Improving performance characteristics of polyamides

Dow offers high quality impact modifiers for engineering polymers to the automotive, consumer and E&E (Electrical and Electronics) industries. A dedicated team is focusing on supporting innovation and growth through technical expertise.

Polyamide Modification

Polyamide (nylon) thermoplastic resins offer an excellent balance of processibility and performance properties and therefore are widely used. Of the many types of polyamide available, the most popular are polyamide 6 (PA 6) and polyamide 6,6 (PA 6,6). Several end-use applications for these resins require improved impact and flexibility performance at ambient or low temperatures. For these applications, toughened grades of polyamide can be used.

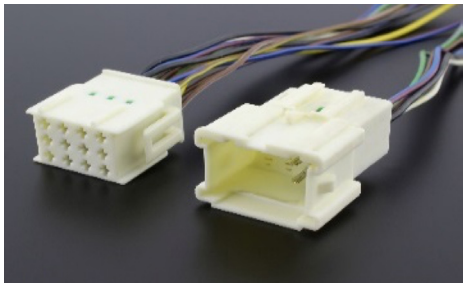
Our Impact Modifiers for Polyamide 6 and 6,6 and long-chain polyamides

Dow offers several polymer modifier technologies that can be used for polyamide toughening. These technologies typically combine increased low-temperature impact properties, with good adhesion to the polyamide. The adhesion is primarily achieved by the reaction of the amine group of the polyamide polymer with the fuctional group of the tougheners. Selected reactions are shown to the right.

Our FUSABOND™ N functional polymer grades are anhydride modified polymers, selected from Dow's extensive range of polyolefin elastomers such as ENGAGE™ polyolefin elastomers and NORDEL™ EPDM. They provide compounders with high-flow impact modification for tough and super-tough PA 6, PA 6,6, and long-chain polyamide compounds including good performance at very low temperature.

Our FUSABOND™ A is a modified ethylene-acrylate copolymer. It provides compounders with a very good combination of flow and toughness for glass-filled polyamide compounds.

Our SURLYN™ ionomer grades provide good impact resistance, improved flow and high gloss to polyamide. For further regulatory information, please find our contact information at the bottom of this document.



Electrical & Electronics

Automotive

High voltage connectors

Consumer

Cable ties/cable binders

OUR PORTFOLIO: FUSABOND™ N, FUSABOND™ A, SURLYN™

Product Overview

The table below provides an overview of the portfolio presenting both physical characteristics and level of grafting (where applicable). Latest additions to the FUSABOND™ N portfolio are highlighted.

Impact modifier	Base Polymer	Grafted MAH	Melt index (190 °C, 2.16kg) dg/min	Density (g/cm3)
FUSABOND™ N495	**Polyolefin Elastomer**	**Medium**	**1.4**	**0.860**
FUSABOND™ N598	Polyolefin Elastomer	Medium	2.0	0.870
FUSABOND™ N493	Polyolefin Elastomer	Medium	1.6	0.870
FUSABOND™ N215	**Polyolefin Elastomer**	**High**	**1.3**	**0.875**
FUSABOND™ N216	**Polyolefin Elastomer**	**High**	**1.3**	**0.875**
FUSABOND™ N525	Polyolefin Elastomer	High	3.7	0.880
FUSABOND™ N302	**EPDM**	**Medium**	**1.2**	**0.875**
FUSABOND™ N416	EPDM	High	23*	0.869
FUSABOND™ A560	**Modified Ethylene Acrylate Copolymer**		**5.6**	**0.930**
SURLYN™ 9520	**Ionomer**		**1.1**	**0.950**
SURLYN™ 9020	**Ionomer**		**1.0**	**0.960**
SURLYN™ 9320	**Ionomer**		**0.8**	**0.960**
SURLYN™ 1705	**Ionomer**		**5.5**	**0.950**

* Melt index measured @ 280 °C, 2.16 kg
1. Measured by DSC

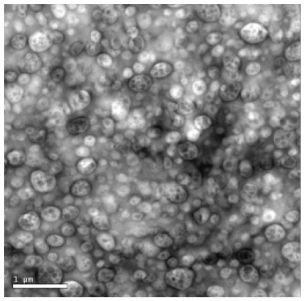
Product comparison of highly compatible modifier chemistries

The comparison of micrographs from impact modified PA 6,6 compounds with our different modifier chemistries shows that small particle size and uniform particle size distribution can be achieved with MAH grafted elastomers from the FUSABOND™ N family and that the higher polarity of FUSABOND™ A acrylate copolymer and SURLYN™ ionomer allows for even finer modifier particle dispersion.

