

Lightweight and high-transmittance low-CLTE polyolefin materials

Kingfa USA Jason Li



KÎNGFA <mark>KÎNGFA</mark> KÎNGFA

### KINGFA Overview

- 2 Lightweight low-CLTE polyolefin materials in liftgate
- 3 High-transmittance low-CLTE polyolefin materials in liftgate

# **Company Profile**



**Modified Plastics** 

Advanced Materials (Biodegradable Plastics, Specialty Engineering Plastics, Carbon Fiber & Composite Materials etc)



### **Main Products**



million (2023)

### The world's most comprehensive supplier of polymer advanced materials

#### **Modified Plastics Advanced Materials Petrochemical Medical & Healthcare** Carbon Medical & Light **Specialty Bioplastics** Modified **Eco-friendly High-Polypropylene** Fiber & Engineering 0.14 million Plastics performance **Hydrogen Energy** 0.43 million tons Polymer Plastics 20.500 Recycled Plastics 0.27 tons 1.85 million million tons Materials 8,593.46 tons **Materials 385** million (2023) tons (2023) (2023)tons (2023)

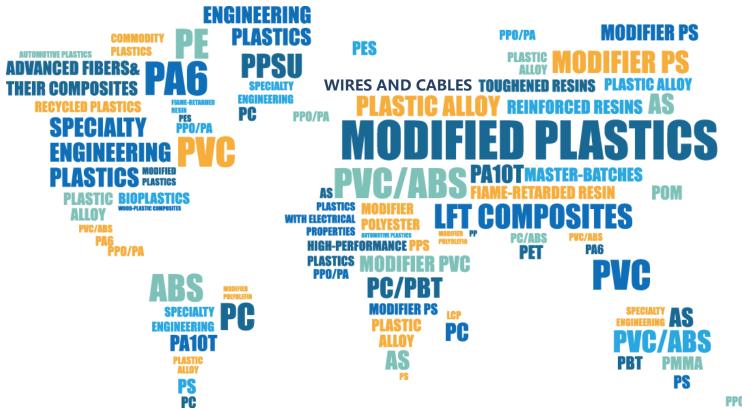
13,400 tons

(2023)

# A full and diverse product portfolio



Whatever you need, we can provide!

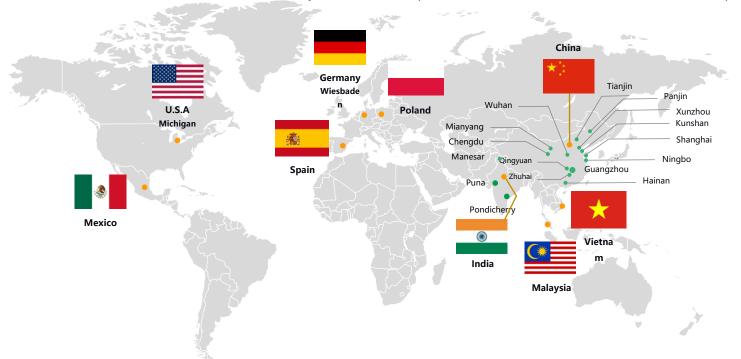


### **Global Collaborative Production & Service Network**



KÎNGFA KÎNGFA

- 20 advanced plastics production factories are strategically located in China, India, United States, Germany, Vietnam and Malaysia with a combined capacity exceeding 3.5 million tons.
- Mexico and Poland Plant under Construction, India and Malaysia Plant under Expansion, South Africa and Indonesia Plant under Preparation



# Kingfa Sci & Tech (USA) Inc.



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Located in	Established in	Employees		
Canton, Michigan	Feb 2015	100+		
Plant Details				
<b>130,000 sqft</b> production, R&D, office, and warehouse area				
ISO 9001, IATF 16949, ISO 17025 Certified				
6 production lines, Including 1 advanced Long Glass Fiber line				



Office

- US: San Francisco, Nashville
- > **MEX:** Monterrey, Querétaro, México City
- BRA: São Paulo

Warehouse

- US: San Francisco, Los Ángeles, Dallas
- MEX: Monterrey, S.L.P., Chihuahua, Guaymas

