

# DuPont Packaging & Industrial Polymers

## Enhancing Package Performance, Value and Sustainability with Modifiers

### WHITE PAPER

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#### **Introduction**

A wide range of DuPont materials and technologies is available to meet needs for packages of different kinds. They enable brand owners to meet consumers' needs for convenience, product freshness and safety, and they help reduce waste, cut packaging costs and improve sustainability.

Most people in the packaging industry recognize DuPont as a resource for polymers that function on their own as package constituents. Many packaging pros are unaware, however, that our materials can modify other polymers to enhance package performance, sustainability and affordability.

DuPont modifiers can:

- Improve mechanical properties, making materials stronger or tougher, thus reducing waste on the packaging line and along the distribution chain.
- Enhance seal strength and reliability. In so doing, they deliver the sustainability benefit of reducing packaging waste.
- Improve adhesion of non-polar resins, like polyethylene, to foil or paperboard by altering the polarity.
- Modify viscosity to add melt strength and improve scrap recyclability.

DuPont modifiers are also used to improve the compatibility of dissimilar polymers, increasing the value of blends and alloys by improving properties such as strength, toughness or clarity. And in so doing, compatibilizers enhance sustainability by enabling the recycling of industrial scrap and post-consumer waste into higher-value products.

DuPont resins may be used also as coupling agents and processing aids. These two types of applications are not covered in this white paper.

The DuPont offering in property enhancers is quite extensive. To give you a flavor of their value, this paper provides examples to illustrate how they improve package performance, sustainability and affordability.

#### **Making Polymers Tougher**

Here's a group of examples showing how DuPont modifiers boost the toughness of three different packaging polymers, namely PLA, PET and polyamides.



*The miracles of science™*

**Toughness and More for PLA**

Many packagers and retailers are turning to polymers like polylactic acid (PLA) because they are renewably sourced. But unmodified PLA polymers are brittle and easily break during processing or in final use.

As **Figure 1** shows, adding just 1 to 5% of DuPont™ Biomax® Strong to PLA makes it much tougher. Increased toughness for PLA has three benefits. First, it reduces damage during packing, shipping and handling. Second, it opens up the possibility of using thinner, lighter packages. Finally, toughening increases productivity in making thermoformed packages by allowing easier and cleaner trimming from the forming web. The later effect reduces cost and improves sustainability by reducing extrusion scrap. Biomax® Strong also enables increased recycling of scrap produced in extrusion and thermoforming.

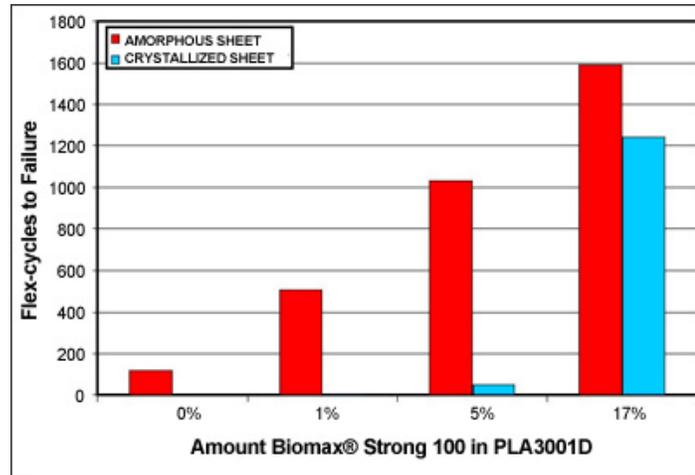
But improving toughness isn't the only benefit of adding Biomax® Strong to PLA.

**Figure 2** shows that the addition of 2 to 5% Biomax® Strong can save up to 30% on power consumption in PLA extrusion.

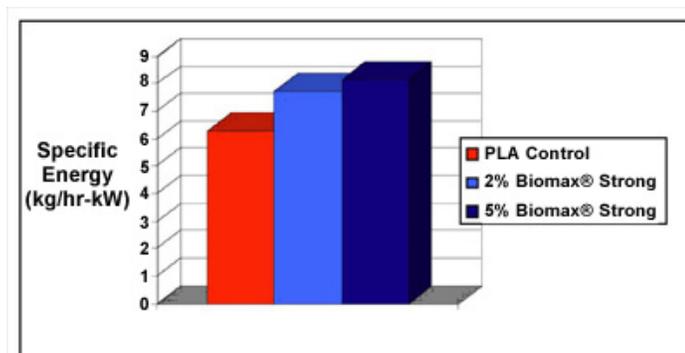
Another PLA shortcoming is that unmodified film makes a crinkling noise when handled, which is undesirable in snack bags. Biomax® Strong can significantly reduce such noise as shown in **Figure 3**.

