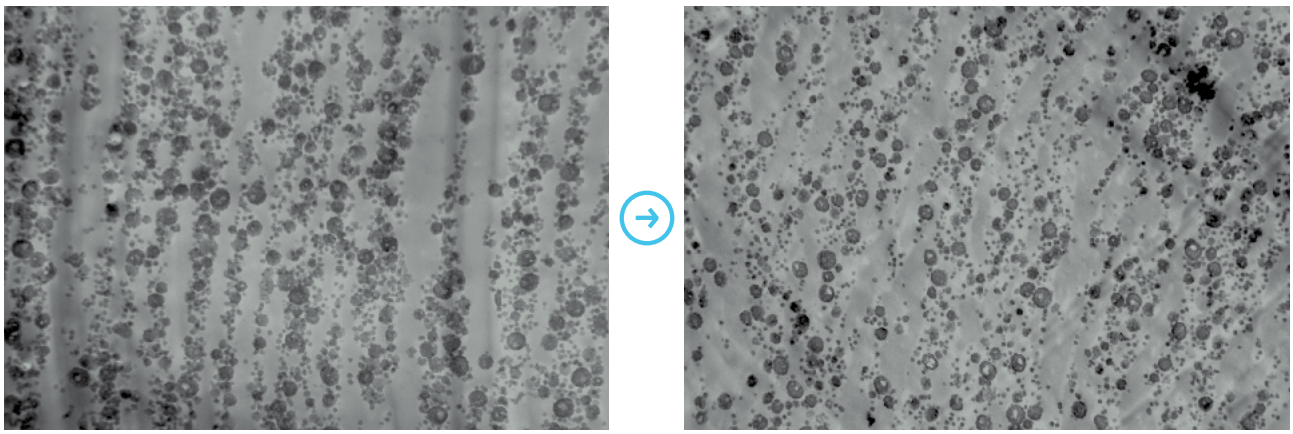
We offer a solution with XIBOND™ 160 and 370.

To show the effectiveness of the XIBOND™ compatibilizer, the properties of 3 PC/ABS blends (65% PC / 35% ABS) are compared in the spiderplot below. The results of the blend compatibilized with XIBOND™ is far better than the results of the references.





The chemical reaction which occurs for morphology improvement in PC/ABS blends with XIBOND™ compatibilizers



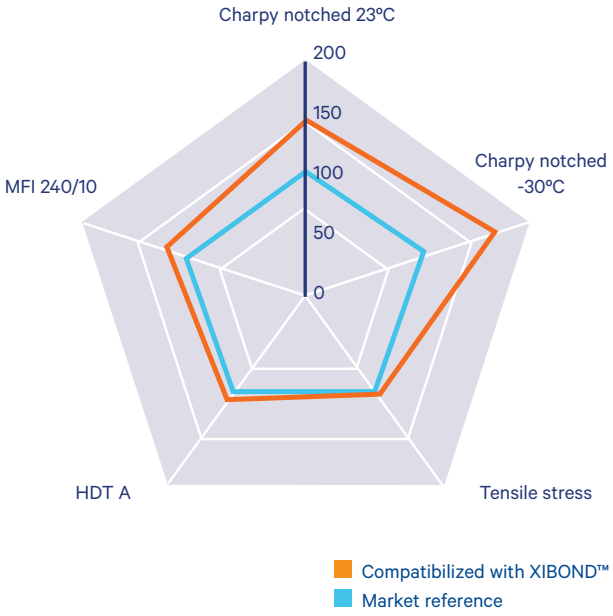
improved blend morphology by the addition of XIBOND™ 160 in a PC/ABS blend (65%/35%)

PA/ABS Blends

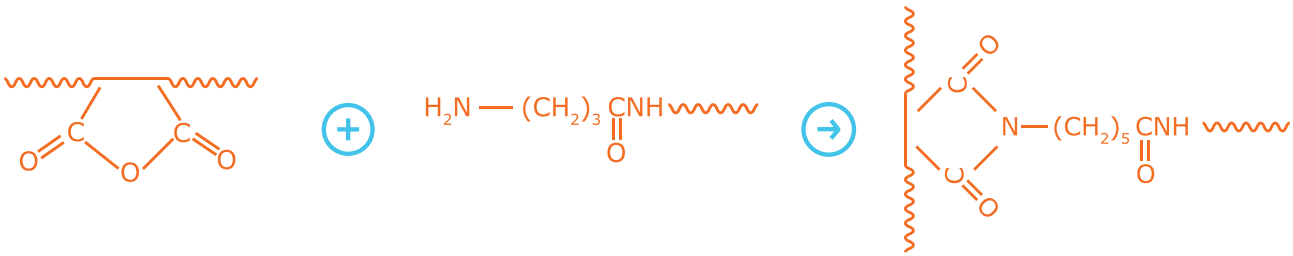
PA/ABS blends offer the optimal balance of properties when combining the crystalline properties of PA and the amorphous properties of ABS. The combination of these properties makes it a very popular blend in the market. A compatibilizer is required to make these blends: without a compatibilizer the blend starts to delaminate.