# Kingfa Sci & Tech (USA) Inc.



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#### **PP Compounds**

**Unfilled PP** 

Mineral Filled PP

SGF Reinforced PP

LGF Reinforced PP



### **PA Compounds**

**GF** Reinforced PA

Toughened PA

GF+MD Filled PA



# PC & ABS Compounds

PC/ABS Alloy

PC/PET Alloy

PC/PBT Alloy

Heat resistant ABS

### **Comprehensive system certification**





### **Advanced Production Lines**



- Automatic raw material loading system
- Precise feeding system



Polyester Compounds

**GF Reinforced PBT** 

**Toughened PBT** 

GF Reinforced PET

# Kingfa Sci & Tech MEXICO, S DE RL DE CV



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KINGFA's **wholly-owned** subsidiary



Integrating enterprise of polymer material *R&D*, *Production and Marketing*;



Total investment of **100 million USD**, Covering a land area of **150,000 square meters** 



Designed with total annual production capacity of *300,000 tons* 



Scheduled to start operation in 2026 Q2



Provide a comprehensive range of compounding plastics, including

PP/PE/PA/PBT/PET/PC/ABS/PPA, LFT-PP, and variety of flame-retardant products





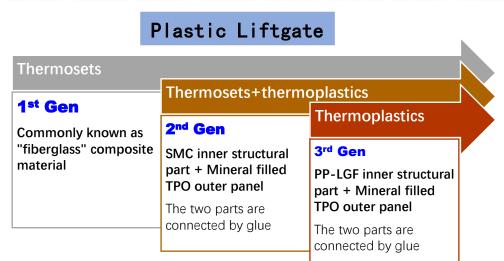
Located in San Luis Potosí (S.L.P.)

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### 2.1 Liftgate: Metal to plastic

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#### Advantage of full-plastic liftgate

- 30% weight down compared to full-metal
- Reduce number of components and improve module integration.

Clarification	Material	Thickness_cm (Inner+outer)	Density_g/cm^3 (Inner+outer)	Total weight)	Weight reduction (kg)	Weight reduction (%)
Full-metal liftgate	Steal	0.07+0.07	7.85	16.8	NA	NA
SMC liftgate	SMC+TPO	0.3+0.25	1.76+1.12	13.5	3.3	19%
Full-thermoplastic liftgate	PP-LGF+TPO	0.3+0.3	1.22+1,12	11.9	4.9	29%

### 2.2 Outer panel: Key points

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### Outer panel TPO



### Key point1: High toughness and stiffness

The tailgate is a semi-safety component. In order to achieve the performance as close as possible to that before lightweighting, the material rigidity and toughness must be as high as possible.



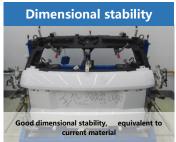
### **Keypoint2: Untra-low CLTE**

Dimensional stability, bond strength retention after high and low temperature cycles, is closely related to the difference in CLTE between the inner and outer panels.

### Key points3: Excellent adheision

Good glue adhesion is the key factor in ensuring that the outer panels do not fall off, which is of great safety significance.







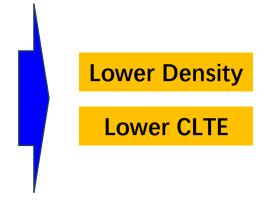
### 2.3 Liftgate TPO material- Lightweight trend

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TPO has already seen mature applications in all-plastic tailgate outer panels. However, the automotive industry continues to pursue further lightweighting. To meet this demand, there is a growing need for innovative solutions that combine low density with a reduced CLTE, enabling enhanced dimensional stability without compromising structural performance.

Combining the current low-CLTE and high-adhesion technology, Kingfa has developed 3 typical liftgate outer panel materials: PP+EPDM (T30, and T35) to meet the needs of various OEMs's requirements.