Finally, although Biomax® Strong reduces the clarity of PLA, the modified material maintains sufficiently good contact clarity to show package ingredients to good advantage (**Figure 4**).

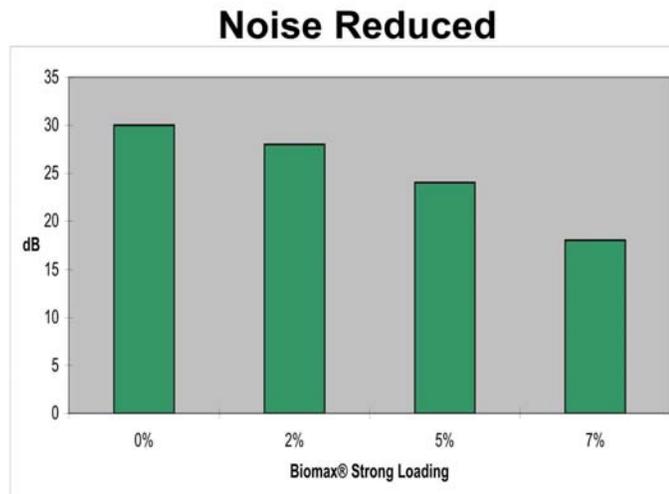
**Figure 1. Biomax® Toughens PLA**



**Figure 2. Less Energy for PLA Processing**



**Figure 3. Quieter Snack Packages**



**Figure 4. Excellent Contact Clarity****Figure 5. Refrigerated Food Packages, Like This, Need to Resist Damage Down to -10°C**

### ***Toughening APET***

Thermoformed amorphous PET (APET) trays are widely used for packaging refrigerated foods (**Figure 5**). These trays require additional toughness in order to resist damage at refrigerated temperatures (0 to -10°C).

DuPont™ Elvaloy® AC can provide the required level of low-temperature toughness in APET and cost-saving benefits as well. It improves regrind recyclability by compensating for the loss of melt viscosity that occurs in second and subsequent passes through the extruder. Another benefit of Elvaloy® AC's viscosity-building action is that it can allow the use of lower-cost, lower-viscosity PET polymers.

It is possible to achieve even higher levels of toughness in APET by adding a compatibilizer to the blend. But since modification with Elvaloy® AC alone can meet the low-temperature toughness target for refrigerated foods, packagers consider that the added cost is not justified.

### ***Toughening Crystallized PET (CPET)***

CPET Trays used to package frozen meals require excellent low temperature toughness as they are packaged at temperatures in the -30 to -40°C range. To achieve it, higher concentrations of Elvaloy® AC and a compatibilizer to improve the dispersion in PET must be added to provide adequate toughness. DuPont has two compatibilizer options for that purpose.

One of them is an Elvaloy® terpolymer that reacts with PET and blends well with Elvaloy® AC. The combination of Elvaloy® AC and the Elvaloy® terpolymer provides the requisite level of low-temperature toughness.

The other compatibilizer option is a DuPont™ Surlyn® sodium ionomer resin. In addition to improving the dispersion of the toughener in the PET matrix, Surlyn® also acts as a nucleant: it accelerates the crystallization of PET during the first stage of the two-stage forming process used to make CPET trays. This avoids the need for a separate nucleating ingredient.

The additive package of Elvaloy® AC and either compatibilizer also minimizes cost in two ways. One is that the reactive Elvaloy® maintains melt viscosity, thus improving regrind recyclability and it allows for use of lower viscosity and less expensive PET polymers.

### Making Tougher Polyamide

DuPont has two very effective tougheners for polyamide, DuPont™ Fusabond® or DuPont™ Surlyn®.

The choice between the two depends on a number of factors. They include end use temperature, degree of toughness needed in the use temperature range, package format, whether the material is in direct contact with food, processing issues such as the mixing capability of the existing extruder screw, and other property requirements such as puncture resistance or clarity. Finally, the choice of toughener depends on whether the performance of the modified product justifies its cost.

