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New Solutions for Polyolefin Stabilization: Advanced UV Stabilizer for Molding Applications and a UV/Thermal Stabilizer for Building & Construction

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FY 2015

Presentation Outline

- A Brief Review of Polymer Photodegradation
- A New UV-8+ Stabilizer for Polyethylene Injection Molding Applications
  - **CYASORB CYNERGY SOLUTIONS® M535 Stabilizer**
- A New UV/Thermal Stabilizer for Building & Construction Applications
  - **CYASORB CYNERGY SOLUTIONS® B878T Stabilizer**
- Conclusions

A Brief Review of Polymer Photodegradation

Wavelength (nanometers)	Photon Energy (kcal/mole)
280	102.3
300	95.5
320	89.5
340	84.3
360	79.6
380	75.4
400	71.6

Chemical Bond	Photon Energy (kcal/mole)
C = C	145
O - H	110
C - H (primary)	106
C - H (secondary)	95
N - H	93
C - H (tertiary)	91
C - O	87
C - C	83
C - Cl	78
O - O	64

UV radiation from sunlight has sufficient energy to homolytically break chemical bonds to form radical species

UV stabilization packages can utilize UV absorbers, radical scavengers and radical deactivators to slow free radical damage to polymer chains and pigments, resulting in retention of color and physical properties

Common Weathering Methods

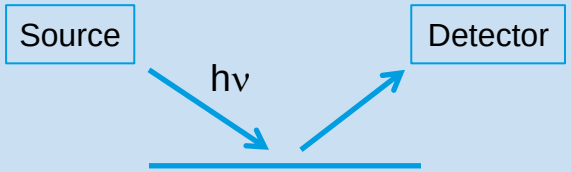
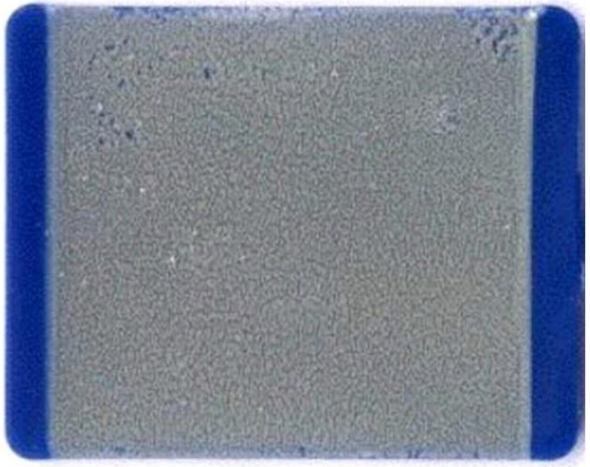
Weathering Method	Industry	Irradiance	Light/Dark Cycles	Water Spray	Temperature	Notes
Sun*		0.30 W/m² @ 340nm				
ASTM G155	"General"	0.35 W/m² @ 340nm	24h light	102min light 18min light+spray	63°C ± 3°C	Mimics solar spectrum with no dark time
ASTM D6878	B&C	0.70 W/m² @ 340nm	24h light	102min light 18min light+spray	80°C ± 3°C	High-irradiance test for B&C

Solvay Artificial Weathering Laboratory – Stamford, CT

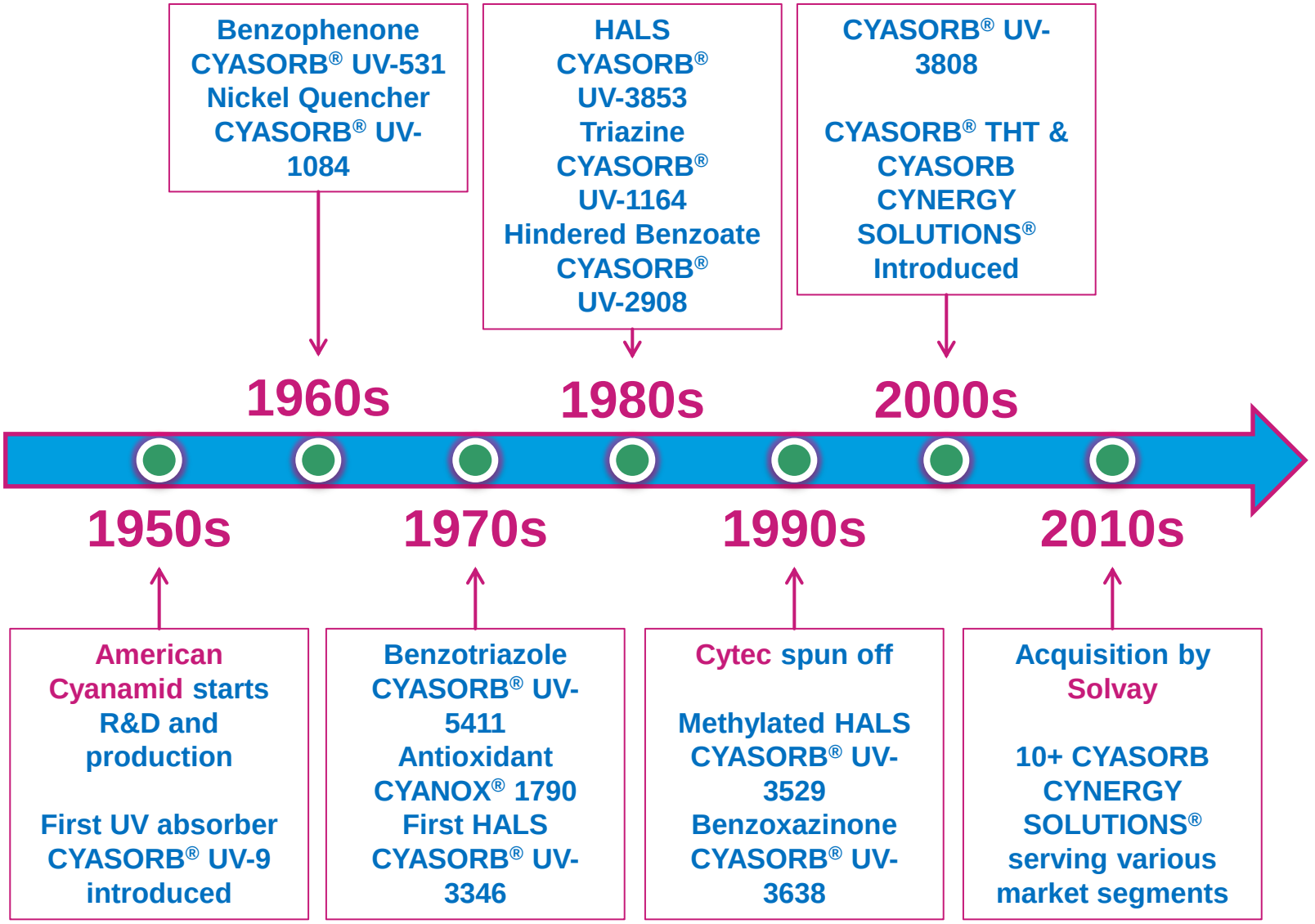
* Solar spectrum data from US National Renewable Energy Laboratory, http://rredc.nrel.gov/solar/spectra/am1.5/astmg173/astmg173.html