1st Gen, Low CL	1st Gen, Low CLTE TPO material(Currently technology)					
	Standard Bumper	Standard low CLTE	Extra-low CLTE			
	material TPO	material	material			
Grade	ABP-2040NA	APO-3018LS	APO-3535HD			
Specification	PP+EPDM+TD20	PP+EPDM+TD30	PP+EPDM+TD35			
Density	1.05	1.14	1.18			
MFR	44	18	32			
Flex modulus	2050	2800	2500			
Notched impact strength	40	20	40			
Shrikage	0.50.8	0.40.55	0.30.4			
CLTE	58	45	40			



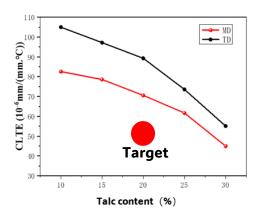
### 2.3 Liftgate TPO material- Pain points

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### **→ Pain point1:**

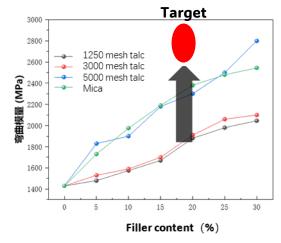
Based on existing research, the CLTE value is positively correlated with filler content: higher talc content indicates lower CLTE. There is a significant conflict between low filler content and low CLTE.





### **→ Pain point 2:**

What ever minerals are they in our formulation, they all follow the same rule: Lower mineral content can help reduce the density. But reducing filler content conflicts with the need of increasing modulus requirement



Of course, we also see that at the same filler content, choosing the right filler can significantly increase the modulus of the material.

# 2.4 Lightweight low CLTE TPO material – Target setting

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■ Based on 1st Gen. low CLTE material TPO PP+EPDM-TD30 material, we are aiming at developing the 2<sup>nd</sup> Gen. lightweight Low CLTE TPO material

**Target1:** TPO material that maintains consistent performance in CLTE while reducing density to meet lightweighting requirements, with higher flexural modulus

**Target2:** TPO material that reduces the while reducing CLTE to meet lightweighting requirements, with higher flexural modulus.

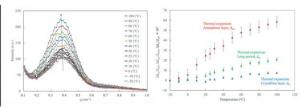
	1st Gen.	2nd Gen. Lightweight Lo	w CLTE TPO material	
Grade	APO-3018LS□	Taxmot1	Toward?	
Specification	PP+EPDM+TD30	Target1	Target2	
Density	1.14	≤1.06	≤1.02	
MFR	18	≥20	≥20	
Flex modulus	2800	≥2700	≥2500	
Notched impact strength	20	≥20	≥20	
Shrikage	0.40.55	0.40.55	0.50.8	
CLTE	45	≤45	≤50	
Feature	Standard low CLTE material	Lower Density	Extra low Density	

## 2.4 Lightweight low CLTE TPO material – Mechanism & Development

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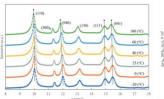
CLTE impact mechanism: the expansion of the amorphous region provides the main contribution

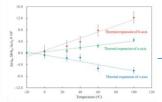




- ◆SAXS: PP片晶沿流动方向取向; iPP的长周期18-20nm, 并且随温度提高略有增加;
- ◆晶区和无定形区的膨胀系数分别为6.3×10<sup>-5</sup>(未考虑晶体取向) 和49×10<sup>-5</sup>/°C







- ◆ WAXS: iPP晶胞呈现取向; (040) / (110) 与C轴沿流动方向取向相关
- ◆ a/b/c轴的膨胀系数分别为3.8×10<sup>-5</sup>、10.2×10<sup>-5</sup>和-5.1×10<sup>-5</sup>/℃

#### Thermal Expansion Behavior of Polymer Matrix

- •Overall CLTE is influenced by:
  - Expansion coefficients of crystalline and amorphous regions
  - Unit cell orientation
  - Degree of crystallinity
- Contribution breakdown:
  - Crystalline region: 0.042 × 10<sup>-5</sup> /°C
  - Amorphous region: 12.25 × 10<sup>-5</sup> /°C
  - Amorphous phase accounts for **99.66%** of total thermal expansion

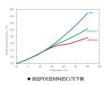
★ Insight: Targeting the amorphous region is key to controlling CLTE in lightweight polymer formulations.