Maleic Anhydride (MA) is reactive towards the amine groups present in polyamides. Polyscope designed XIBOND™ 315 with low MA functionality for blending polyamides with styrenics. The XIBOND™ compatibilizer portfolio has solutions for various blend ratios. In this example, XIBOND™ 315 offers an optimized compatibilizer for PA/ABS blends with 65% PA.

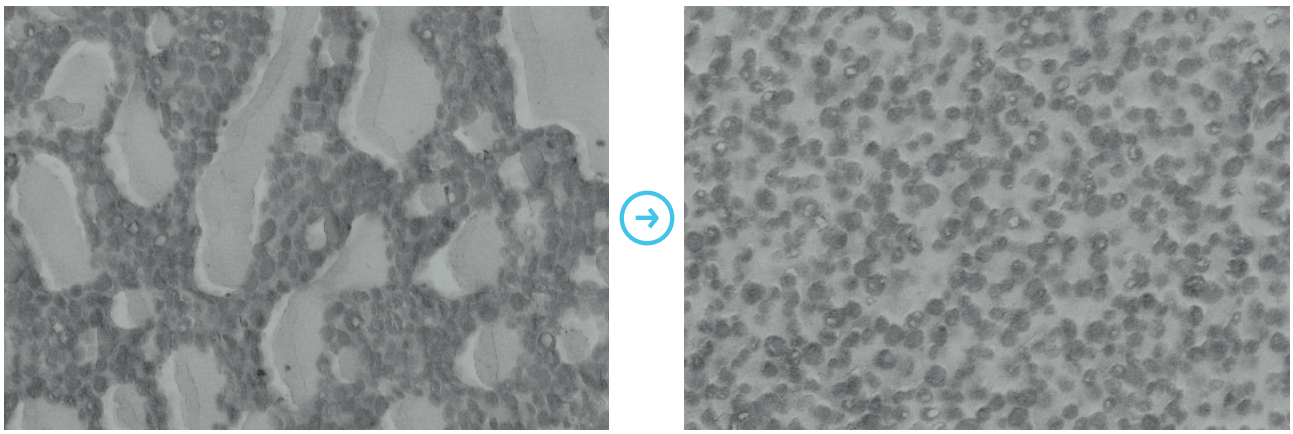
The overall mechanical properties of the with XIBOND™ compatibilized PA/ABS blends are impressive as shown in spider plot.



The spider plot represents the most relevant properties for this 65% PA blend compatibilized with XIBOND™ and a market reference.



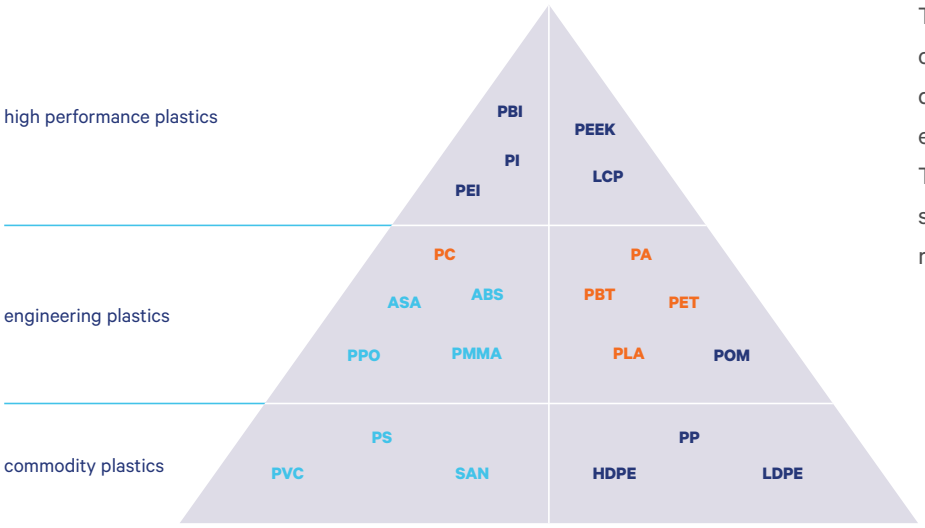
The chemical reaction which occurs for morphology improvement in PA/ABS blends with XIBOND™ compatibilizers



Improved blend morphology by the addition of XIBOND™ 315 in a PA/ABS blend (65%/35%)

What is your challenge?