20% Loading of Modifiers in PA 6,6 (TEM)

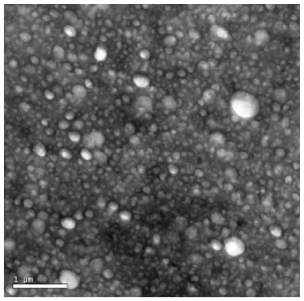
Fusabond functional polymers

FUSABOND™ N493
Avg: 200 nm



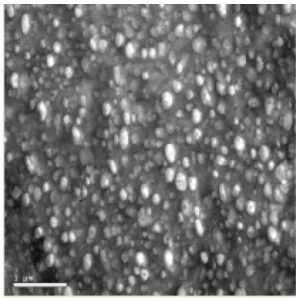
Fusabond functional polymers

FUSABOND™ A560
Avg: 80 nm



Surlyn ionomers

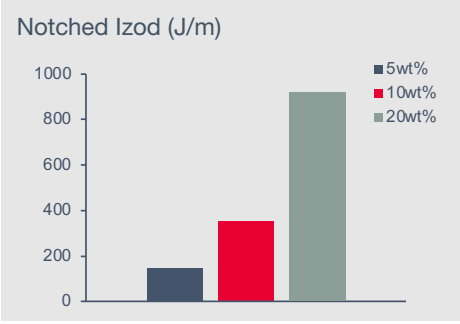
SURLYN™ 9320
Avg: 150 nm



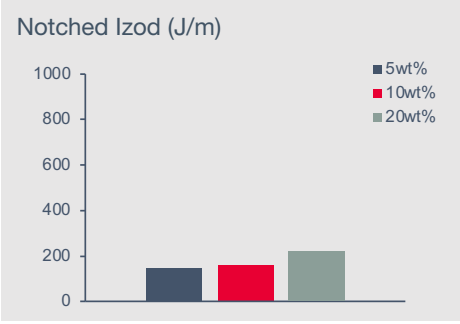
PA 6 Modification – Notched Izod Impact Resistance at 23 °C

For intermediate toughening, SURLYN™ 9020 is recommended for PA 6 besides FUSABOND™ N493. Advantages of using SURLYN™ modifier include its FDA compliance, its low color, excellent surface finish and short cycle time.

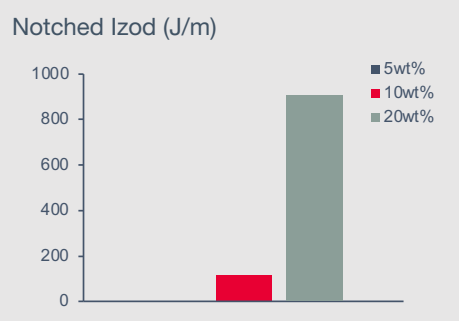
FUSABOND™ N493



FUSABOND™ A560



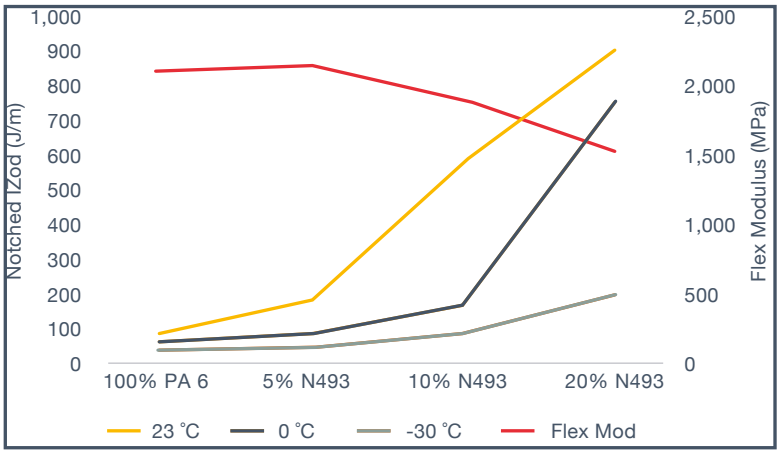
SURLYN™ 9320



OUR PORTFOLIO: for Polyamide 6 and 6,6

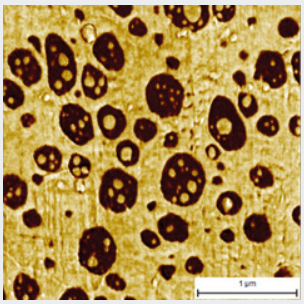
FUSABOND™ N493 has been a benchmark as a polyamide 6 and 6,6 impact modifier for a wide range of final applications. Adding different levels gives flexibility for the compound formulation to be adjusted to specific customer needs. The following graphs show the toughness level achieved at loadings between 5 and 20% in PA 6 and an overall performance comparison for FUSABOND™ N493, FUSABOND™ N216 and FUSABOND™ N495.