#### ■ Minimize amorphous phase content

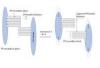
- ①Crystallinity Control
- ②Filler Volume Effect
- 3Alloying

#### ■ Strategies to Limit Amorphous Phase Expansion:

①Regulation of
Elastomer Phase State





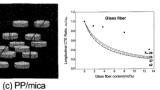


E外延生长 ◆ POE收缩使得晶体聚并的模型解释

②Construction of Filler Network



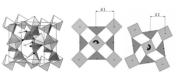


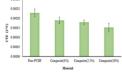


③ Incorporation of

Low-Expansion

Components





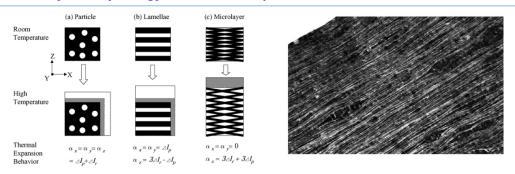
NET填料钨酸锆的刚性八面体结构

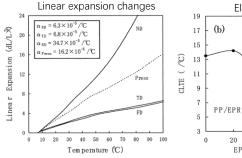
■ NET填料在降低PVDF膨胀系数上的研究

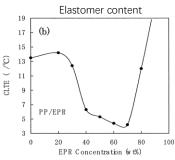
# 2.4 Lightweight low CLTE TPO material – Elastomer Study

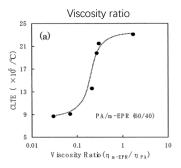
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Micro-layer morphology is determined by a combination of elastomer content, viscosity ratio of the system, and phase compatibility.



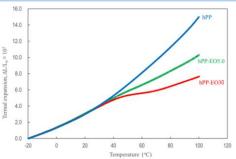




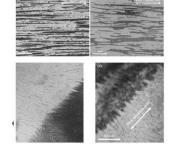


Polymer, 2004, 45(9):3085-3090

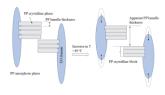
The incorporation of elastomers increases the overall coefficient of CLTE of the material. However, when a micro-layered elastomer morphology is formed, the modulus mismatch between the elastomer and the matrix resin drives expansion along the normal direction (ND), thereby suppressing the thermal expansion of the amorphous region in the flow direction.



CLTE decreases after adding POE



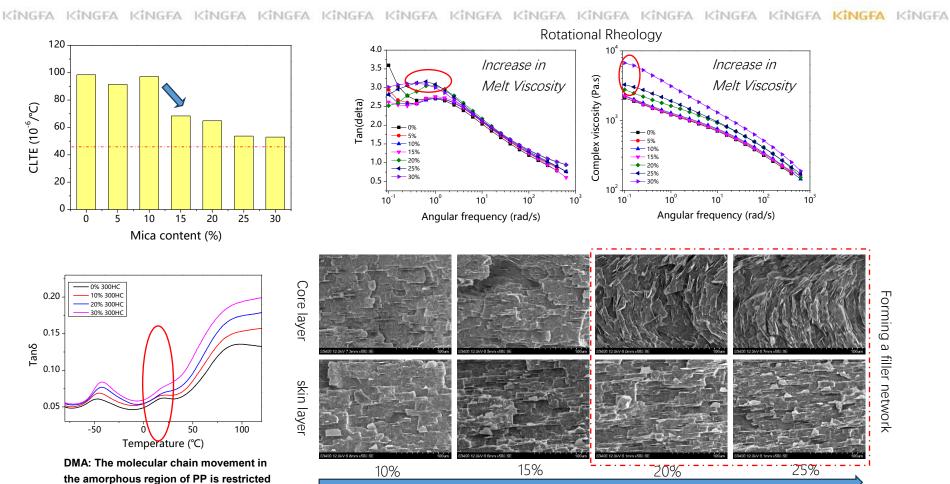
POE is molded in a stretched state, enabling epitaxial growth of PP crystals on the POE phase."



Model Explanation: Crystallite Coalescence Induced by POE Shrinkage

The interfacial tension arising from the compatibility difference between the elastomer and the matrix resin drives the shrinkage of the stretched elastomer upon temperature increase.

