INNOVATING FOR A BRIGHTER FUTURE:

Translucent TPO

Engage™ 11000 series polyolefin elastomers

The need

As the automotive industry evolves, manufacturers are looking for innovative lighting options that help their vehicles stand out – both on the road and in an increasingly crowded industry.

The rise of EV is driving a range of design trends – from "hidden" and "dimmed" lighting, to illuminated front bars and grilles, and customizable light signatures – which elevate a vehicle's aesthetics, increase differentiation, and enhance brand perception.

The opportunity

Producing vehicle parts like bumpers and fenders from translucent TPO (thermoplastic polyolefin) can unlock a range of exciting new exterior lighting opportunities, in addition to the material's inherent design and sustainability benefits:

TPO benefits

Design flexibility
TPO gives designers more creative freedom, because it's easier to style and process than comparable polymers.

Lightweighting
TPO is 30% less dense than either polycarbonate (PC) or PMMA.

Recyclability
Mono-material TPO parts can be recycled, unlike those made with mixed materials, without having to dismantle them into separate components.

Translucence benefits

"Hidden" lighting
Design exterior lighting that is only visible when turned on.

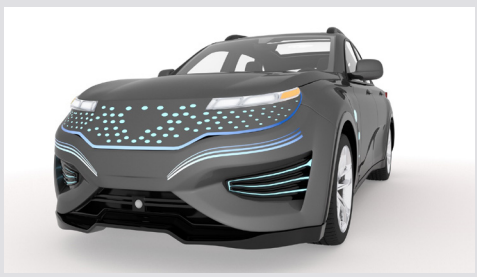
Integrated lighting
Integrate simple lighting systems, instead of adding a "clip-in" component.

Seamless bumpers
Hide radar sensors within the vehicle bumper.

"Hidden" exterior lighting: how it works

Backlight off

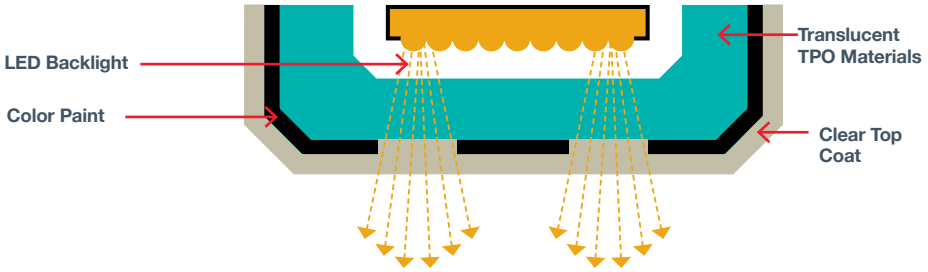
Backlight on



Styling/Aesthetics
- Brand logo
- Lighting patterns on grilles

Additional Lighting Signal
- Battery/charging indicators
- Dot matrix display

Cross-section of a translucent bumper



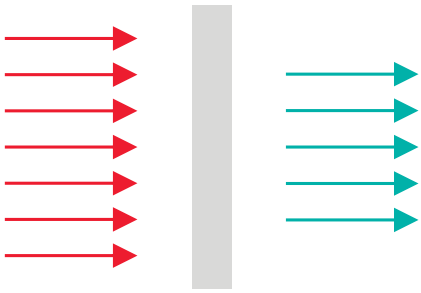
Key optical properties of translucent TPO compounds

This “hidden” lighting design requires the TPO to have a specific set of optical properties. These properties ensure that the material will allow enough light through with the right clarity and uniformity to create the desired visual effect.

Transmittance %

Preferably high: 30% – 60%

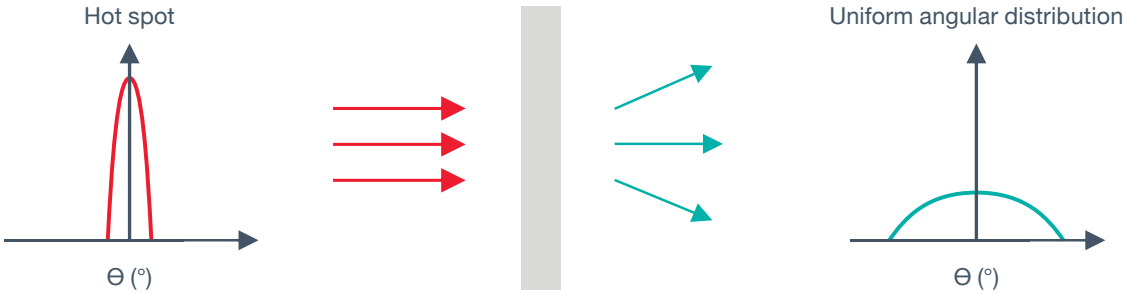
- Pure polypropylene (PP) ~70% transmittance at 3mm thickness
- Reduced by incorporating talc