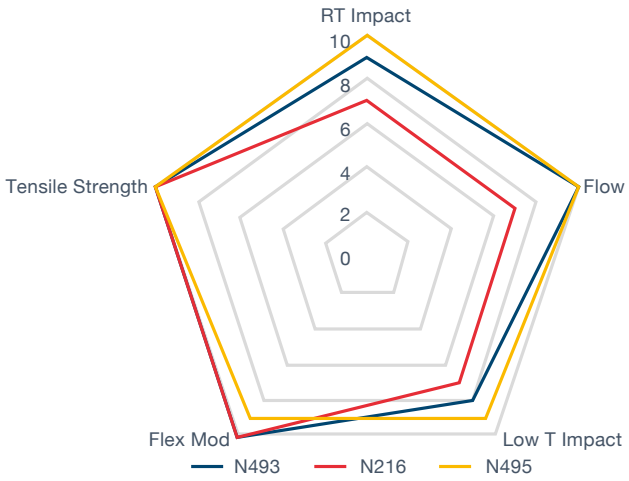
Tests conducted by Dow's R&D department show that FUSABOND™ N495 can be used to achieve a higher performance level (performance combination in terms of stiffness/toughness and flow) compared to FUSABOND™ N493.



PA 6 toughening using impact modifier FUSABOND™ N493.

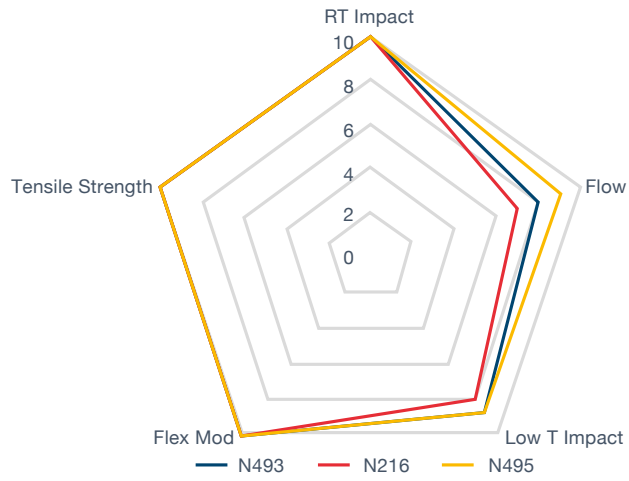
Morphology with well dispersed particles.





PA 6 toughening using different impact modifiers from the FUSABOND™ N family.

In PA 6 FUSABOND™ N495 shows the best impact performance at high and low temperature, at slightly lower modulus compared to FUSABOND™ N493.



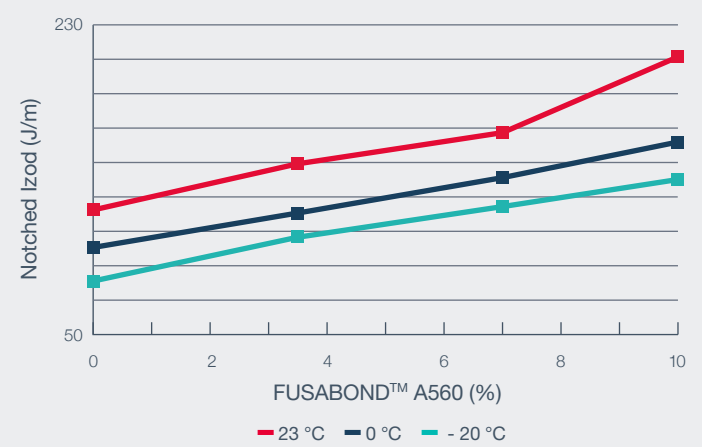
PA 6,6 toughening using different impact modifiers from the FUSABOND™ N family.