The XIBOND™ compatibilizer portfolio can offer you the most optimal blend morphology, that results in the best overall properties. Especially impact properties outperform competitive solutions. Polyscope can support you in creating the most optimized blends in various ratios.



The addition of a reactive compatibilizer can combine different polymers in the engineering plastics landscape. The engineering plastics triangle show blending opportunities with reactive compatibilizers.

Reactive polymers
Miscible polymers

Engineering Plastics Triangle: miscible polymers react with the functional groups of the reactive polymers with the use of a compatibilizer

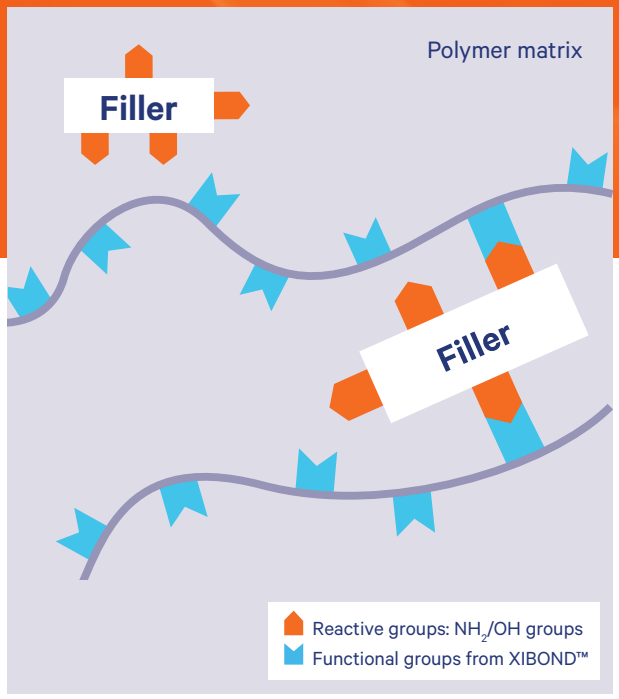
XIBOND™ Coupling Agents

Composite materials consist of a polymer matrix in which fillers are dispersed. In order to achieve an optimized morphology there are typically additives necessary to improve the bonding between the polymer matrix and the filler. Coupling agents can be added in small percentages to chemically bond the filler and the polymer matrix.

XIBOND™ can act as a coupling agent when it is miscible with the polymer matrix. The functional groups in the XIBOND™ coupling agent range can interact with the reactive groups such as –OH and $–NH_2$ present in the filler. The interaction between the polymer matrix and the filler is dependent on the sizing or the end groups of the filler.

Fillers that can easily interact with XIBOND™ coupling agents:

- Glass fiber
- Glass beads
- Carbon fiber
- Different natural fillers such as:
  - Wood fibers
  - Hemp fibers
  - Flax fibers



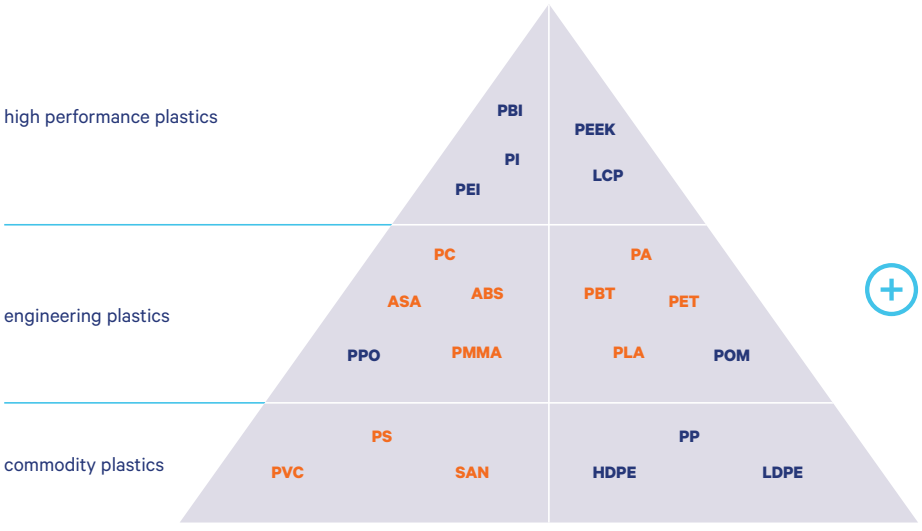
Interaction of reactive groups such as -OH and NH_2 present in the filler can interact with the MA/GMA of the XIBOND™ Couping Agent.

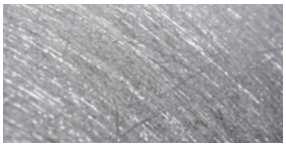
Benefits of XIBOND™ coupling agents:

XIBOND™ coupling agents improves the adhesion of fillers in the composites.

