APPLICATION INFORMATION

TOUGHNESS MODIFICATION OF POLYAMIDE COMPOUNDS

TP-A 6

A member of ALTANA

Contents

The challenge

Polyamide, especially PA6 and PA6.6, has a broad range of applications including transportation, construction, and electronic applications. The brittleness of polyamide is one of its key limitations. To access a broad range of applications, from extruded sheets for construction to automotive under the hood applications, polyamide needs a toughness modifier.

For general purpose and low-cost toughness modification, terpolymers and core-shell particles are frequently used. However, those technologies provide only minor improvement in impact strength, with notched Charpy impact strength not exceeding 20 kJ/m².

To increase impact beyond this level, three key challenges need to be addressed:

- Efficient uptake of the impact load
- Proper energy dissipation
- Prevention of crack propagation

This requires interfacial compatibility between the polyamide matrix and impact modifier as well as effective dispersion of the elastomer phase.

Note

To ensure the best appearance and full functionality, please open in Adobe Acrobat.

The solution

SCONA TSPOE 1002 GBLL has reactive moieties, enabling it to act as an amphiphilic compatibilizer, thus building a tenside molecule with the base polyamide during compounding. This compatibilization reduces the interfacial tension between the polyolefin elastomer phase and the brittle polyamide matrix as well as improving dispersion of the elastomer phase. It must be emphasized that reactive blending of polyamides with polyolefins requires sufficient shear energy and optimized screw design.

SCONA TSPOE 1002 GBLL

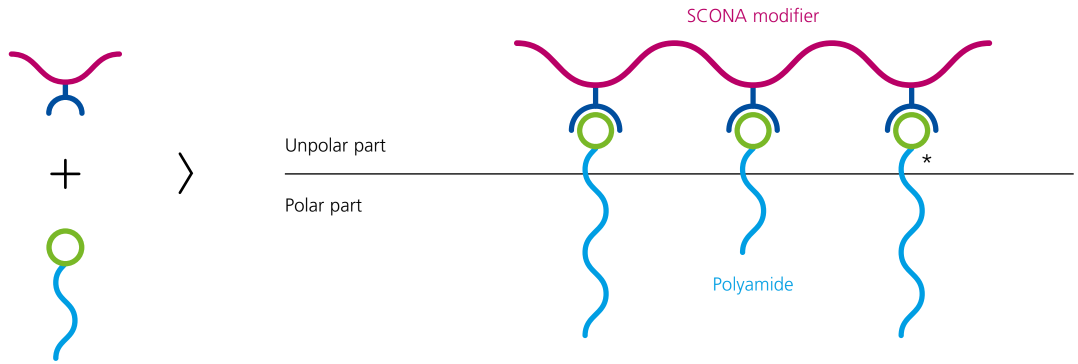
Product type
Maleic-Anhydride-Grafted Polyolefin Elastomer

Application
Polyamide Compounds

Key benefits
- Superior toughness modification
- Concentrate approach for maximum formulation freedom and cost optimization
- Excellent low temperature impact

Compatibility enhancement mechanism of SCONA TSPOE 1002 GBLL

Amphiphilic compatibilizer "tenside molecule"



Acidic/Anhydride group · Amine group · SCONA modifier · Polyamide

G.01

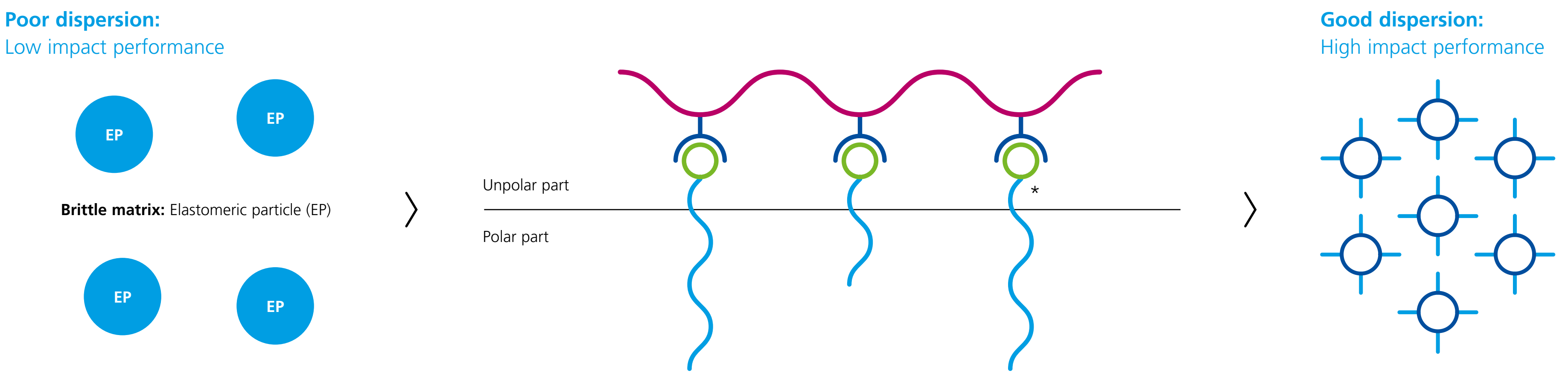
* Simplified reaction scheme with the amine end-group, however the internal amide groups can also take part in the reaction.