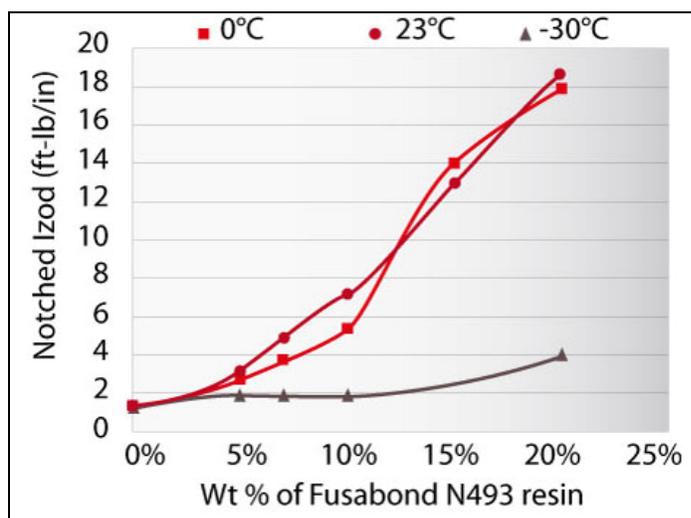
Fusabond® is the most effective toughening modifier for polyamide in our product portfolio. As shown in **Figure 6**, it enables super-tough performance in PA6 at 15% to 25% loading. Fusabond® is also quite effective at very low temperatures, as shown in the gray -30°C curve in the chart. If only moderate toughening is required, a reduced loading of less than 15% can be used. Use of twin-screw extruders (separate compounding step) or modified screw designs in single screw equipment may be required to obtain the proper dispersion of Fusabond® in the nylon matrix.

Polyamide polymers modified with Fusabond® are not acceptable for direct food contact. However, in most multilayer food packages, the polyamide layer is inside the structure and does not come into contact with the food product. Typical applications include multilayer barrier bottles and puncture-resistant films for red meat.

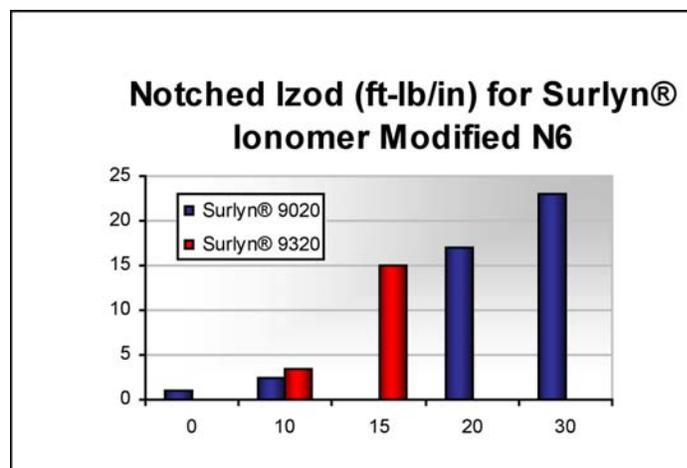
DuPont™ Surlyn® provides excellent toughening of PA 6 and PA 6,66 copolymers at ambient and refrigerated temperature (**Figure 7**). At higher loadings of Surlyn®, polyamides can reach super-tough levels at room temperature.

Surlyn® can be used in polyamides in direct food contact. It adds gloss to nylon films, although clarity is reduced. Applications include multilayer films and bottles.

**Figure 6. Fusabond® Toughens PA6**



**Figure 7. Surlyn® Toughens Polyamides**



A major advantage for Surlyn® is that it readily disperses in the polyamide matrix. It can be easily dispersed with a single screw extruder fitted with a good mixing screw.

### Modifiers to Meet Other Needs

You can also rely on DuPont polymer modifiers to improve polyolefin sealing performance, pigment dispersion, PE-to-foil adhesion or resistance to static buildup.

#### **Improved polyethylene sealing**

Polyethylene is a widely used sealant in packaging applications, but sometimes does not provide adequate sealing properties. DuPont™ Elvaloy® AC provides the needed assistance. It increases seal strength and improves key sealing characteristics by reducing seal initiation temperature, broadening the hot tack range, and increasing hot tack strength. The bottom line is greater seal reliability, faster speeds on the packaging line and fewer failures on the line and along the distribution chain.

