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Tips from technology

Tougher molded PET articles

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Using Vistamaxx™ performance polymers combined with the right compatibilizer you can effectively modify the impact resistance of polyethylene terephthalate based molded articles. Furthermore, addition of Vistamaxx polymers increases the blend crystallization temperature, allowing for potential cycle time reduction.

Key advantages

- Higher crystallization temperature even when compared to a nucleated injection molding grade polyethylene terephthalate.
- Improved impact strength up to -20°C.
- Good dispersion in PET matrix using compatibilizer.

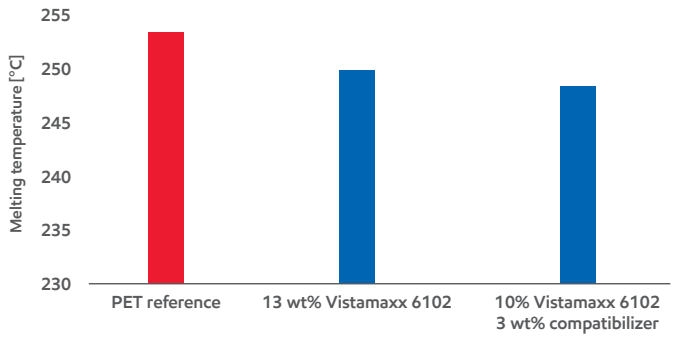
Polyethylene terephthalate, a valuable thermoplastic

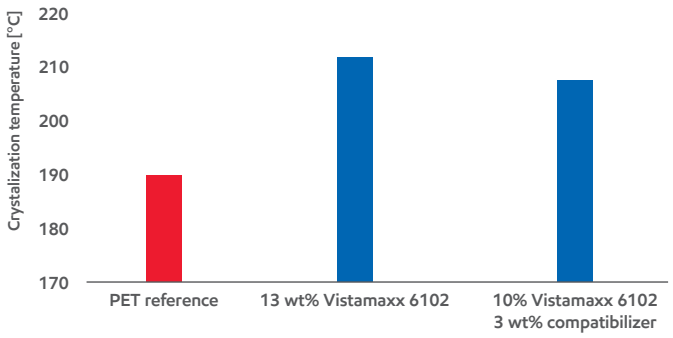
Polyethylene terephthalate (PET) is among the most widely used engineering thermoplastic due to its excellent mechanical and thermal properties, good chemical resistance and barrier properties. Its main applications consist of beverage bottles and textile fibers. Additionally, PET based compounds are suitable for applications in automotive, construction, equipment housings and materials handling. Due to its widespread availability from post-consumer recycled stream and relatively low price of the virgin resin, PET can be considered as low-cost base material for the production of engineering compounds. Main drawbacks of PET are its slow crystallization and relatively low impact strength. Compounding with Vistamaxx performance polymers can correct these shortcomings and tailor properties to meet specific requirements.

Higher crystallization temperature with Vistamaxx polymers

One of the primary limitations of PET is its slow crystallization. Relatively long cycle times and high mold temperatures are required to provide PET some crystallinity. Commercial injection molding PET compounds usually contain nucleating agents intended to induce a small and regular crystalline structure and decrease molding time. Studies carried with an injection molding nucleated PET grade show that Vistamaxx polymers can help by increasing the crystallization temperature. The addition of Vistamaxx polymer has shown to increase the crystallization temperature by as much as 20°C while barely reducing its melting temperature (Figure 1). The addition of a compatibilizer to improve Vistamaxx polymer dispersion in PET does not affect this trend.