Analytical Methods for Polymer Degradation

Common quantitative methods to assess the extent of polymer degradation

Color Lightfastness	Surface Properties	Mechanical Integrity
Colorimetry ΔE – Total Color Change YI – Yellowness Index Based on CIE Color Coordinates (L, a, b)	**Gloss Measurement**  	**Physical Testing** Elongation Retention Tensile Stress Retention
		

Solvay Polymer Additives – A History of Innovation



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CYASORB CYNERGY SOLUTIONS® M535 Stabilizer: An Advanced UV Stabilizer for Molding Applications

CYASORB CYNERGY SOLUTIONS® - M Series

- Designed to deliver excellent UV stabilization to PE molded durable applications and superior surface protection for pigmented and natural parts

Applications

- Trash & Roll out carts
- Storage & Industrial containers
- Crates, boxes & drums
- Sports equipment
- Toys
- Patio & Gardening articles

Products

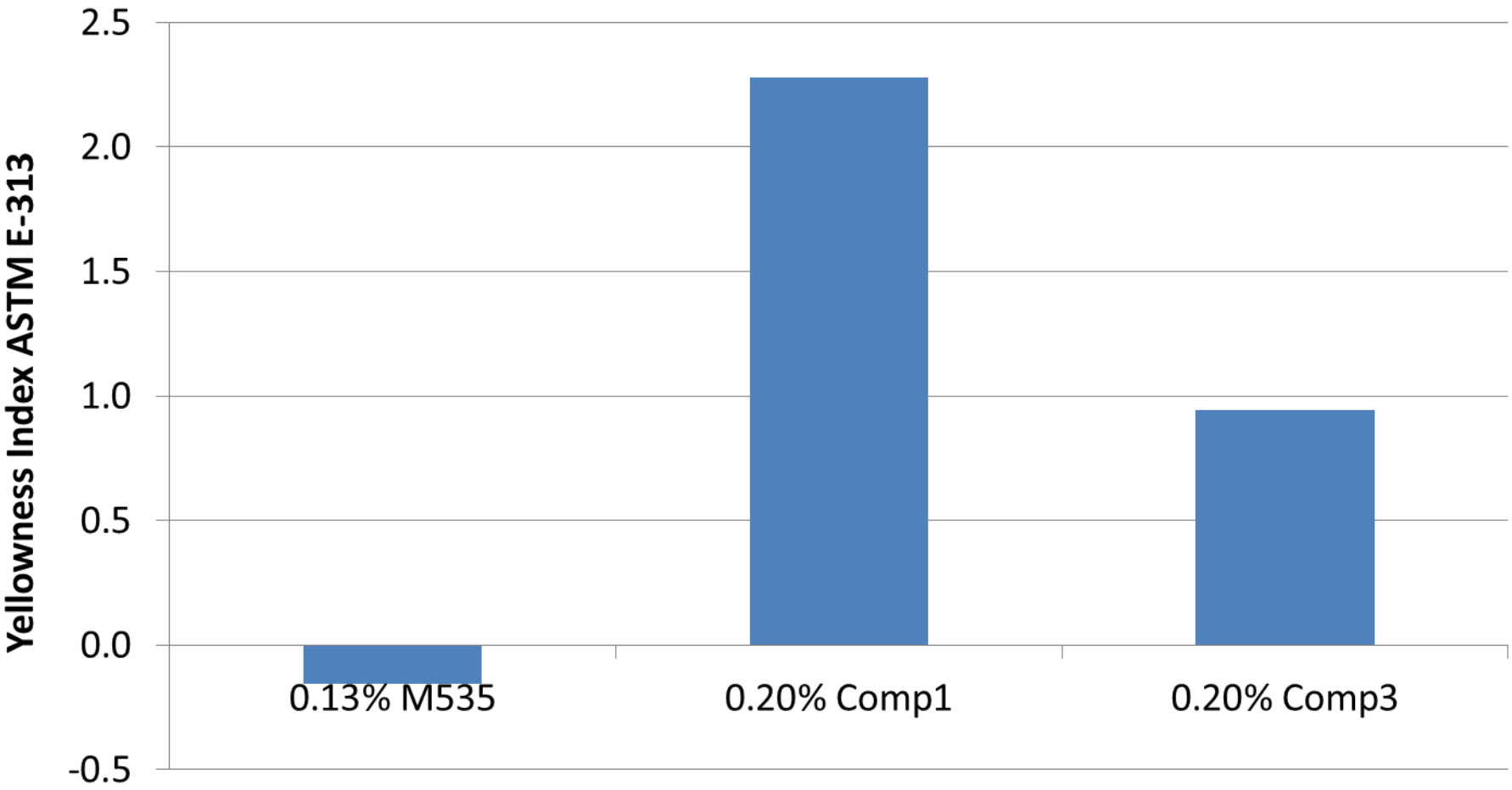
CYASORB CYNERGY SOLUTIONS®

M535 Light Stabilizer

Delivers excellent physical property retention after UV exposure to UV-8+, superior initial color and color & gloss retention in natural and pigmented PE molded parts and allows formulation flexibility with a broad food contact approval