Light diffusion

Uniform illumination, without LED hot spots

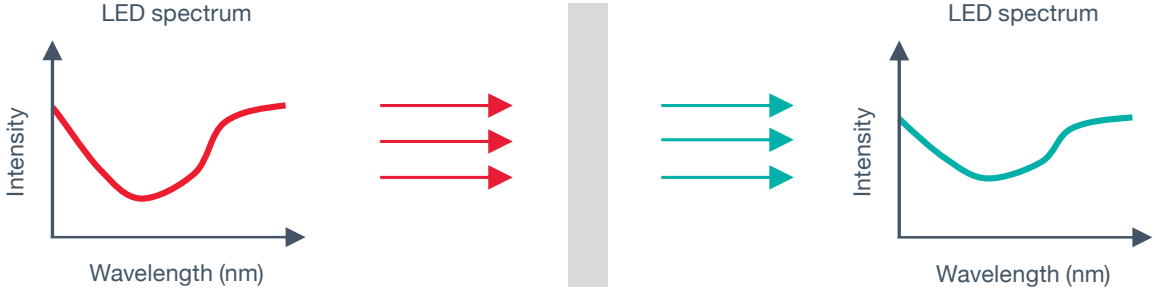
- Sufficient uniformity due to reinforcements, polyolefin elastomer (POE), and ~3mm thickness
- Relatively easy to enhance with low weight (%) light diffuser



Optical quality

Neutral intrinsic color as molded and after aging

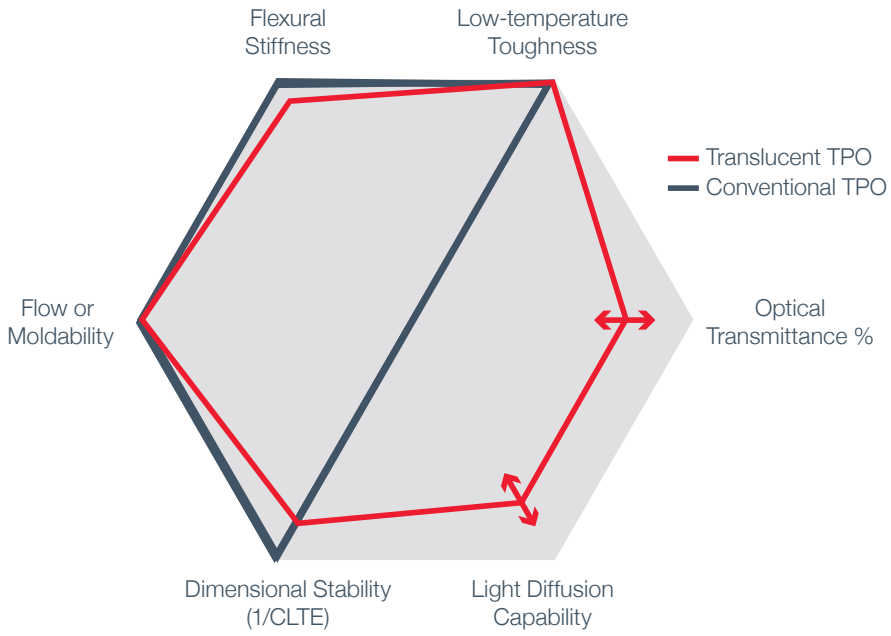
- POE and PP as color-neutral and UV/thermal-stable with additive or coating
- Additives can mitigate unwanted yellow/brown hue caused by talc reinforcements