This results in:

- Lower viscosity. This gives the opportunity of adding more filler while retaining optimal processing conditions
- Improved creep
- Improved tensile properties





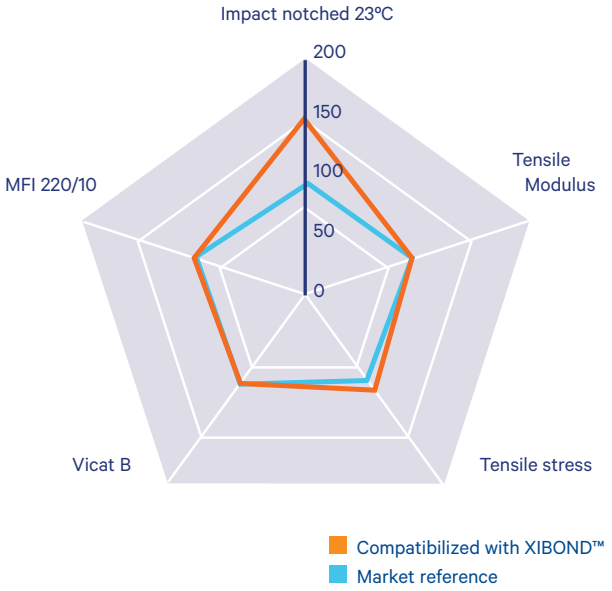
XIBOND™ Coupling agents can improve the bonding between polymer matix and the filler by a chemical or physical bonding. There are unlimited combinations possible were the bonding can be optimized. Some examples are shown by combining the orange polymers in the engineering plastic with the fillers shown on the right.

XIBOND™ Coupling Agent example

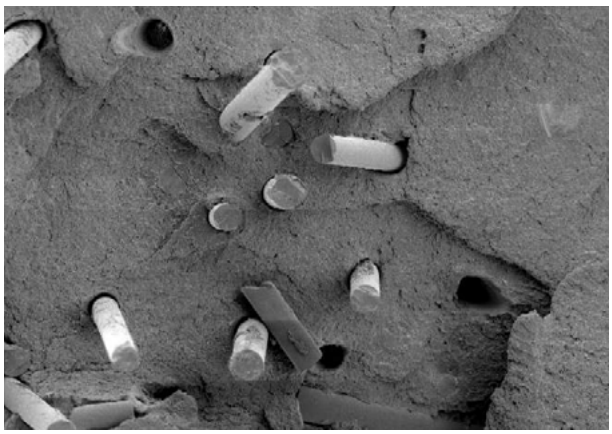
ABS - GF

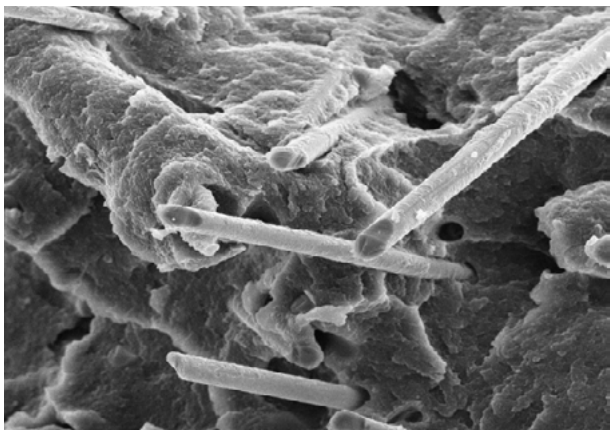
A composite material of ABS and glass fiber is a well known combination in the compounding industry.
The addition of the fibers will reduce the coefficient of thermal expansion and lowers mold shrinkage compared to standard ABS grades. However the bonding of glass fibers and the polymer matrix is not always optimal and can be optimized with the addition of a coupling agent. XIBOND™ 160 ensures an improved wetting and results in an improved morphology in the composite.

In this example, the addition of 1.5% XIBOND™ coupling agent will contribute to a better bonding of the polymer matrix and the filler. For a composite of ABS with glass fiber, we offer the XIBOND™ 160.



The spider plot shows a significant increase of the impact properties by adding just 1,5% XIBOND™.