CYASORB CYNERGY SOLUTIONS® M535 Stabilizer

Natural HDPE, CYANOX® 2777 Antioxidant
Injection Molded Plaques



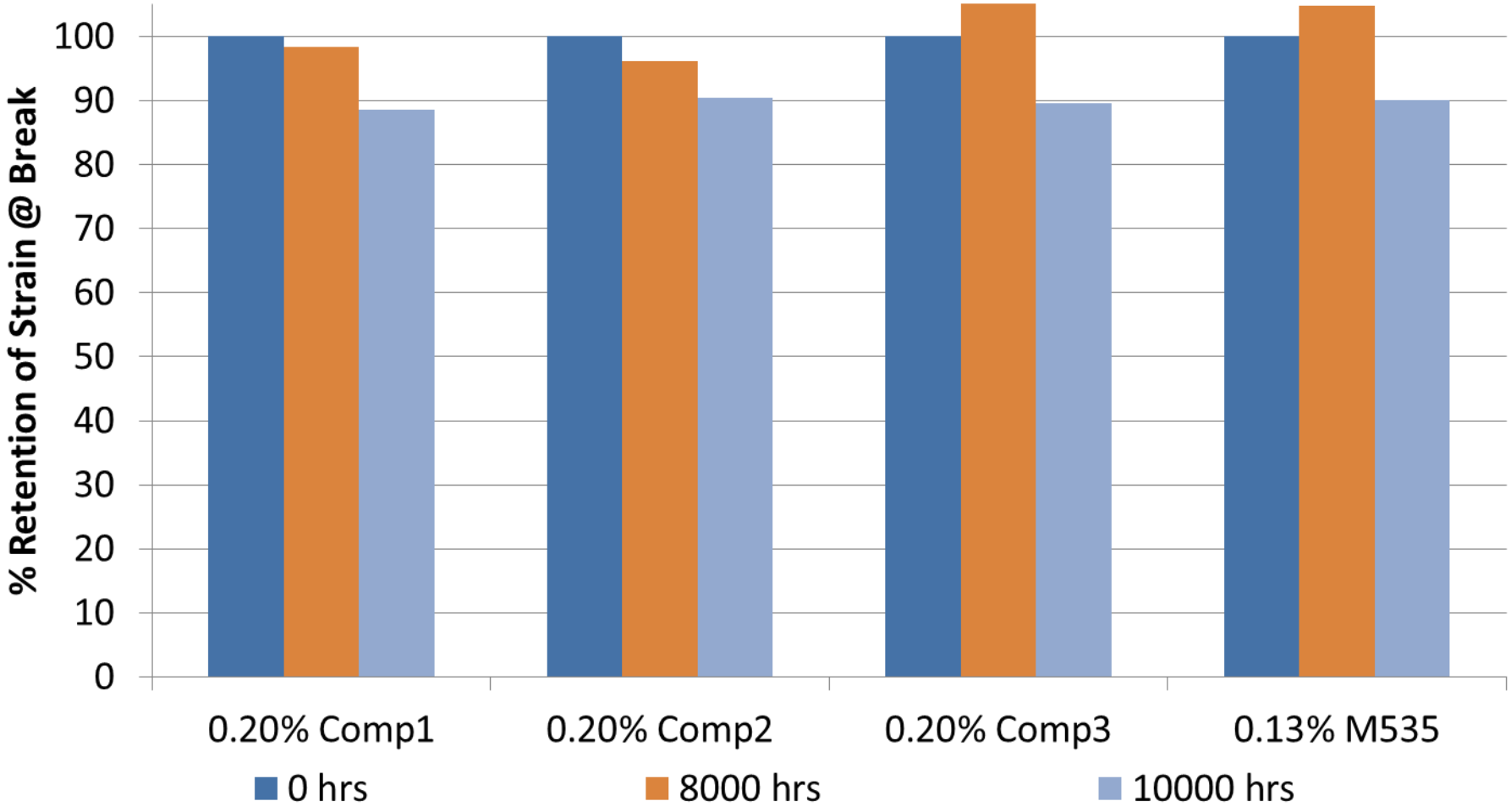
M535 has low initial color, allowing for facile color matching

CYASORB CYNERGY SOLUTIONS® M535 Stabilizer

ASTM G155 (Cycle 1) Weathering

HDPE, 1% white pigment MB, CYANOX® 2777 Antioxidant

Injection Molded Type V Tensile Bars



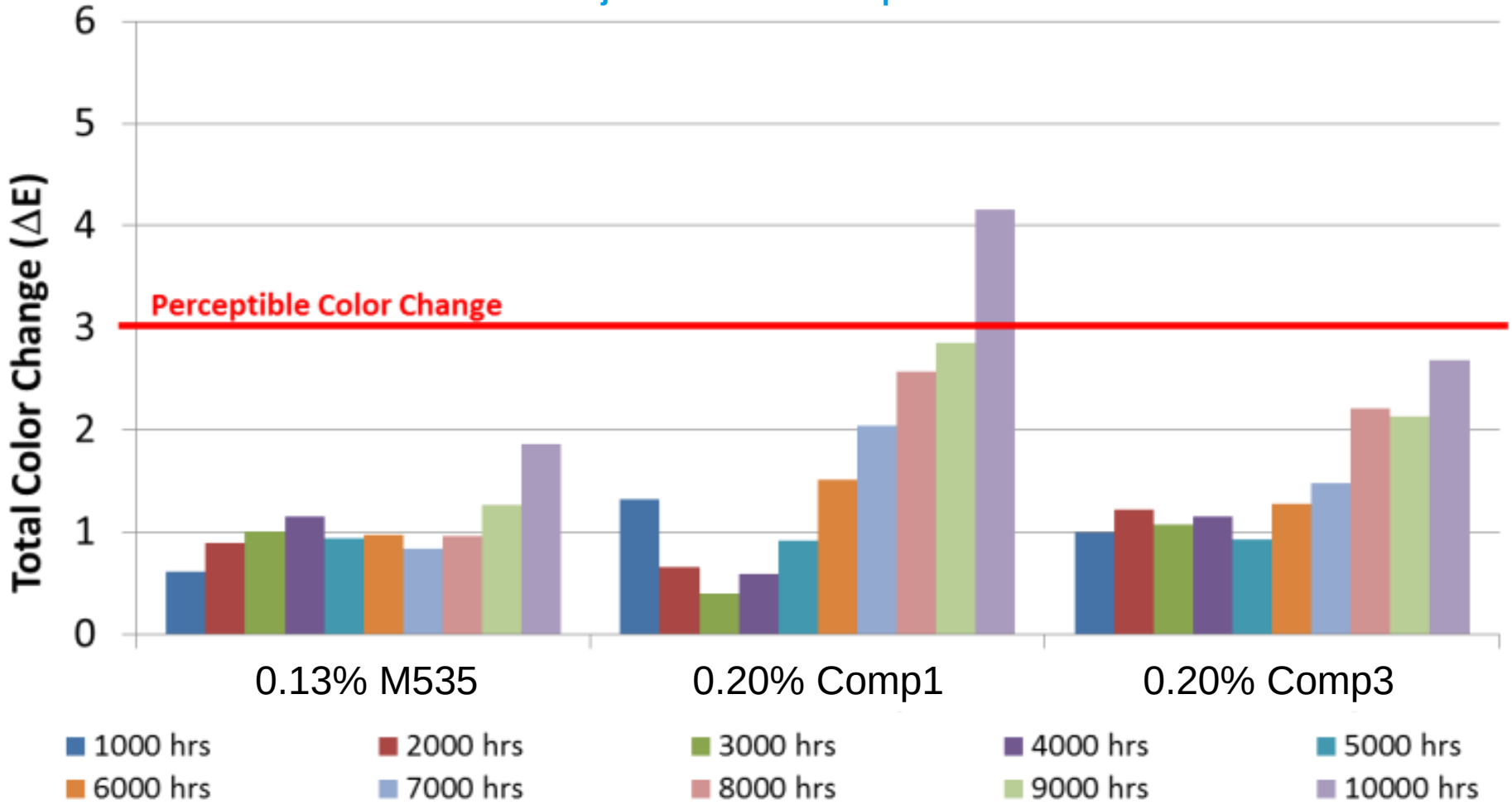
M535 demonstrates parity with competitive formulations at nearly half the concentration