The challenge

Achieving the right mix of characteristics

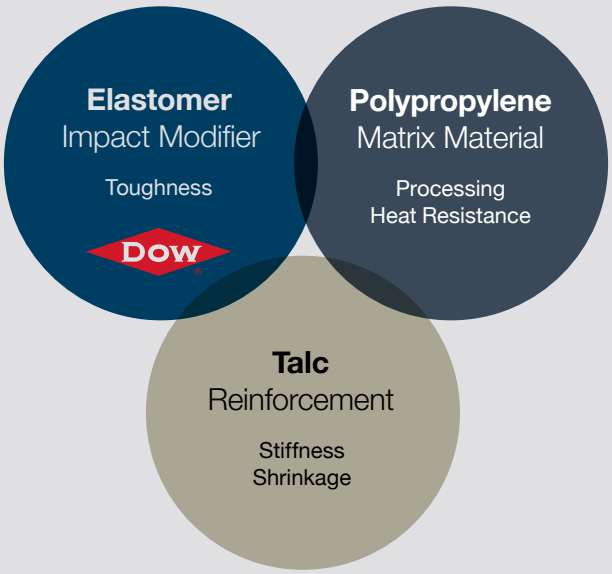
Applications like bumpers and fenders require a TPO formulation that offers the right combination of stiffness, moldability, low-temperature toughness and dimensional stability. However, in order to make TPO translucent, this formulation also needs to have two additional characteristics: **Optical Transmittance** and **Light Diffusion.**



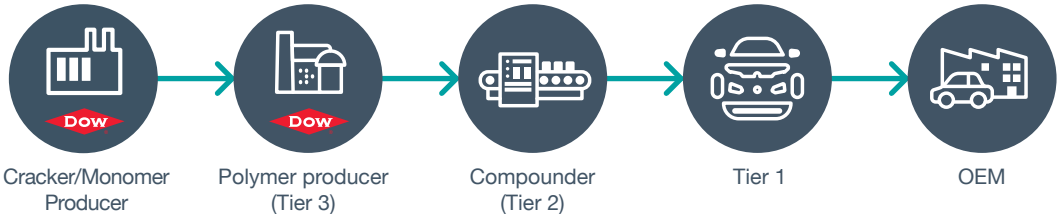
TPO design

TPO is a polymer blend with three ingredients: **polyolefin elastomer (POE)**, **polypropylene (PP)** and **talc**. The quantity of each ingredient can be adjusted to produce a formulation that delivers exactly the right balance of toughness, and stiffness.

Thermoplastic Polyolefin (TPO) Compound Design



Creating a TPO formulation that delivers all these characteristics, as well as translucence, is a complex materials science challenge, involving players across the value chain:



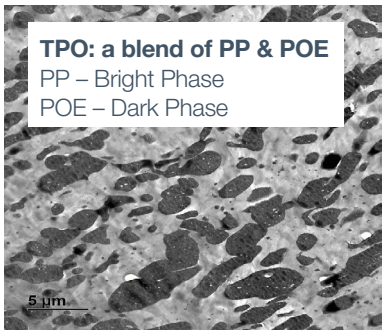
Factors to consider when designing a translucent TPO compound

A. Effects of POE choice on optical properties of TPO

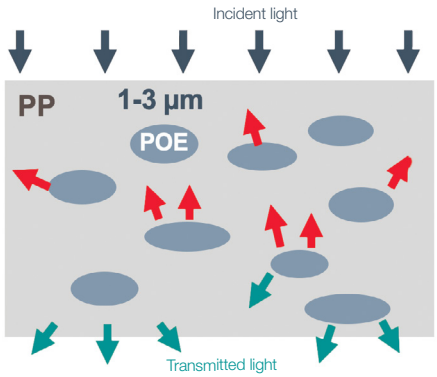
1. Particle size

The type of polyolefin elastomer (POE) used within the formulation is key to making TPO translucent: the smaller the particle size, the more light can pass through it, instead of being reflected back.

Reducing the particle size of the elastomer and its glass transition (Tg) also has the benefit of increasing the TPO's **low-temperature toughness** (Charpy notch and dart impact).



Light passing through TPO



2. Difference between PP and POE Refractive indices (ΔRI)

To produce a TPO blend with the right optical properties, we need to match the refraction index of the POE as closely as possible to that of the PP component, so entire mix can achieve required optical properties (i.e. **light transmittance** and **light diffusion** capability).

B. Effects of talc and PP choice

Balancing the physical properties of translucent TPO: Creating a TPO formulation that is translucent, that also offers the necessary safety performance is a complex challenge, because each of its three ingredients – PP, POE, and talc – offers both **benefits and trade-offs**.

	Translucency	Stiffness	Low-temperature impact	CLTE
Minimizing the amount of talc in the formulation improves translucence, but reduces stiffness and thermal expansion performance (CLTE).	↑	↓		↑
Alternative PP with high stiffness and increased light transmittance can be selected. However, it can reduce the material's low temperature impact.	↑	↑	↓	

Our solution

	Low-temperature impact	CLTE
Upgrade POE to **high-impact elastomer** (XUS 38648.00 Developmental POE)	↑	↓

By upgrading to Dow's developmental POE (XUS 38648.00), property effects described in Section B above can be managed by changing the formula to produce a TPO with **high-impact resistance and low CLTE**.