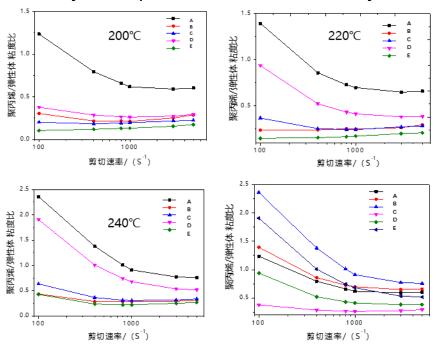
# 2.4 Lightweight low CLTE TPO material – Filler study



# 2.4 Lightweight low CLTE TPO material – Process study

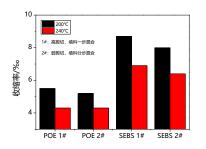
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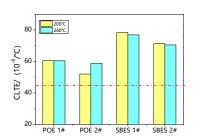
#### Viscosity Ratio Experiment Based on the PP MD20 System



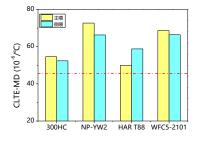
- □ High shear rates are unfavorable for increasing the viscosity ratio between PP and elastomers, as PP exhibits more pronounced shear thinning behavior compared to elastomers.
- Elevated temperatures are beneficial for improving the PP/elastomer viscosity ratio, since elastomer viscosity is more sensitive to temperature changes than that of PP.

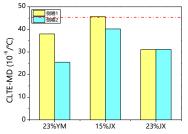
#### Effect of Temperature on the Material's CLTE





#### ◆ Impact of Side-Fed Powder on the Material's CLTE





Increasing the extrusion temperature and using side-feed powder technology can help reduce the CLTE of the material to a certain extent.

### 2.4 Lightweight low CLTE TPO material – Performance

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By systematically studying the key influencing factors, two solutions with reduced CLTE TPO material solutions were successfully developed the 2<sup>nd</sup> generation **Lightweight low CLTE TPO material**.

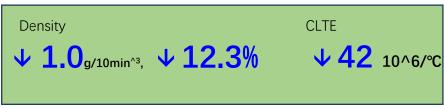
Solution 1	Standard	Test condition	Unit	Specific ation	1st Gen	2 <sup>nd</sup> Gen.
Impact strength	ISO 179	23°C	kJ/m²	≥20	20	<b>21.4</b>
Flex Modulus	ISO 178	23°C	MPa	≥2700	2800	<b>2783</b>
Density	ISO 1183	23°C	g/cm³	≤1.06	1.14	1.05
CLTE-MD	GB/T 36800	-30~100°C	10 <sup>-6</sup> /°C	≤45	45	<b>39.4</b>

Compared to the 1<sup>st</sup> Gen. Low CLTE material, 2<sup>nd</sup> Gen.

Density	CLTE
<b>↓ 1.05</b> <sub>g/10min<sup>3</sup></sub> , <b>↓ 7.0</b> %	<b>√39</b> 10^6/℃

Solution 2	Standard	Test condition	Unit	Specific ation	1st Gen	2 <sup>nd</sup> Gen.
Impact strength	ISO 180	23°C	kJ/m²	≥20	20	<b>27.6</b>
Flex Modulus	ISO 178	23°C	MPa	≥2500	2800	<b>2590</b>
Density	ISO 1183	23°C	g/cm³	≤1.02	1.14	1.00
CLTE-MD	GB/T 36800	-30~100°C	10⁻6/°C	≤50	45	<b>42.2</b>

Compared to the 1<sup>st</sup> Gen. Low CLTE material, 2<sup>nd</sup> Gen.



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### 3.1 Translucent bumper application review - Kingfa/Geely illuminous Bumper

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☐ Galaxy E8 - The world's first mass-produced integrated luminous fascia. In the market since Jan-2024





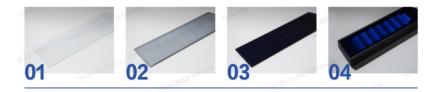
□ Galaxy E5 - New design. High performance translucent TPO material solution. In the market since **Aug-2024 / SPE award** 

# 3.1 Translucent bumper application review - innovation / Design

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# Luminous bumper design solutions

- One-piece bumper
- Integrate all Illuminated trims on bumper
- > Bumpers partly translucent & light from behind
- Translucent bumper substrate(diffusion)
- Laser etching



- 01—Nature resin, Injection molding
- 02—Painting & Laser etching pattern
- 03—Painting on the surface
- 04—Light On







Laser etching for microporous paint





Dynamic lighting modulus

### 3.1 Translucent bumper application review - Innovative translucent TPO material

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### **Comparison of different translucent plastic**