CYASORB CYNERGY SOLUTIONS® M535 Stabilizer

ASTM G155 (Cycle 1) Weathering

Natural HDPE, CYANOX® 2777 Antioxidant

Injection Molded Plaques

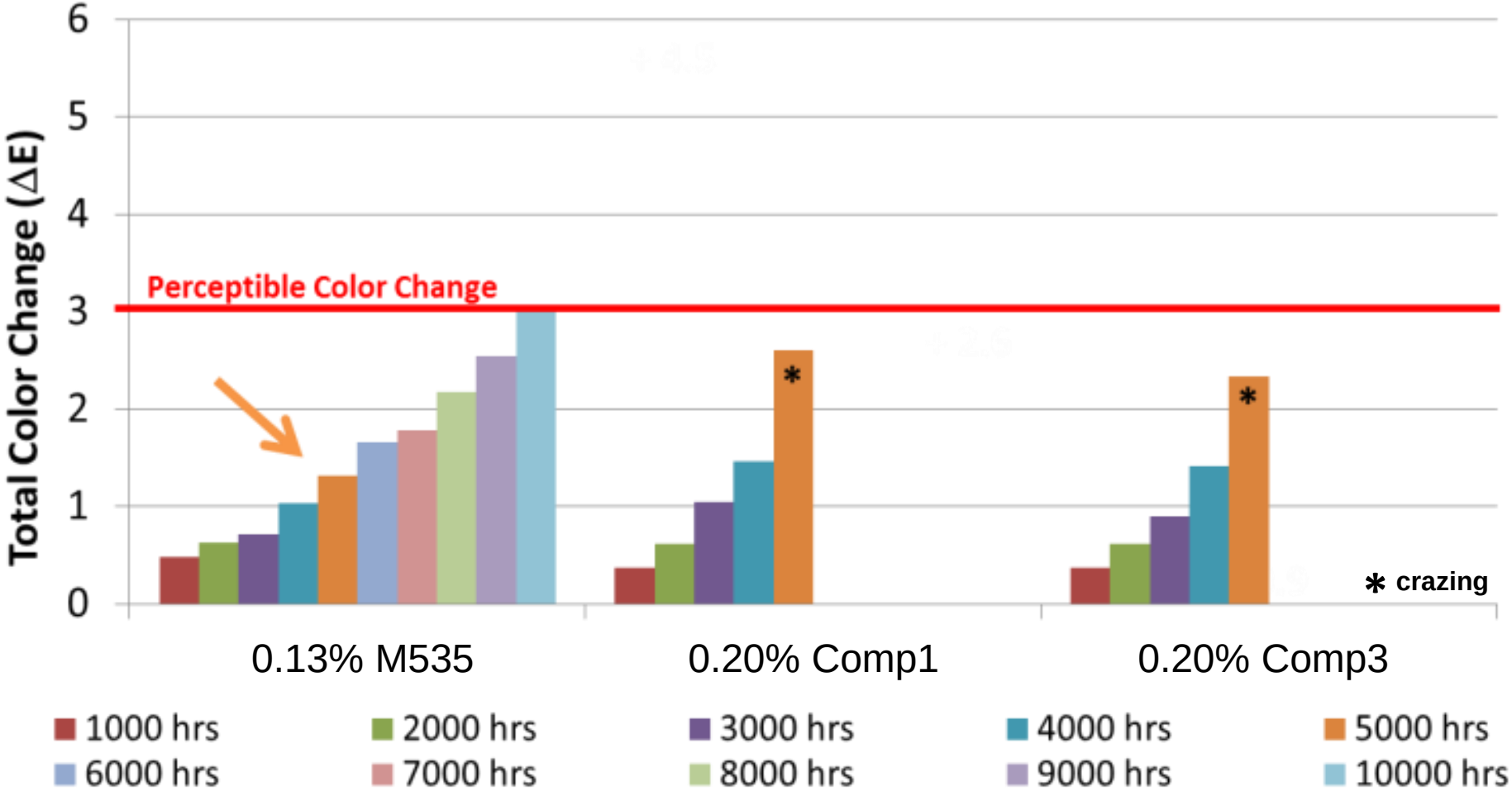


M535 demonstrates superior weatherability at nearly half the loading of competitive solutions