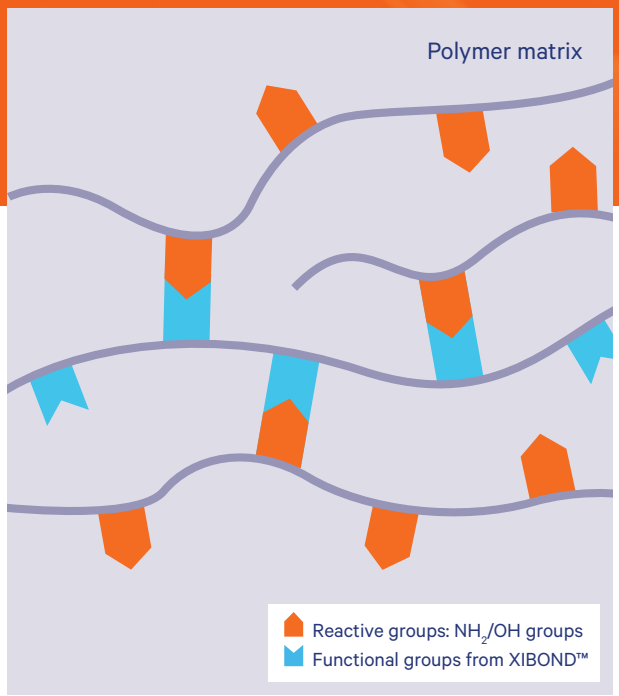


Improved wetting of the glass fibers with the ABS matrix with the addition of XIBOND™ 160, resulting in improved bonding between the matrix and the filler.

XIBOND™ Chain Extenders

Polycondensation polymers, like polyesters and polyamides tend to degrade during processing, which results in the loss of molecular weight. This leads to loss of important material properties, especially melt strength. Chain extenders can improve the melt strength by connecting the chains via a chemical reaction with the OH, COOH and NH_2 groups of the polymer. This results in a reduced melt flow index (MFI) and thus increased viscosity.

The addition of XIBOND™ chain extenders to thermoplastic polyesters and polyamides will lead to branched structures, since it has multiple groups which can react with the polymer matrix. Our XIBOND™ portfolio offers a wide range of maleic anhydride functionality that can react with polyamides and epoxy functionality that can react with thermoplastic polyesters. Melt viscosity is increased as a result of the reaction of the functional groups with either carboxylic or amine end groups. In most cases the use of the additive leads to an improvement in the mechanical properties of the polymer, in addition to the observed stabilization in melt flow.



Increased chain length with XIBOND™ chain extenders

Benefits of XIBOND™ Chain Extenders:

- Improved melt strength
- Improved process ability
- Improved productivity
- Improved product robustness to process variation and changes
- Controllable flow properties
- Controllable thickness

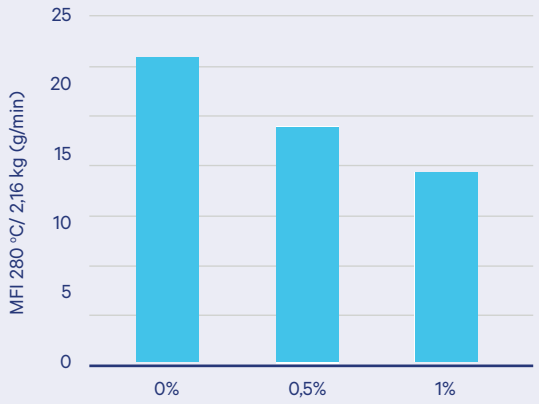
XIBOND™ Chain Extenders examples

Polyamide

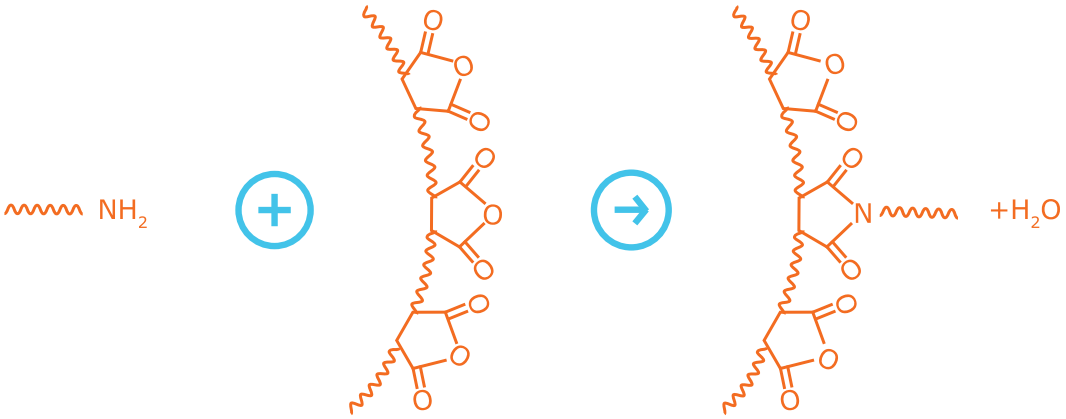
The addition of XIBOND™ 230 and XIBOND™ 370 can cause a branched chain extending reaction due to the highly reactive maleic anhydride with amine functionality of polyamide, forming polyimide bonds.