The degree of functionalization of SCONA TSPOE 1002 GBLL is up to three times higher than conventional impact modifiers for polyamide. This enables either superior toughening or the flexibility to combine it with virgin POE (polyolefin elastomer) for cost optimization. To take advantage of this degree of functionalization, high shear forces during compounding are required to ensure proper dispersion.

SCONA TSPOE 1002 GBLL is a maleic-anhydride-grafted POE with an exceptionally high level of grafting resulting in key benefits:

- Superior toughness modification
- Concentrate approach for maximum formulation freedom and cost optimization
- Excellent low temperature impact

Good dispersion for high impact performance



* Simplified reaction scheme with the amine end-group, however the internal amide groups can also take part in the reaction

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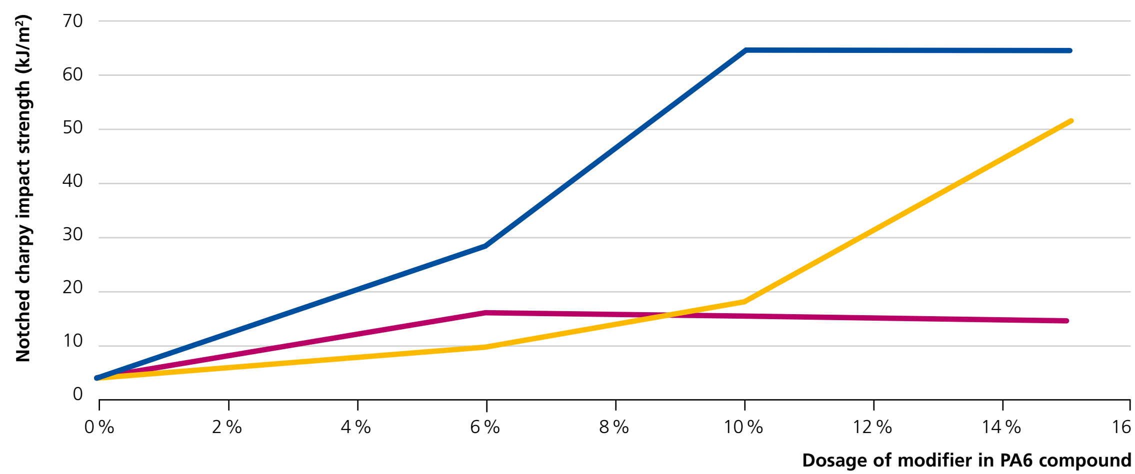
Superior toughness modification

As previously mentioned, typical terpolymers do not provide notched Charpy impact strength exceeding 20 kJ/m². Additionally, typical grafted elastomers can only exceed that above 10 % dosage. In contrast, SCONA TSPOE 1002 GBLL provides almost 30 kJ/m² at 6 % dosage, making it almost twice as effective. At 10 % dosage, SCONA TSPOE 1002 GBLL provides a **350 % increase in impact performance versus competitive technologies.**

Grafted-POE performance impact vs. dosage level

Impact strength of SCONA TSPOE 1002 GBLL vs. other additives



Competitive material: grafted elastomer
Competitive material: Ethylene-acrylic-MAH-terpolymer
SCONA TSPOE 1002 GBLL