CYASORB CYNERGY SOLUTIONS® M535 Stabilizer

ASTM G155 (Cycle 1) Weathering

Green Pigmented HDPE, CYANOX® 2777 Antioxidant
Injection Molded Plaques



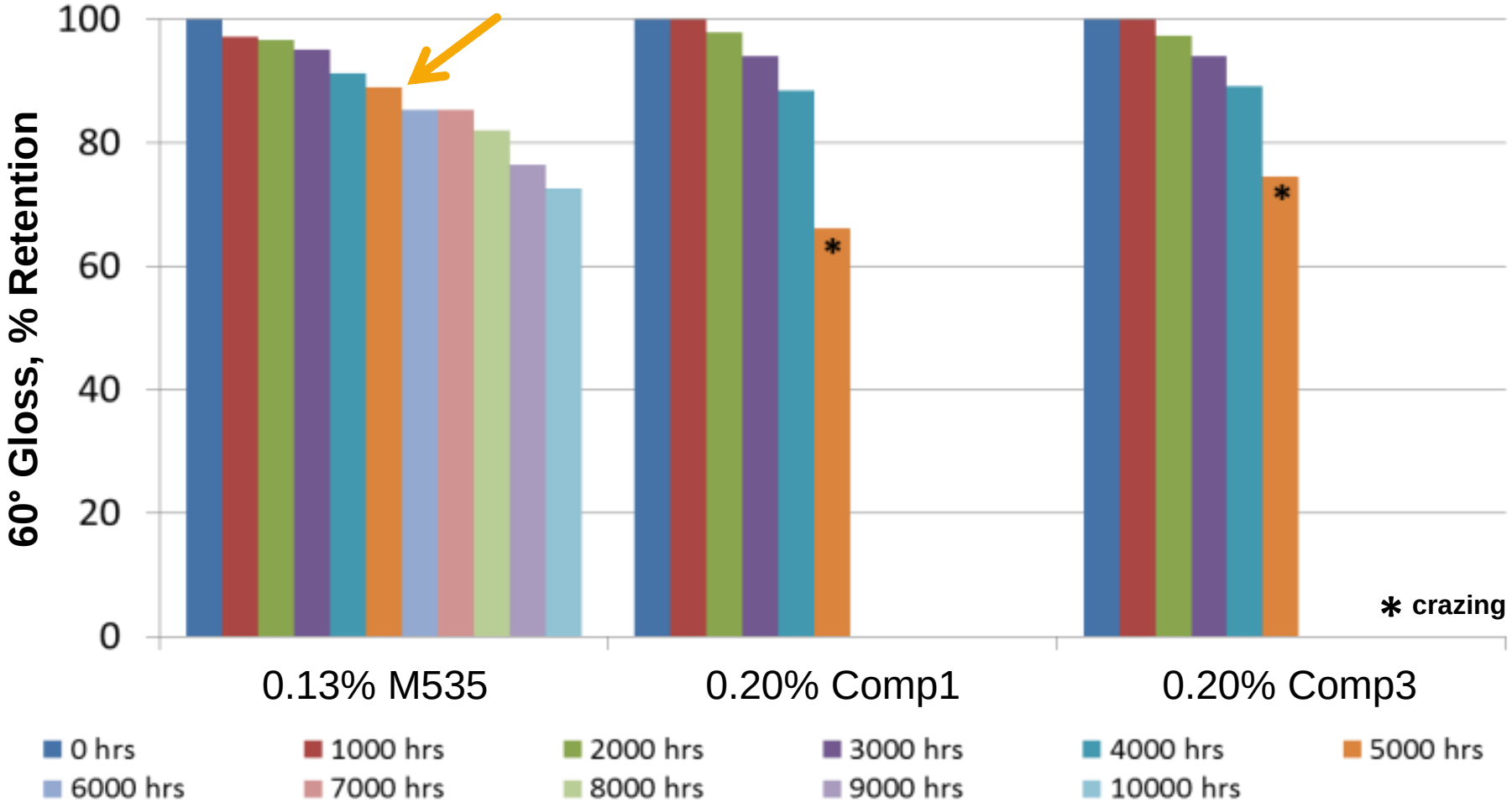
M535 provides exceptional protection against photobleaching to pigmented systems

CYASORB CYNERGY SOLUTIONS® M535 Stabilizer

ASTM G155 (Cycle 1) Weathering

Green Pigmented HDPE, CYANOX® 2777 Antioxidant

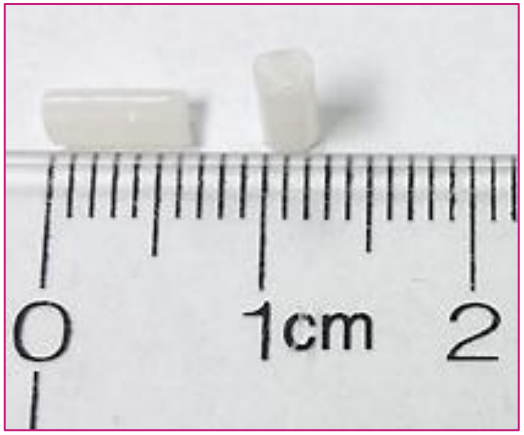
Injection Molded Plaques



M535 provides exceptional surface protection to pigmented systems

CYASORB CYNERGY SOLUTIONS® M535 Stabilizer

Features & Benefits



- Easy-to-handle, non-dusting product form
- Does not stick to screw or feeder
- Suitable for PE IM and BM applications
- Good resistance to gas fading
- Excellent surface protection
- Broad food approvals

Applications

- Sports Equipment
- Trash cans
- Leisure equipment
- Toys
- Pallets
- Containers – crates, bins, boxes, drums

M535 is suitable for “general” IM applications and BM applications

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CYASORB CYNERGY SOLUTIONS® B878T Stabilizer: UV+Thermal Stabilizer for Building & Construction Applications

CYASORB CYNERGY SOLUTIONS® - B Series

- Designed to deliver exceptional UV and long-term thermal protection to polyolefins used in outdoor construction applications.

Applications

- TPO roofing
- Polyolefin roofing tiles
- Polyolefin roofing shakes
- Solar shingles
- Siding
- Shutters
- Geomembranes
- Sport Tiles

Products

- **B877**

- Designed for optimized UV protection for TPO, PP & HDPE used in outdoor Building & Construction applications

- **B878T**

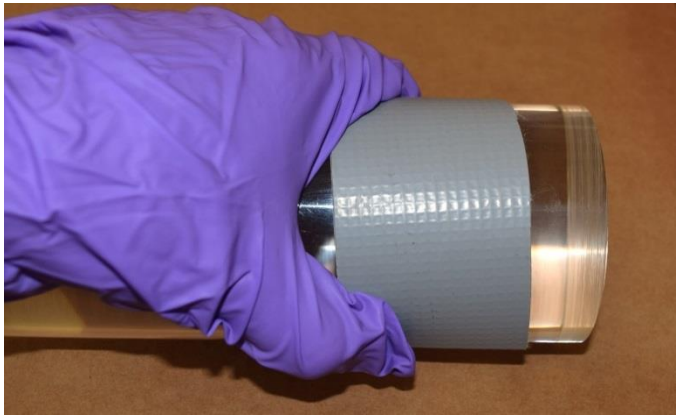
- Single solution stabilizer that enables TPO & PP to meet the challenges of extreme thermal and UV specifications