Moreover, this developmental POE also helps make TPO translucent, since it has both of the desired properties mentioned in Section A above:

- **A small particle size**
- **Minimum ΔRI**

Minimum ΔRI
High Transmittance
Low Light Diffusion Capability

High ΔRI
Low Transmittance
High Light Diffusion Capability

ΔRI = refractive index difference between PP and POE within TPO formula

Standard TPO formulations (with talc)

By upgrading both the PP and the POE, we can produce a TPO with a **comparable balance of stiffness and toughness**, that also has **excellent low temperature toughness** and **moldability.**

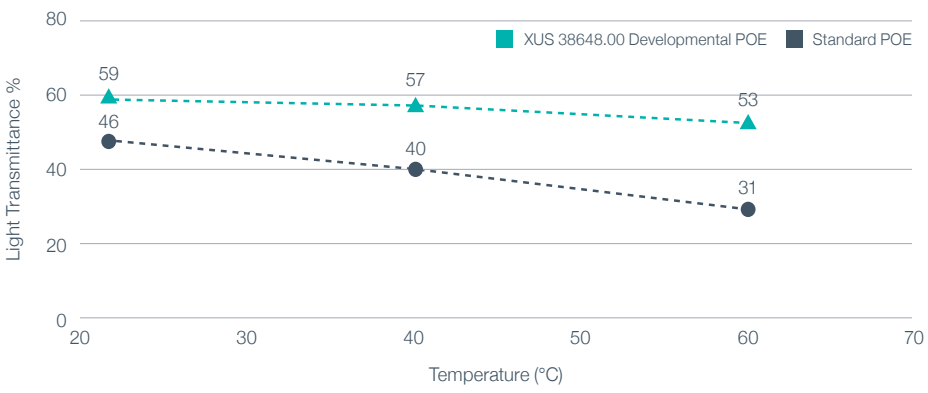
Testing	**Formulation 1:** Standard PP, standard POE & talc	**Formulation 2:** Alternative PP & **XUS 38648.00 Developmental POE** & talc	
Density (g/cc)	0.99	**0.92**	**30% less weight than current polycarbonate-based translucent solutions**
MFR 230°C (dg/min)	32	**22**	**Easy injection molding**
Notched Izod 23°C (kJ/m²)	42	**38**	**Excellent low temperature toughness**
Notched Izod -30°C (kJ/m²)	4	**5.1**	
Dart Ductility % 2.2m/s	100 at -30°C	**100 at -30°C**	
Transmittance at 23°C (%, 3.2mm)	**<10**	**36**	**High diffusive light transmittance**
Flex Mod (MPa)	1,670	**1,530**	**Stiffness can be improved for applications requiring less toughness**

Modified TPO formulations (without talc)

Our developmental POE structure enables even **higher light transmittance**, of up to 60%, without compromising **low-temperature toughness.** It also has a much lower drop in light transmittance at high (40°C and 60°C) temperatures.

Testing	**Formulation 1:** Standard PP & standard POE	**Formulation 2:** Alternative PP & **XUS 38648.00 Developmental POE**	
Density (g/cc)	0.89	**0.89**	**30% less weight than current polycarbonate-based translucent solutions**
MFR 230°C (dg/min)	20	**20**	**Easy injection molding**
Notched Izod 23°C (kJ/m²)	60	**60**	**Excellent low temperature toughness**
Notched Izod -30°C (kJ/m²)	10	**10**	
Dart Ductility % 2.2m/s	100% at -40°C	**100% at -40°C**	
Transmittance at 23°C (%, 3.2mm)	**46**	**59**	**High diffusive light transmittance**
Flex Mod (MPa)	1100	**1150**	**Stiffness can be improved for applications requiring less toughness**