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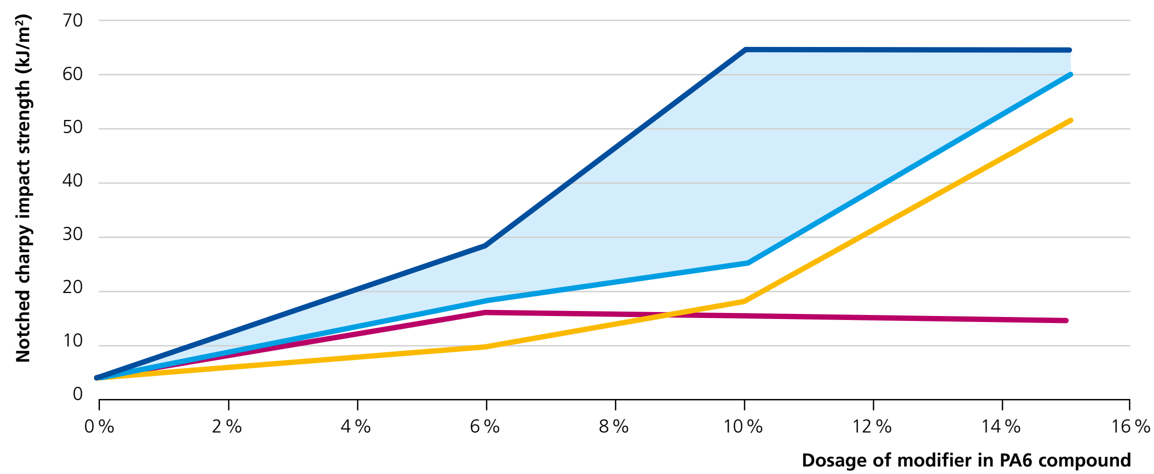
Concentrate approach for maximum formulation freedom and cost optimization

SCONA TSPOE 1002 GBLL is a superior toughener for polyamide and due to its high grafting level, it **can be diluted with unmodified POE and/or a polyethylene copolymer to meet a wide range of required impact performance.** BYK offers such a blended product, SCONA TSPOE 1002 CMB 1–2, that demonstrates this concept. Figure 4 highlights the improved performance of the blended product versus the competition.

The blue space in figure 4 between SCONA TSPOE 1002 CMB 1–2 (blended product) and SCONA TSPOE 1002 GBLL (unblended product) shows the flexibility of this technology. By diluting SCONA TSPOE 1002 GBLL with virgin POE, a compounder can achieve superior impact performance and benefit from cost savings.

Grafted-POE performance impact vs. dosage level

Increased impact strength range using SCONA TSPOE 1002 GBLL and SCONA TSPOE 1002 CMB 1–2



Competitive material: grafted elastomer
Competitive material: Ethylene-acrylic-MAH-terpolymer
SCONA TSPOE 1002 GBLL
SCONA TSPOE 1002 CMB 1–2

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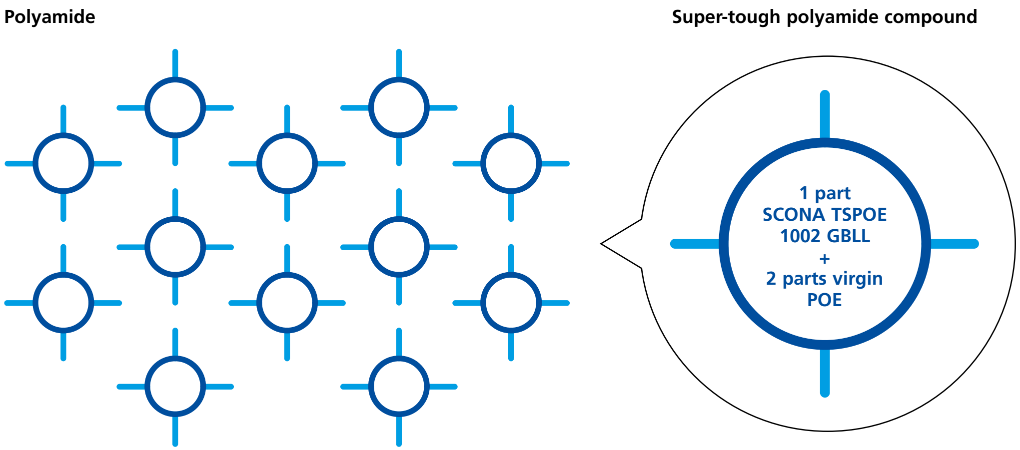
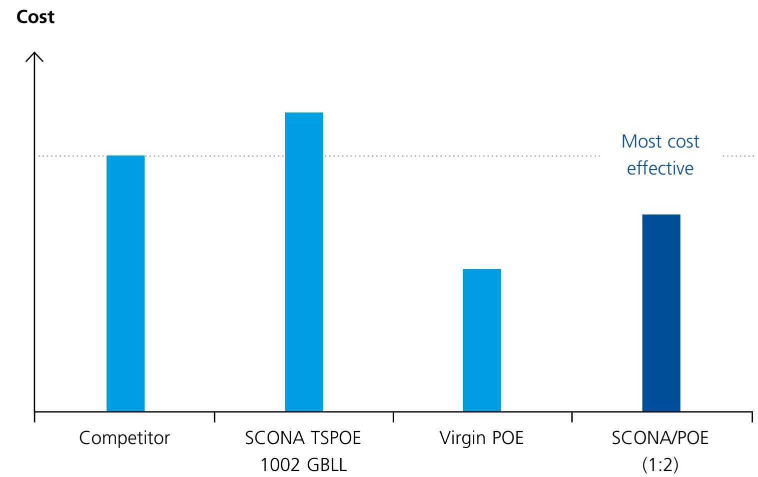
Optimized total cost using SCONA TSPOE 1002 GBLL and SCONA TSPOE 1002 CMB 1–2