Roofing Materials: Standards & Specifications

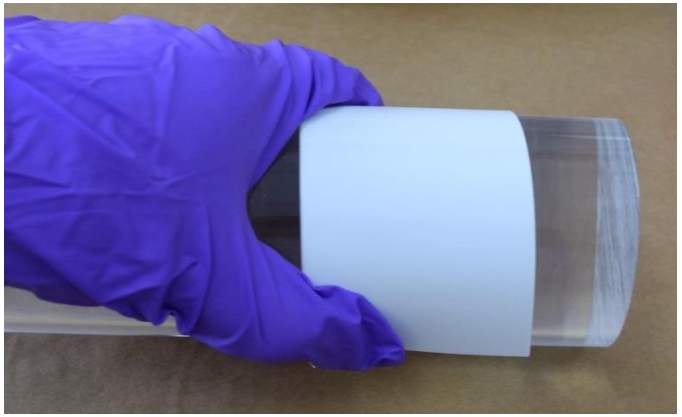
North America ASTM D6878 Standard for Thermoplastic Based Sheet Roofing			
Test	ASTM Test Method	Test conditions	Passing requirements
Heat Aging	ASTM D573	5,376 hours at 116 °C/240 °F	>90% retained elongation and breaking strength
Weather Resistance	ASTM G155	10,080 kJ/m^2 at 340 nm and 80 °C, BPT, 50 °C air temperature	7x magnification No cracks/crazing

Roofing Materials: Standards & Specifications

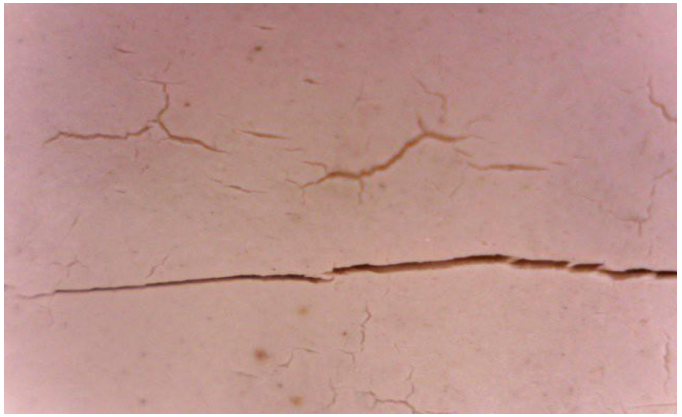
Grey TPO roofing membrane



White single ply membrane



Examples of cracking



Sample Description & Test Methods

- **TPO resin, $Mg(OH)_2$, TiO_2, stabilizers**
- **27 mil (~0.7mm) TPO roofing sheet for single ply membranes**
- **Specimens testing according to ASTM D6878 + ASTM D573**
- **ASTM D6878 Xenon conditions: 0.70W/m^2 @ 340nm, 80°C**
- **ASTM D573: Oven aging at 116°C and 138°C**
- **Tensile testing according to ASTM D751**
- **Color measurements according to ASTM E313**

CYASORB CYNERGY SOLUTIONS® B878T Stabilizer

ASTM D6878 Weathering

Single Ply TPO Sheets

Mandrel Testing

ASTM UV Requirement

kJ/m^2	2520	5040	7560	10080	20160	25200	27470	30240
B878T	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
Commercial Reference	Pass	Pass	Pass	Pass	Pass	Pass	Failed	Failed

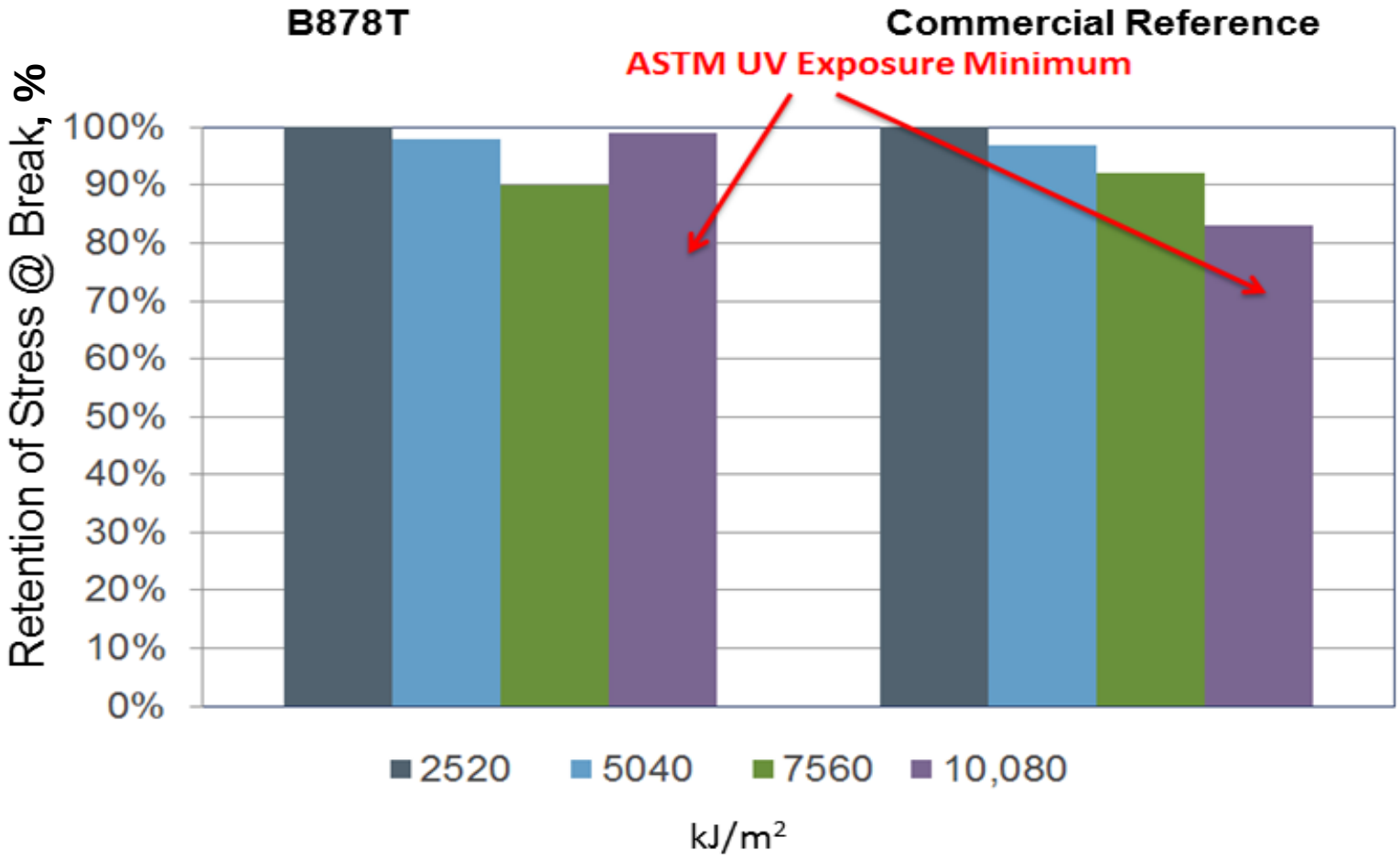
B878T can pass more than 3x the current radiant energy requirement for roofing sheets