The reaction of MA and NH_2 will lead to water formation. When addition levels exceed 1%, this can even lead to foam formation. The foam formation can occur due to the water release within the extruder.

It is critical to prevent a high dosage of XIBOND™ when applying it as chain extender for Polyamides.



The chart shows the influence of XIBOND™ 370 grade in a PA6 matrix.



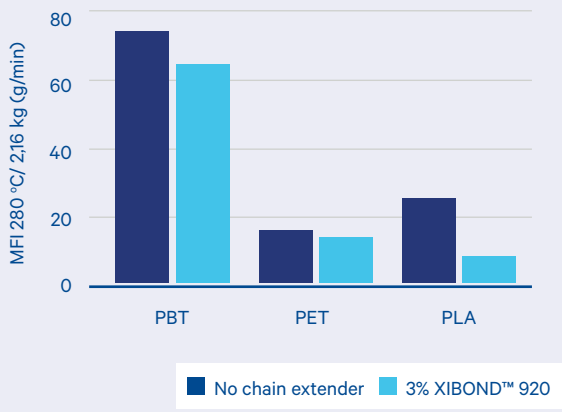
Polyamide XIBOND™ Chain extended Polyamide

Chain extending mechanism of polyamide with XIBOND™ 230/370.

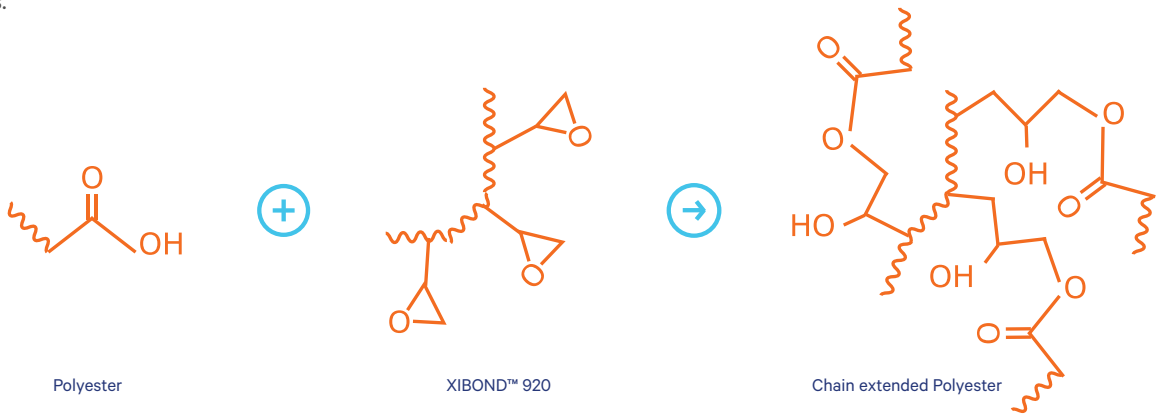
Polyesters

Polycondensates such as PBT, PET and PLA tend to degrade during processing of virgin materials but also for recycled material. The addition of branched chain extenders increases their viscosity ensuring better process ability.

The GMA functionality present in XIBOND™ 920 has an excellent affinity with polycondensates resulting in a branched structure which offers optimal processing conditions.



The chart shows the addition of XIBOND™ 920 to different polymers. Improved viscosity of the material leads to easier processing, lower shear, and part stress.



Polyester

XIBOND™ 920

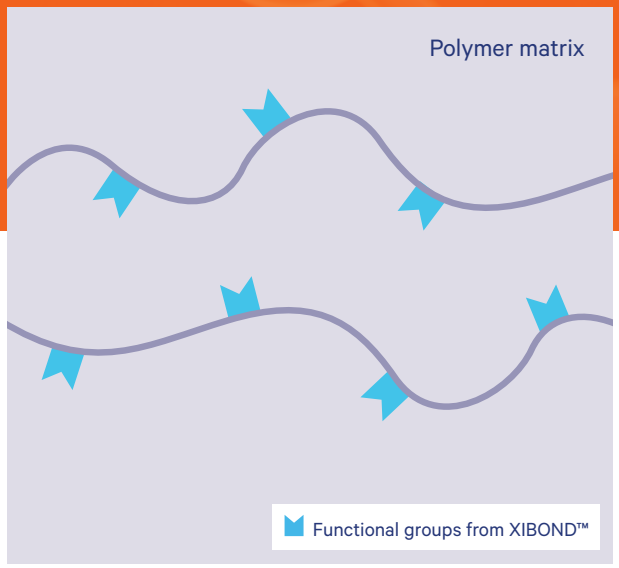
Chain extended Polyester

Chain extending mechanism of polyester with XIBOND™.