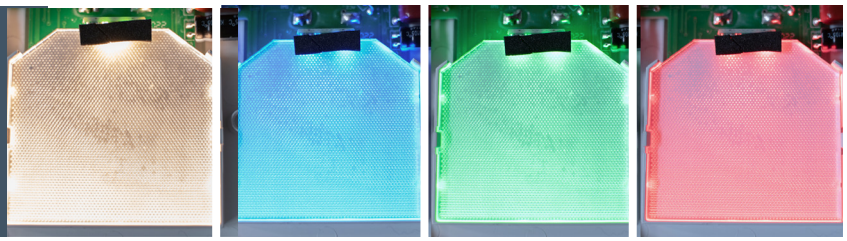
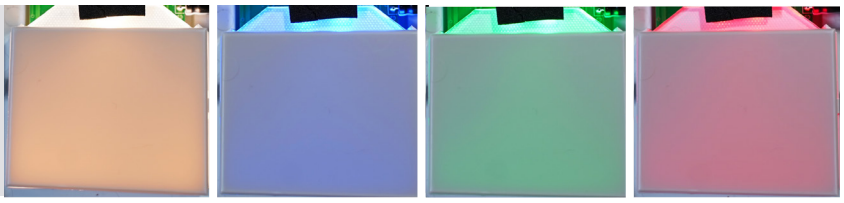
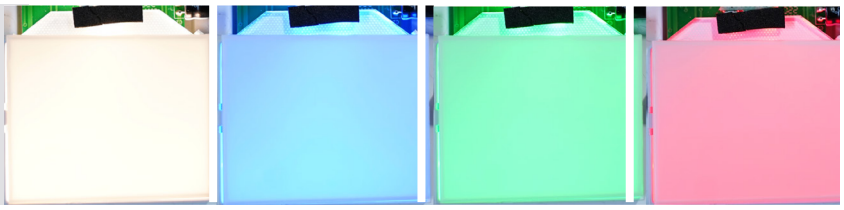
XUS 38648.00 Developmental POE vs Standard POE in Modified TPO formulations without talc



*Typical values, not to be construed as specifications. Users should confirm results by their own tests.

Optical performance of our translucent fascia TPO

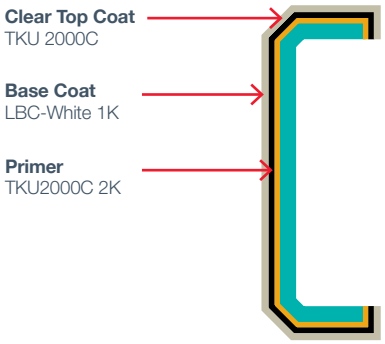
Our translucent fascia compounds have better optical quality, with clear color and uniform illumination from LED backlighting.

LED multicolor light source		
Current fascia compounds 3.2 mm thickness Standard PP, standard POE, 14 wt% Talc	• <**10%** light transmittance • LED color significantly shifted, due to brownish hue	
Translucent fascia compounds 3.2 mm thickness Alternative PP, XUS 38648.00 Developmental POE, 5 wt% Talc	• >**35%** light transmittance • Uniform illumination • Clear color from LED backlighting	

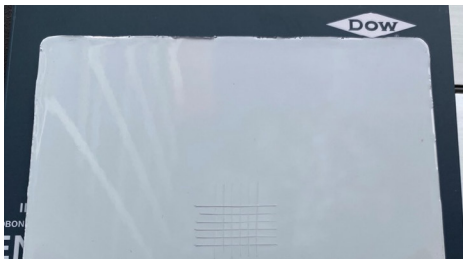
Paintability of our translucent TPO formulation (with low talc, upgraded PP and XUS 38648.00 Developmental POE)

In addition to all its other benefits, the developmental translucent TPO also has excellent paintability.

Applying standard automotive exterior paints:



Tape-peeled after 240h Humidity



After Water Jet

Paintability Test	Results
Tape Adhesion – Cross Hatch (GMW14829)	No loss of adhesion, **pass**
Chip Resistance (23°C) (GMW 14700)	Chips < 1.0 mm, **pass**
Chip Resistance (-18 °C) (GMW 14700)	Chips < 1.0 mm, **pass**
Thermal Shock (GMW 15919)	No removal, **pass**
Water Jet (GMW 16745-B)	No removal, **pass**
Tape Adhesion – Cross Hatch after 240h Humidity (GMW14729 + GMW14829)	Adhesion, **pass**

*Performed at Technical Finishing, Inc.

Observed comparable paintability of XUS 38648.00 Developmental POE vs. Standard POE in the study

*Typical values, not to be construed as specifications. Users should confirm results by their own tests.

A brilliant technology for more innovative lighting

Our translucent TPO formulation unlocks a whole range of **exciting new opportunities for automotive design** – from front fenders to liftgates and bumper fascias.

With Dow's POE innovation, it's now possible to produce **translucent TPO** with the **ideal optical quality for LED backlighting**, combined with the **excellent physical performance** needed for exterior automotive parts:

- Balanced stiffness and toughness
- Better light transmittance
- Optical quality for LED backlighting

Dow's developmental POE can be incorporated in a range of filler-free formulations to produce a range of TPO compounds with **excellent low temperature toughness** and up to **60% light transmittance.**

Images: dow_56420102503, dow_55764565464

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