CYASORB CYNERGY SOLUTIONS® B878T Stabilizer

ASTM D6878 Weathering

Single Ply TPO Sheets

Tensile Testing



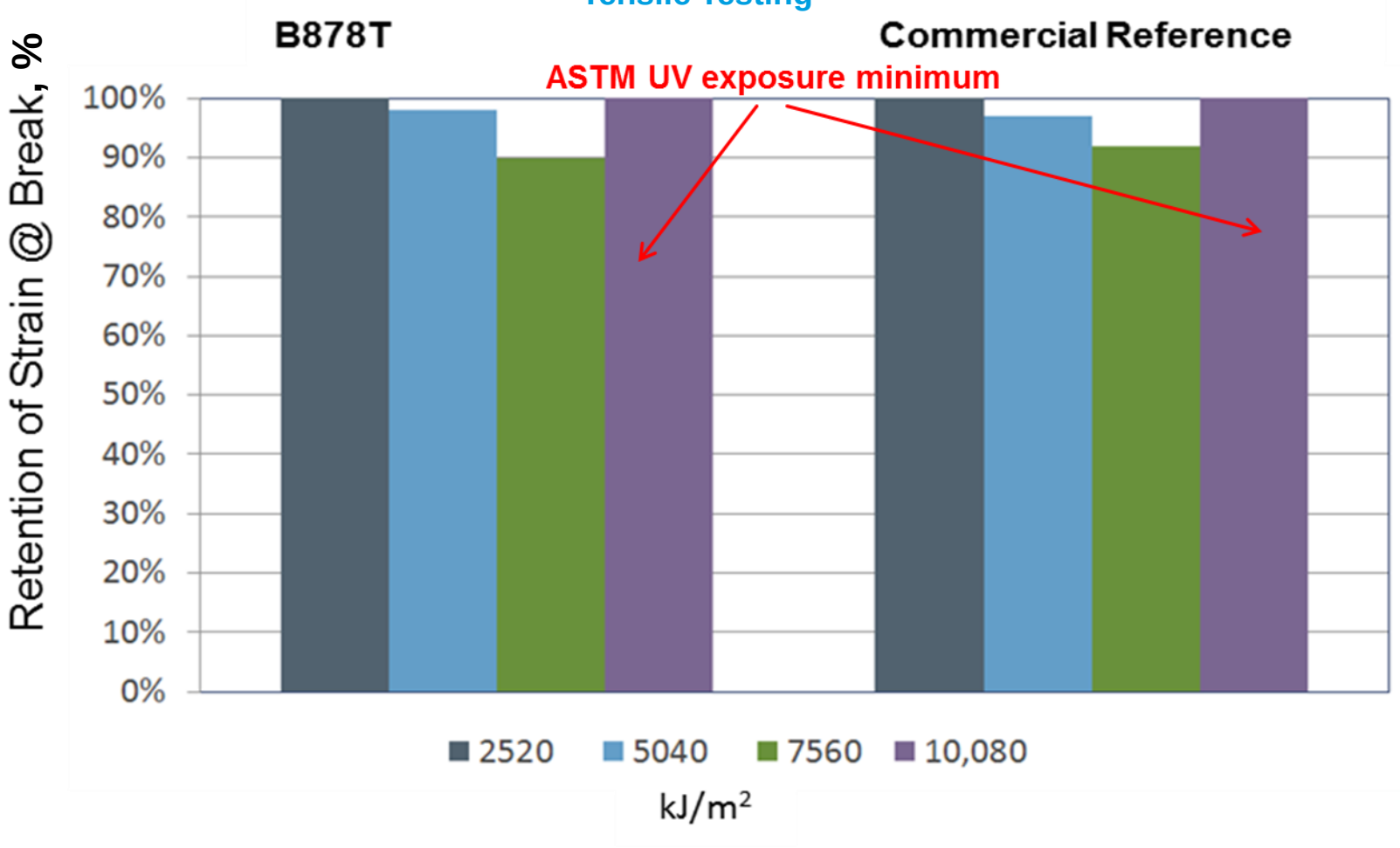
Single ply TPO sheets maintain ~100% of retention of stress at break after the radiant exposure requirement