XIBOND™ Viscosity Modifiers

Viscosity modifiers can increase or decrease the viscosity of certain polymers. This viscosity modification will not occur via a chemical reaction, but due to the miscibility of these low molecular weight additives with polymers such as styrenics, acrylics and PVC. The viscosity modification can act as processing aid for several processes such as blow molding or extrusion.

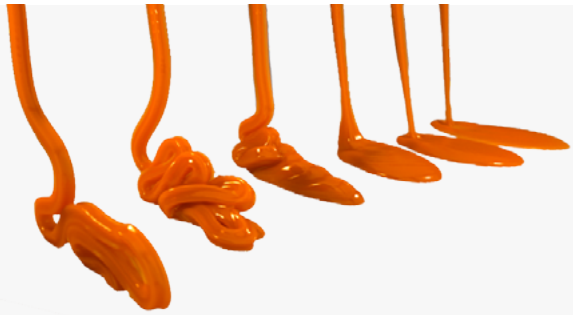
The XIBOND™ viscosity modifiers can influence the flow behavior of various polymers such as ABS, T-ABS, PMMA and PVC. When XIBOND™ is (partially) miscible with a polymer matrix it can lead to a different flow behavior due to a difference in the molecular weight of the products. For example, by increasing the flow of PMMA with XIBOND™, the PMMA is more applicable in an extrusion process. When using a XIBOND™ with low molecular weight, the flow of for instance ABS and T-ABS will increase.



The XIBOND™ viscosity modifies are partly miscible with the polymer matrix and influence the flow of the polymer.

Benefits of XIBOND™ viscosity modifiers:

- Shorter cycle time with injection molding
- Increased spiral flow length
- Lower molding temperature (=less degradation)
- Better surface appearance



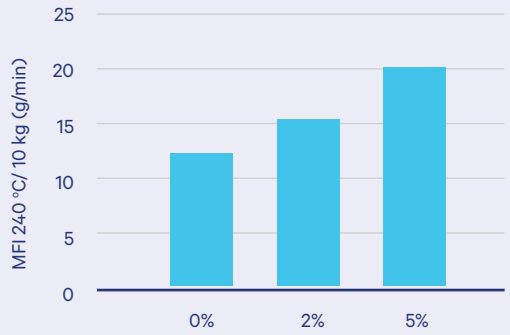
Viscosity modifiers vs waxes

One of the most common ways to improve the flow is by the addition of waxes to the polymer matrix. Waxes tend to migrate to the surface since these materials are typically immiscible also known as moldeposit. XIBOND™ viscosity modifiers are miscible in the polymer matrix and will prevent moldeposit.

XIBOND™ Viscosity Modifier examples

ABS

Flow properties of an ABS based blend can be influenced by adding a viscosity modifier of the XIBOND™ 200 series, an increase in the flow properties will take place. The flow modification can be influenced by selecting a different type of XIBOND™ grade.



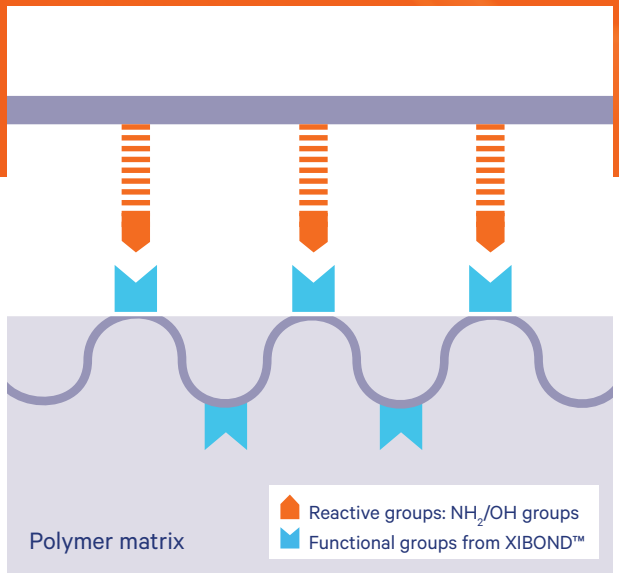
The chart shows the influence of XIBOND™ 280 on the melt flow index in an ABS blend.

XIBOND™ Surface Modifiers

For specific secondary operations such as printing, painting and gluing, a polymer material needs to have a certain surface tension. The addition of surface modifiers bring reactive groups to the surface of a polymer system and change the polarity of that surface and thus influences the surface tension. Furthermore, these reactive groups can optimize the interfacial tension and by this the adhesion between two materials in a co-extrusion or multilayer process.