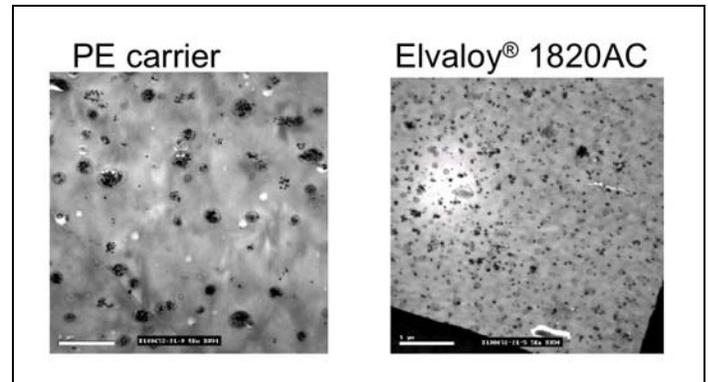
#### **Finer masterbatch dispersion improves properties**

Elvaloy® AC also gives outstanding performance as a masterbatch carrier resin for pigments and other additives. It is relatively compatible with most packaging polymers, including polyamides, PET, most polyethylene types, polypropylene, polycarbonate and PVC.

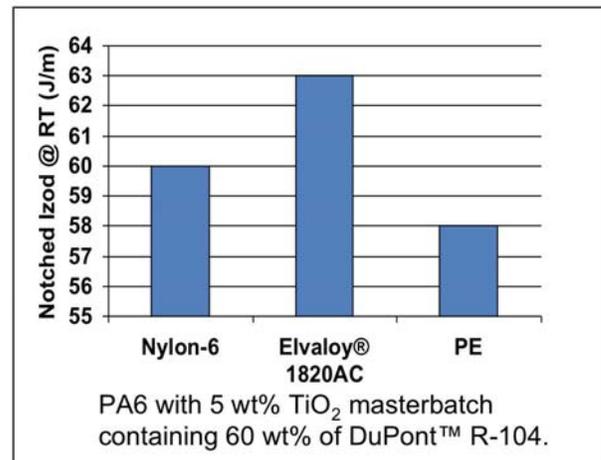
Elvaloy® AC provides a number of other advantages over alternative carriers such as PE, EVA or other competitive EMA resins:

- Finer dispersion of additives and fillers (**Figure 8**), including materials that are difficult to disperse;
- Increased impact resistance for filled resins (**Figure 9**);
- Broader compatibility with polar and non-polar additives used to improve toughness and stress crack resistance.
- Savings on additive costs because it enables lower additive loading for the same level of effectiveness.
- Acceptance of very high additive loading when required.
- High thermal stability, up to 300°C, much higher than that of EVA carriers.
- Higher melting temperature than other EMA carriers, with less sticking in the feed hopper.

**Figure 8. Improved Filler Dispersion**



**Figure 9. More Impact Strength for Filled Compounds**



To sum up, masterbatches using Elvaloy® AC deliver higher performance and can save costs compared with concentrates using alternative carrier resins.

### ***Conquering Static in Polyolefins***

When it comes to combating static charges in polyolefin packaging, DuPont™ Entira™ overcomes the limitations of many other antistatic agents. It has outstanding performance, even at low humidity. Unlike antistats that can migrate, Entira™ is permanent and takes effect instantaneously.

The use of Entira™ delivers several benefits and performance advantages. They include:

- Pristine shelf presentation of the package without dirt pickup;
- Reduced in-plant static problems or hazards.
- Excellent, lasting clarity with no yellowing.
- Good processibility
- Maintenance of a polyolefin film's smooth surface for printing, sealing, labeling.

Packages that can benefit from Entira™ antistat modifier include liners for powder and granule packages, packaging bags, bottles and thermoformed cups, tubs, etc.

### ***Foil Adhesion Without Priming***

LDPE films used in foil/film structures and metallized films usually require a separate, solvent-based primer layer to bond the LDPE polymer PE to the metallic elements. Modification of LDPE with DuPont™ Nucrel® AE can eliminate the need for the primer. It's a solid, solvent-free material that releases virtually no VOC during extrusion.

Nucrel® AE works well in all of the extrusion processes used for LDPE, including conventional extrusion coating, coextrusion coating and extrusion laminating. The degree of adhesion improvement depends on blend composition and processing conditions. Typical use levels range from 20 to 40%

Kinds of packages that benefit from Nucrel® AE include foil-containing pouches, sachets for food and non-food products and snack packaging structures. In other foil, metallized film, or coated paper applications Nucrel® AE can serve as a heat-seal or tie layer.

### **Compatibilizers Enable Dissimilar Polymers to Work Together**

Driving to increase sustainability and reduce costs, manufacturers of consumer packaged goods and their converter suppliers are increasing recycling of mixed scrap generated in making multilayer packages. Further downstream, recyclers of post-consumer waste are aiming to make materials and products of higher value from mixed and contaminated waste streams.