Figure 1: Melting (left) and crystallization (right) temperatures measured by DSC(1)



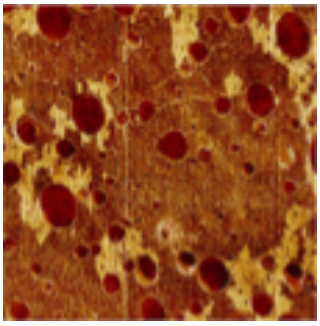


(1) Test method: ExxonMobil method

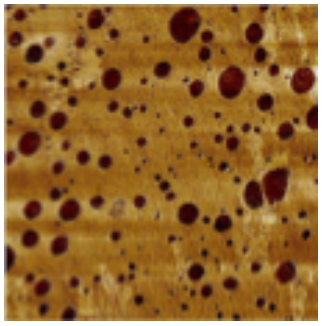
Controlling the blend morphology by selecting the right compatibilizer

Polar polyesters and nonpolar polyolefins are not compatible. Although intensive mixing during compounding might disperse an incompatible modifier in PET, the modifier might coalesce downstream and form large domains with limited adhesion to the PET matrix, leading to poor mechanical properties. The use of non-reactive polyolefins as modifier of PET has been therefore limited to a minority of the cases and reactive modifiers are usually preferred, even though the latter usually imply higher raw material cost. By choosing the right compatibilizer (e.g. grafted polyolefinic elastomer like Acti-Tech 16MA13), nonpolar polymers like Vistamaxx™ performance polymers can be used to effectively modify PET. The compatibilizer: modifier ratio plays a key role in defining the morphology of the blend. The micrographs below show atomic force microscope (AFM) images of PET/Vistamaxx polymers blends using different content of compatibilizer. It can be seen that by varying the compatibilizer: modifier ratio, blend morphology changes from relatively large Vistamaxx polymers domains (Figure 2, Blend A) to finely dispersed regular submicron sized Vistamaxx polymers domains (Figure 2, Blend D).

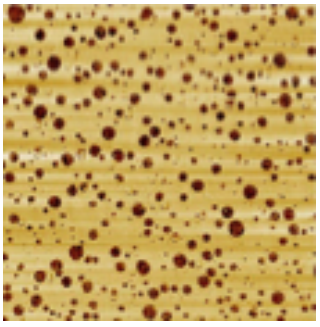
Figure 2: AFM micrographs of blends with varying compatibilizer content. AFM image size: 20 µm x 20 µm. Non-continuous, darker domains are Vistamaxx polymers.



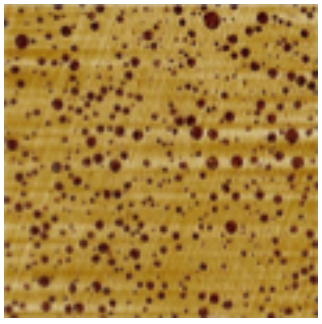
Blend A



Blend B



Blend C



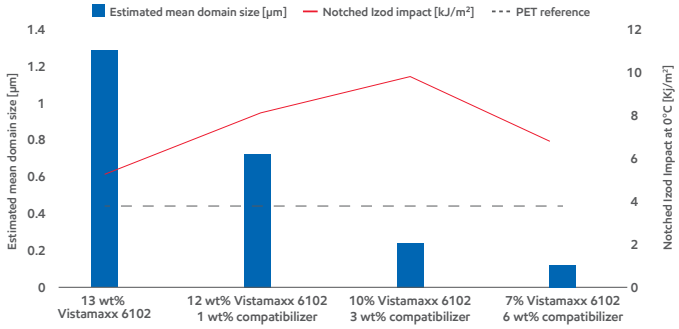
Blend D

	Formulation [wt%]		
Blend	**PET**	**Vistamaxx 6102**	**Compatibilizer**
A	87	13	-
B	87	12	1
C	87	10	3
D	87	7	6

Impact strength improvement using Vistamaxx performance polymers

The properties of the blend are strongly dependent on its morphology. The higher the compatibilizer: modifier ratio the smaller the size of the Vistamaxx polymers domains. Figure 3 shows an estimation of the mean domain size obtained via image analysis of the AFM micrographs shown in Figure 2. The optimum compatibilizer: modifier ratio seems to be around 3: 10. Further addition of compatibilizer, although reducing further the size of Vistamaxx polymers domains, not only is less attractive from a raw material cost standpoint but also does not yield further toughening.