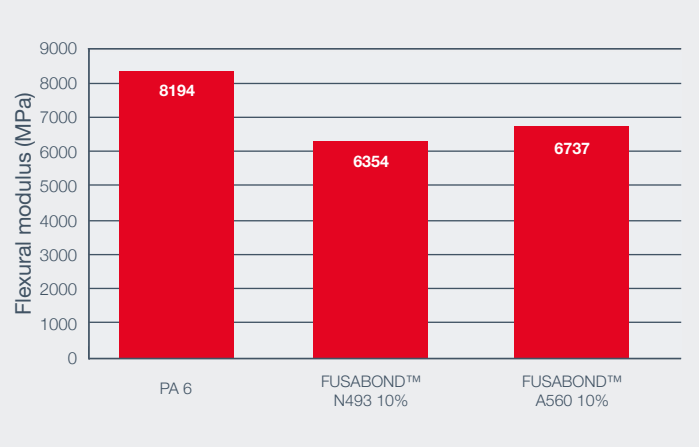
In PA 6,6 FUSABOND™ N495 reaches a high performance level with improved compound flow over FUSABOND™ N493.

OUR PORTFOLIO: for glass-filled polyamide

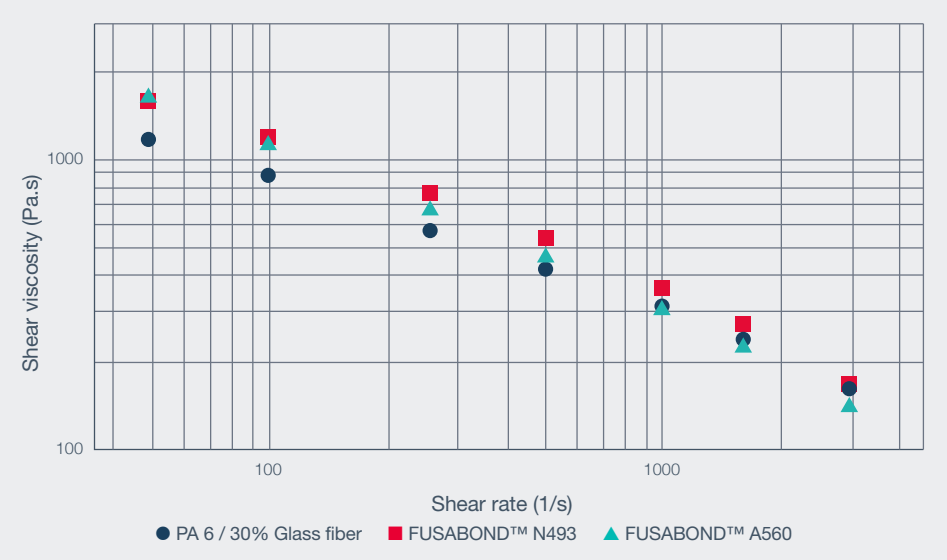
This chart shows the benefits of FUSABOND™ A560 in glass fiber reinforced PA 6 compounds. FUSABOND™ A560 is in particular effective at low addition levels and has the added advantage that flexural modulus and temperature resistance are only slightly reduced. MAH-grafted tougheners like FUSABOND™ N grades at the same concentration have a higher effect on stiffness and temperature resistance.

Toughening glass-reinforced polyamide 6 with FUSABOND™ A560 and FUSABOND™ N493 (30% Glass Fiber)





FUSABOND™ A560 reduces melt viscosity in the processing shear rate region compared to FUSABOND™ N493



Compounds toughened with FUSABOND™ A560 will show better flow, lower viscosity compared to compounds toughened with the same amount (10%) of MAH-grafted high performance tougheners such as FUSABOND™ N493.

Better flow of the glass reinforced polyamide compounds provide TIER 1/ part manufacturers with manufacturing efficiency benefits such as improved mold filling and better surface appearance of the glass filled molded parts.

Contact and more information

Contact your Dow representative or visit **Dow.com** to learn more about how our modifier and compatibilizer solutions for engineering polymers can help meet challenging requirements in automotive, consumer and E&E applications.

With our unique back-integration through ENGAGE™ and NORDEL™, combined with our technical know-how, we feel well-positioned to support your requirements. We invite you to work with us to explore innovative solutions that will help you succeed in your market.

Safety Data Sheets, Regulatory Data Sheets and Technical Data Sheets can be downloaded from our Dow website, www.dow.com, or you can request them from our Customer Information Group www.dow.com/contactus.

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