DuPont compatibilizers meet the recycling needs of both groups. They help improve production efficiency, reduce the waste load and reduce costs by enabling the production of high-value materials and products with greater toughness and strength than those of unmodified mixed waste.

One of our best and most versatile compatibilizers, Fusabond®, enables in-line recycling of multilayer scrap made with a variety of materials. These include high barrier rigid and flexible packaging containing PE/PA, PE/EVOH, Surlyn®/EVOH, Surlyn®/PA, PP/PA or PP/EVOH.

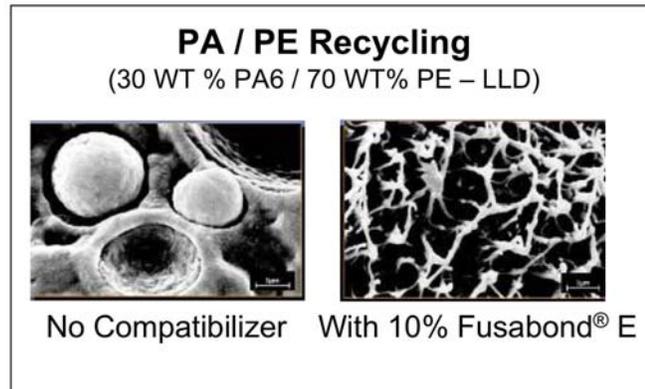
### **Improved Dispersion Improves Properties**

Fusabond® sharply improves the toughness and strength of final products because it enables a fine dispersion of mixed polymers in each other.

**Figure 10** shows the effect of Fusabond® on dispersion in a 30/70 mixture of PA6 and LLDPE.

By allowing the reuse of mixed scrap, Fusabond® lowers the cost of multilayer packages and reduces the package's environmental footprint.

**Figure 10. Excellent Dispersion Improves Recyclate Properties**



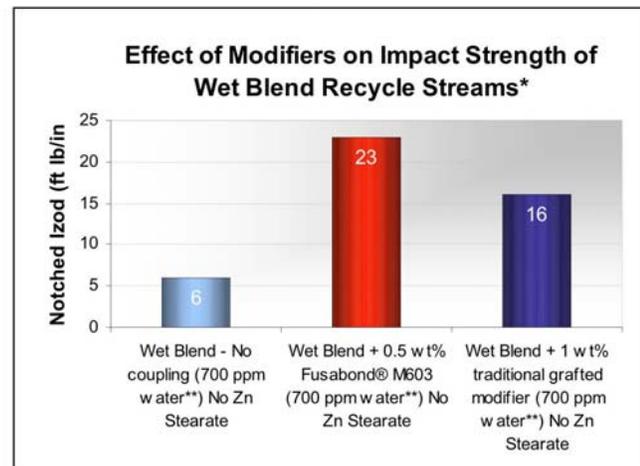
Fusabond® also provides another benefit in films containing polyamide and/or EVOH layers: reduced haze and gels.

### **PE/EVOH Blends Get Tougher**

Fusabond® delivers dramatic improvement in the impact resistance of PE/EVOH blends at very low additive levels, even in wet conditions. Only 0.5% of Fusabond® provided nearly four times the impact resistance of a blend without compatibilizer (**Figure 11**). The wet blend represents the case in which the hygroscopic EVOH material has absorbed considerable moisture after original processing.

The same 0.5% addition of Fusabond® raises notched Izod to nearly 5 times the level of an unmodified blend (**Figure 12**). In this case the blends were dried.

**Figure 11. Wet EVOH Blends Get a Lot Tougher**



In both cases, we also measured the effect of an alternative traditional compatibilizer at 1% addition level, as shown in the dark blue columns on the right in the charts. Fusabond® provided much greater impact resistance than the alternative at half the use level. Fusabond® is also effective in the presence of processing aids, such as stearates (**Figure 12**).

To sum up, Fusabond® as a compatibilizer for mixed PE and EVOH waste raises product performance, reduces cost and advances sustainability.