	Current Material TPO	PMM A	Modifie d PC	General translucent TPO	KLUX translucent TPO
Transmittance	0~20%	> 85%	>85%	70~85%	50~80%
Mechanical	++	+++	+++	+	++
Impact -30℃	++	+	+++	+	+++
Painting	++	++	++	+	++
Flowability	++	+	+	+++	+++
UV resistance	++	+	+	+	++
Cost	+++	+	+	++	++

### **KLUX-5019 HM**

Properties[1]	Test Standard	Test Condition	S.I. Unit	S.I. Typical Value[1,2]
Mechanical				
Tensile Strength	ISO 527	50mm/min	MPa	22
Elongation at Break	ISO 527	50mm/min	%	50
Flexural Strength	ISO 178	2mm/min	MPa	30
Flexural Modulus	ISO 178	2mm/min	MPa	1600
Charpy Notched Impact Strength	ISO 179-1/1eA	23°C	kJ/m²	50
Thermal				
Temperature of Deflection Under Load	ISO 75	0.45MPa	°C	95
Optical				
Haze Light Transmission	ASTM D1003 ASTM D1003	3.0mm 3.0mm	% %	>99 60
Others				
Density	ISO 1183	23°C	g/cm <sup>3</sup>	0.97

**Key issues:** 

**Current TPO**: Low transmittance **PMMA**: Poor impact property

PC: Poor flowability, Stress crack, UV resistance General translucent TPO: Poor Mechanical

KLUX series translucent TPO materials can meet the requirements of light transmission, mechanical properties, weather resistance, paint adhesion and so on

# 3.2 Low CLTE translucent liftgate material – background

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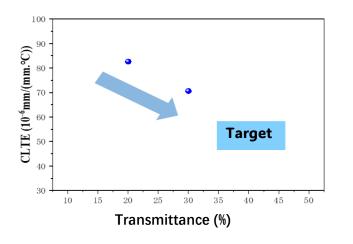
- The luminous tailgate is an innovative point in future design.
- ☐ High-transmittance, low-CLTE materials: Based on existing low-CLTE materials, they maintain consistent performance and increase transmittance to meet new demands for intelligent interactive exterior design of new EVs.



	1st Gen, Low CLTE TPO KINGFATranslucent		2rd Gen, High trans	smittance Low CLTE
	material(Current)	TPO material	<b>TPO material target</b>	
Grade	APO-3018LS•	Klux-5019 HM	Torget 1	Target 2
Specification	PP+EPDM+TD30	PP+EPDM+TD10	Target 1	Target 2
Density	1.14	0.97	≤1.15	≤1.06
MFR	18	32		
Flex modulus	2800	1800	≥2700	≥2400
Notched impact strength	20	50	≥20	≥20
Shrikage	0.40.55	1.0-1.2		0.50.8
CLTE	45	90	≤45	<b>≤50</b>
Transmittance	NA(Opaque)	50	≥35	≥45
Feature	Standard low CLTE material	Translucent bumper	Low CLTE Translucent	Low CLTE Lightweight Hight translucent

# 3.3 Low CLTE translucent liftgate material – Challenge

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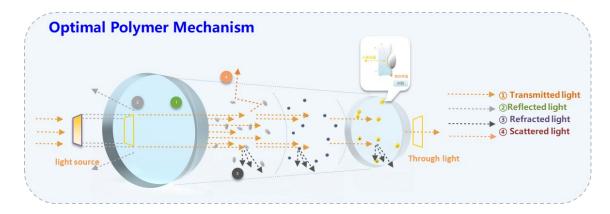


### **Key requirements:**

- Low density
- Balance between stiffness & toughness
- Low CLTE
- High transmittance
- > UV resistance

- Challenge 1: The 1st Gen. low CLTE materials was opaque and could not meet the requirements of transparent tailgate designs.
- Challenge 2: The maximum modulus of the translucnet TPO is only 1800MPa, and there is an obvious conflict between the low filler content and the high modulus requirement. Meanwhile, the CLTE is too big to meet the dimensional stability requirements.
- Challenge 3: Low CLTE translucent liftgate material needs to meet the requirements of low CLTE, high modulus and light transmittance at the same time. It is not a simple superposition of the above technologies. It needs to jump out of box and reconstruct the formula.