Concentrate approach



Relative cost comparsion



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Excellent low temperature impact

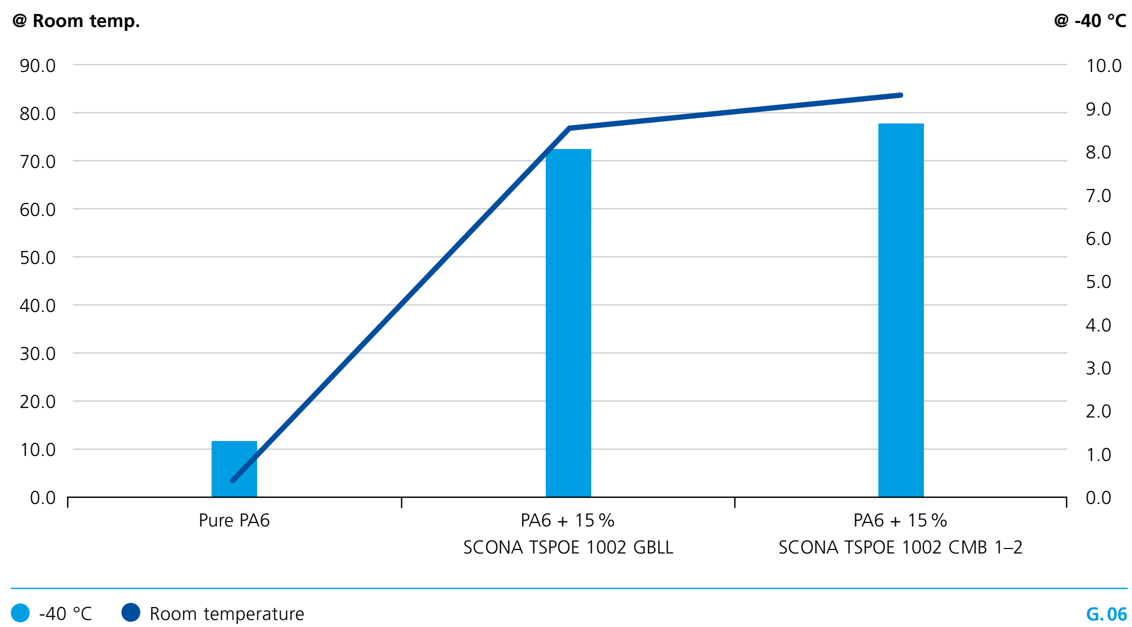
Good low temperature performance is critical to any application using polyamide. SCONA TSPOE 1002 GBLL and SCONA TSPOE 1002 CMB 1–2 both ensure impact strength improvement down to -40 °C. Figure 6 demonstrates increased impact performance of these two SCONA products at loadings of 15 weight%. Compared to virgin polyamide 6, notched **Charpy impact strength is increased by almost one order of magnitude.**

Conclusion

SCONA TSPOE 1002 GBLL is an impact modifier for polyamide compounds resulting in **superior toughness improvement** in polyamide compounds in temperatures down to -40 °C. Due to its high content of functional groups, it **can be used as a concentrate** and diluted with virgin (unmodified) polyolefin elastomer to provide both **performance flexibility** and **cost optimization.**

Improved low temperature impact performance of PA6

Notched Charpy impact strength
(kJ/m²)



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BYK-Chemie GmbH
P.O. Box 10 02 45
46462 Wesel
Germany
Tel +49 281 670-0
Fax +49 281 65735

info@byk.com
www.byk.com

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