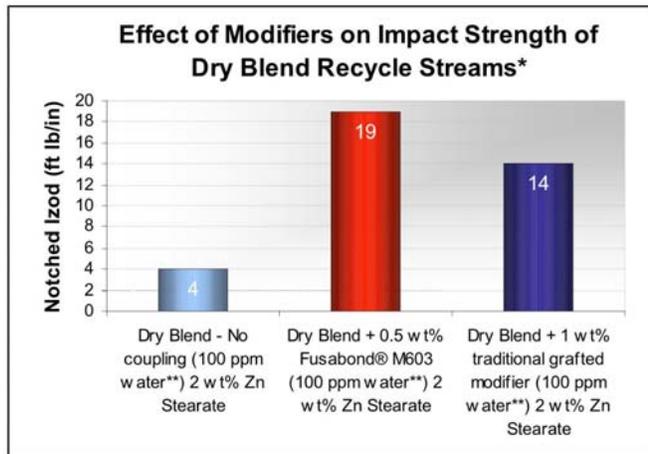
Fusabond® is also a highly effective compatibilizer for mixed polyamide and polyethylene scrap. When no Fusabond® is used, test samples made from a 70/30 mixture of PE and PA 6 are very brittle. But when the mixture is compounded with 6% Fusabond®, its elongation exceeds 500% (**Figure 13**). Again, Fusabond® as a compatibilizer raises product performance, reduces cost and increases sustainability.

**Upgrading Post-Consumer PET/PE Scrap**

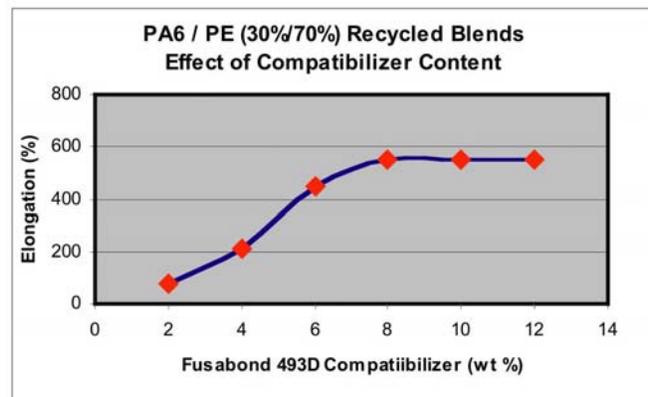
Thanks to curbside collection programs, a large waste stream of PET and PE bottles exists today. Despite advances in separation technology, contamination of PE streams with PET and vice versa is common.

DuPont offers two viable ways to upgrade the performance of such mixed waste streams, Elvaloy® PTW and Fusabond®. Both compatibilizers improve the toughness of the mixed stream by promoting dispersion of one polymer in the other. **Figure 14** shows the improvements in elongation at break and impact strength achieved in a 25/75 blend of PET and PE by using each compatibilizer.

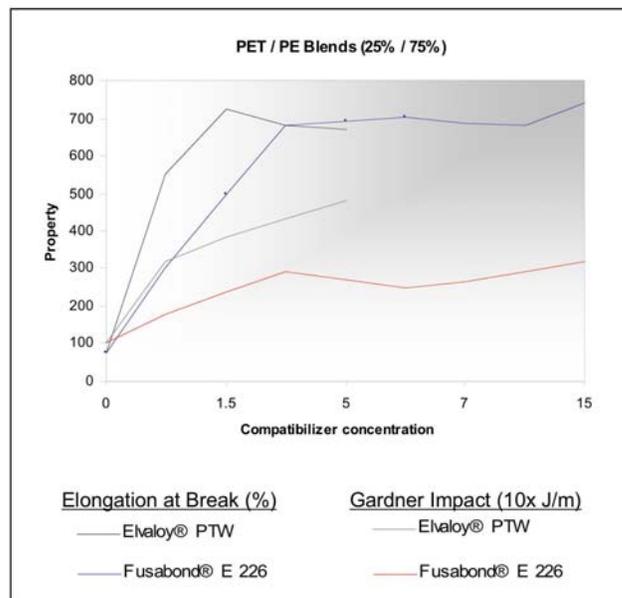
**Figure 12. Dry EVOH Blends Get Tougher, Too**



**Figure 13. Brittle PE/PA Scrap Gains**



**Figure 14. Adding value to Curbside Scrap**



## Summary

DuPont modifiers and processing aids can deliver benefits in a wide range of packaging structures. They can help packagers and converters reach their business goals in three ways: raising performance, reducing costs and making the production and use of packaged goods more sustainable by cutting waste volume and weight.

This paper illustrates the benefits achieved with several DuPont modifiers and compatibilizing agents. The products covered represent only about half of our line of such ingredients. To learn more about our full range, please visit [www.packaging.dupont.com](http://www.packaging.dupont.com).

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