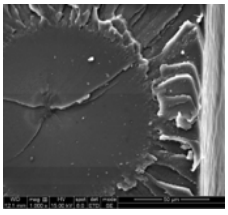
Figure 3: Estimated mean domain size(2) and notched Izod impact strength(3) at 0°C



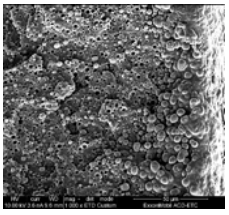
(2) Domain size was estimated via image analysis. Values are indicative only and should not be interpreted as specifications.
(3) Test method: Based on ISO 180 1/A

Inspection of scanning electron microscopy micrograph of fracture surfaces of tested notched Izod specimens at 0°C reveals the toughening mechanisms taking place when the right compatibilizer is present. Figure 4, PET reference presents relatively featureless fracture surface of the reference PET, characteristic of brittle materials. When Vistamaxx polymers without compatibilizer are added, the crack follows the weak Vistamaxx polymers/PET interfaces, increasing the surface area created during crack propagation, and consequently consuming more energy during fracture (Figure 4, Blend A). When a compatibilizer is used, stronger interfaces are obtained and plastic deformation of the PET is promoted resulting in a much tougher blend (Figure 4, Blend C). As shown in Figure 5, combining Vistamaxx polymers with a compatibilizer, PET impact strength is improved not only at room temperature but also at low temperatures (-20°C).

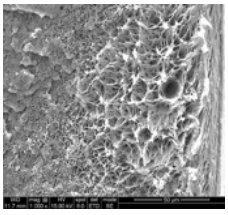
Figure 4: SEM micrographs of fracture surface of notched Izod specimens fractured at 0°C



PET reference

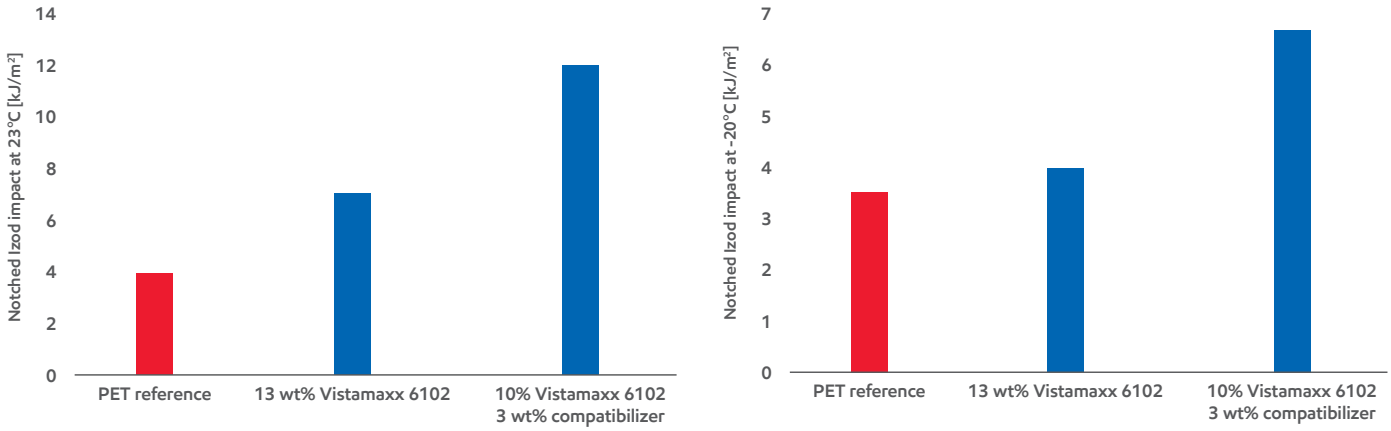


Blend A



Blend C

Figure 5: Impact strength. 13 wt% loading in PET at different temperatures[3]



(3) Test method: Based on ISO 180 1/A

Raw material properties[4]

	Arnite 04 900	Vistamaxx 6102	Acti-Tech 16MA13
Description	Medium viscosity, nucleated polyethylene terephthalate	Polypropylene copolymer	Maleated polypropylene copolymer
Density (g/cm³)	1.37	0.86	0.86

(4) Properties taken from corresponding product datasheets.

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