### 3.4 Low CLTE translucent liftgate material - Mechanism



#### **Influencing factors**

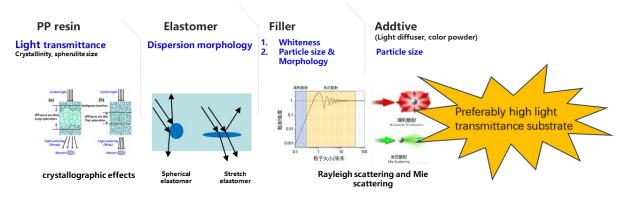
There are many factors affecting the transmittance of the material, and there are four main kinds of light in the polymer,

- 1 transmitted light,
- 2 reflected light,
- <u>refracted light</u>
- § scattered light.

They make up the light transmittance of the material

#### Formulation thought:

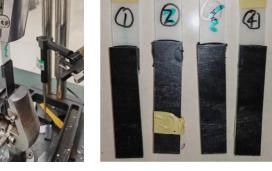
The high transmittance of a single composition cannot achieve the high transmittance of compounding. It is necessary to combine all the compositions with high transmittance.



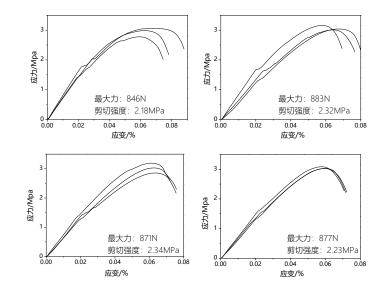
# 3.5 Low CLTE translucent liftgate material – Adhesion study

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拉伸剪切测试

透光材测试后: 未脱粘

破坏形貌: 胶开裂

- Adhesive testing was conducted in reference to ISO 4587. The shear strength of the adhesive for eight sample groups ranged from 2.1 to 2.9 MPa, all exceeding the benchmark value of 1.96 MPa.
- ☐ The failure mode observed was cohesive failure within the adhesive layer, with no interfacial delamination.
- □ Variations in PP content, elastomer type and ratio, as well as filler type across the eight sample groups did not negatively affect the adhesive performance of the material.

# 3.6 Low CLTE translucent liftgate material – Performance

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By thoroughly investigating the key influencing factors, we successfully developed two **Low CLTE translucent materials,** enabling the advancement of the second-generation translucent liftgate material..

Solution I	Standard	Test condition	Unit	Target1	1 <sup>st</sup> Gen	2 <sup>nd</sup> Gen
Impact strength	ISO 179	23°C	kJ/m²	≥20	50	21.7
Flex Modulus	ISO 178	23°C	MPa	≥2700	1800	3245
Density	ISO 1183	23°C	g/cm³	≤1.15	0.97	1.15
Transmittance	ISO 13468		%	≥35	50	48.7
CLTE-MD	GB/T 36800	-30~100°C	10 <sup>-6</sup> /°C	≤45	90	42.3

Compared to the 1<sup>st</sup> Gen, 2<sup>nd</sup> Gen.

Transmittance	Modulus	CLTE
48.7%	<b>2783</b> мРа	90 <b>→39.4</b> 106/°C

Solution 2	Standard	Test condition	Unit	Target2	1 <sup>st</sup> Gen	2 <sup>nd</sup> Gen
Impact strength	ISO 180	23°C	kJ/m²	≥20	22.5	20.3
Flex Modulus	ISO 178	23°C	MPa	≥2500	1929	2929
Density	ISO 1183	23°C	g/cm³	≤1.06	1.05	1.06
Transmittance	ISO 13468		%	≥45	45.3	<b>52.2</b>
CLTE-MD	GB/T 36800	-30~100°C	10 <sup>-6</sup> /°C	≤50	75.15	47

Compared to the 1<sup>st</sup> Gen, 2<sup>nd</sup> Gen.

Transmittance	Modulus	CLTE
<b>42.2</b> %	2590мРа	90 <b>→42.2</b> 106/°C

# 3.7 Low CLTE translucent liftgate material – Part Trial

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# Thanks!