XIBOND™ Surface Modifiers range influences the polarity of the surface due to the presence of polar maleic anhydride (MA) functionality. This increases the surface tension of polymer matrices, especially for styrenics such as ABS and PS.

The addition of XIBOND™ surface modifiers enables a better wetting of the surface, and that influences the surface tension that leads to a modified contact angle. This can be a benefit in different secondary operations such as gluing and painting.



The XIBOND™ surface modifiers change the polarity of the surface and thus influences the surface tension in the polymer matrix. The reactive groups on the surface improve the ability to have excellent adhesion.

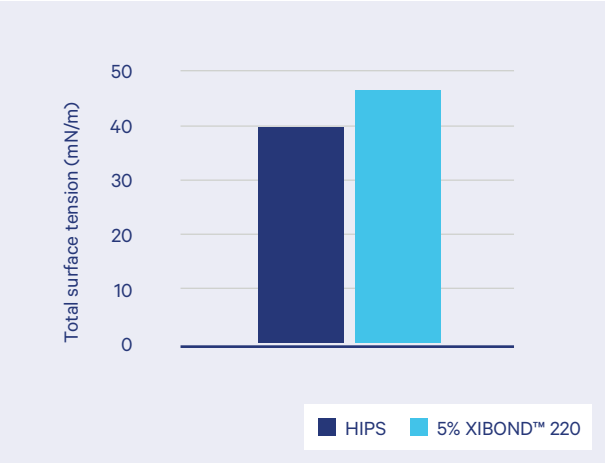
Benefits of XIBOND™ Surface Modifiers:

- Changes the polarity of a product, leading to a different surface tension of the polymer matrix
- Modifies the adhesion properties of the polymer for specific applications
- Optimizes the adhesion in co-extrusion processes

The wetting is improved by the addition of a surface modifier

HIPS

The addition of 5% XIBOND™ 220 shows an increase of the surface tension and thus an improved wetting of the surface. This indicates that the MA functional group is migrated to the surface which can benefit the printability but also improves the adhesion properties in secondary operations such as overmoulding and paint adhesion.



The chart shows the addition of 5% XIBOND™ 220 to HIPS that results in an increase of the surface tension and thus an improved wetting of the surface.

XIBOND™ product portfolio overview

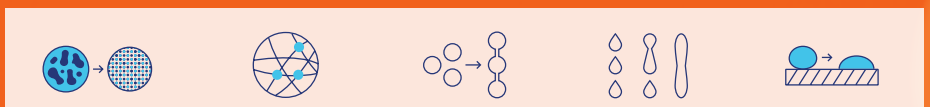
100 SERIES → Styrene Maleic Anhydride (SMA) with Mw ≥ 30.000 g/mol

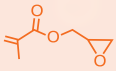
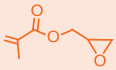
200 SERIES → Styrene Maleic Anhydride (SMA) with Mw ≤ 30.000 g/mol

300 SERIES → Modified Styrene Maleic Anhydride

800 SERIES → Polyolefin grafted with modified Glycidyl methacrylate (GMA)

900 SERIES → Styrene, Glycidyl methacrylate (GMA) and/or Methyl methacrylate (MMA)



Range	Functional groups	Compatibilizers	Coupling Agents	Chain Extenders	Viscosity Modifiers	Surface Modifiers
100 SERIES		✓	✓	✗	✓	✗
200 SERIES		✓	✓	✓	✓	✓
300 SERIES		✓	✓	✓	✗	✓
800 SERIES		✓	✓	✗	✗	✗
900 SERIES		✓	✓	✓	✗	✓

Challenge us

We are continuously expanding the XIBOND™ blend optimizers portfolio to offer solutions for the entire Engineering Plastic landscape. Different functionalities are necessary to cover most needs within the market. The XIBOND™ portfolio is growing beyond the current range. Challenge us and our distribution partners to find the solution for your polymer blend.

POLYSCOPE
fresh thinking, great products

Polyscope at a glance

Polyscope is the global leader in research, product development, production and supply of styrene maleic anhydride (SMA) copolymers, SMA based compounds, aqueous solutions and styrene, maleic anhydride, N-phenylmaleimide (SMANPMI) terpolymers. New in our product portfolio are functional styrenics with Glycidyl methacrylate (GMA).

A global customer base is supported from corporate headquarters with production and research & development in Geleen, the Netherlands, as well as local compounding and sales & marketing support in Europe, North America and Asia.

Our addresses:

Global Headquarters Polyscope Polymers Office
Prins de Lignestraat 28
6161 CZ Geleen

P.O.Box 1073
6160 BB Geleen
The Netherlands

T +31(0) 46 75 000 10
E info@polyscope.eu

Polyscope International Offices
Ann Arbor, USA | Shanghai, China

www.polyscope.eu

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