CYASORB CYNERGY SOLUTIONS® B878T Stabilizer

ASTM D6878 Weathering

Single Ply TPO Sheets

Tensile Testing



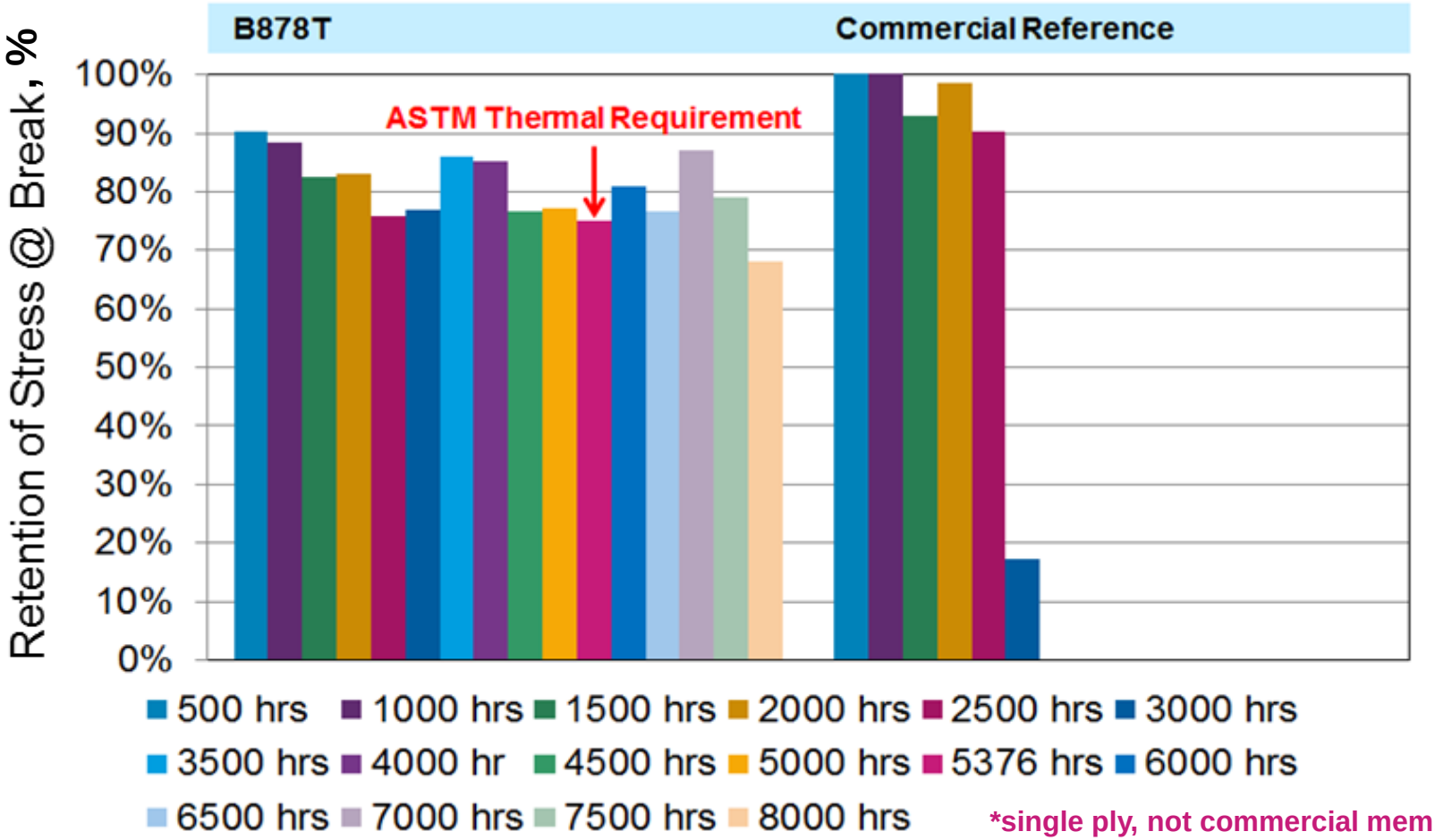
Single ply TPO sheets maintain 100% of retention of strain at break after the radiant exposure requirement

CYASORB CYNERGY SOLUTIONS® B878T Stabilizer

116°C Oven Thermal Aging

Single Ply TPO Sheets*

Tensile Testing



*single ply, not commercial membranes

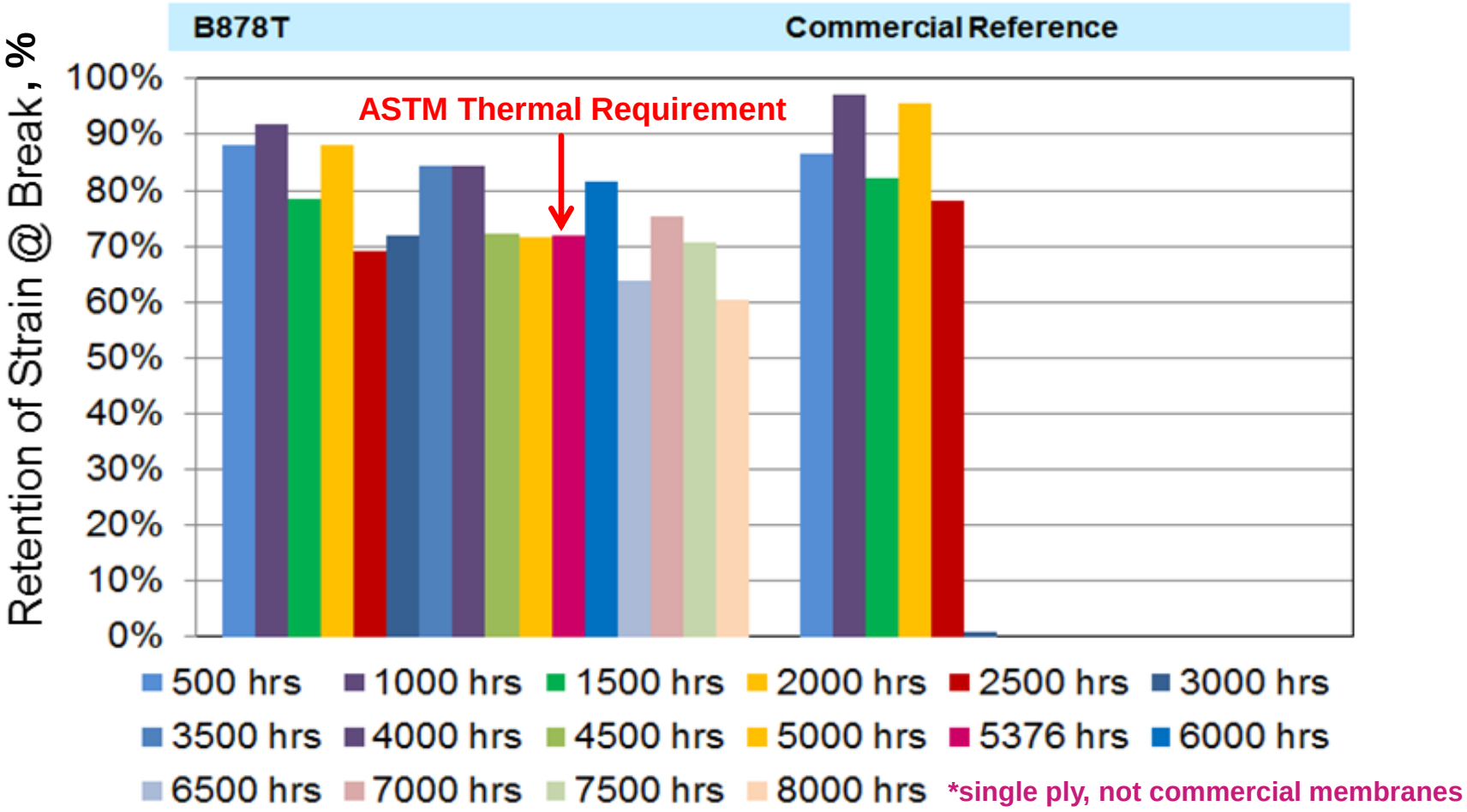
B878T maintains over 70% retention of stress at break after 7,500 hours of 116°C thermal aging

CYASORB CYNERGY SOLUTIONS® B878T Stabilizer

116°C Oven Thermal Aging

Single Ply TPO Sheets*

Tensile Testing



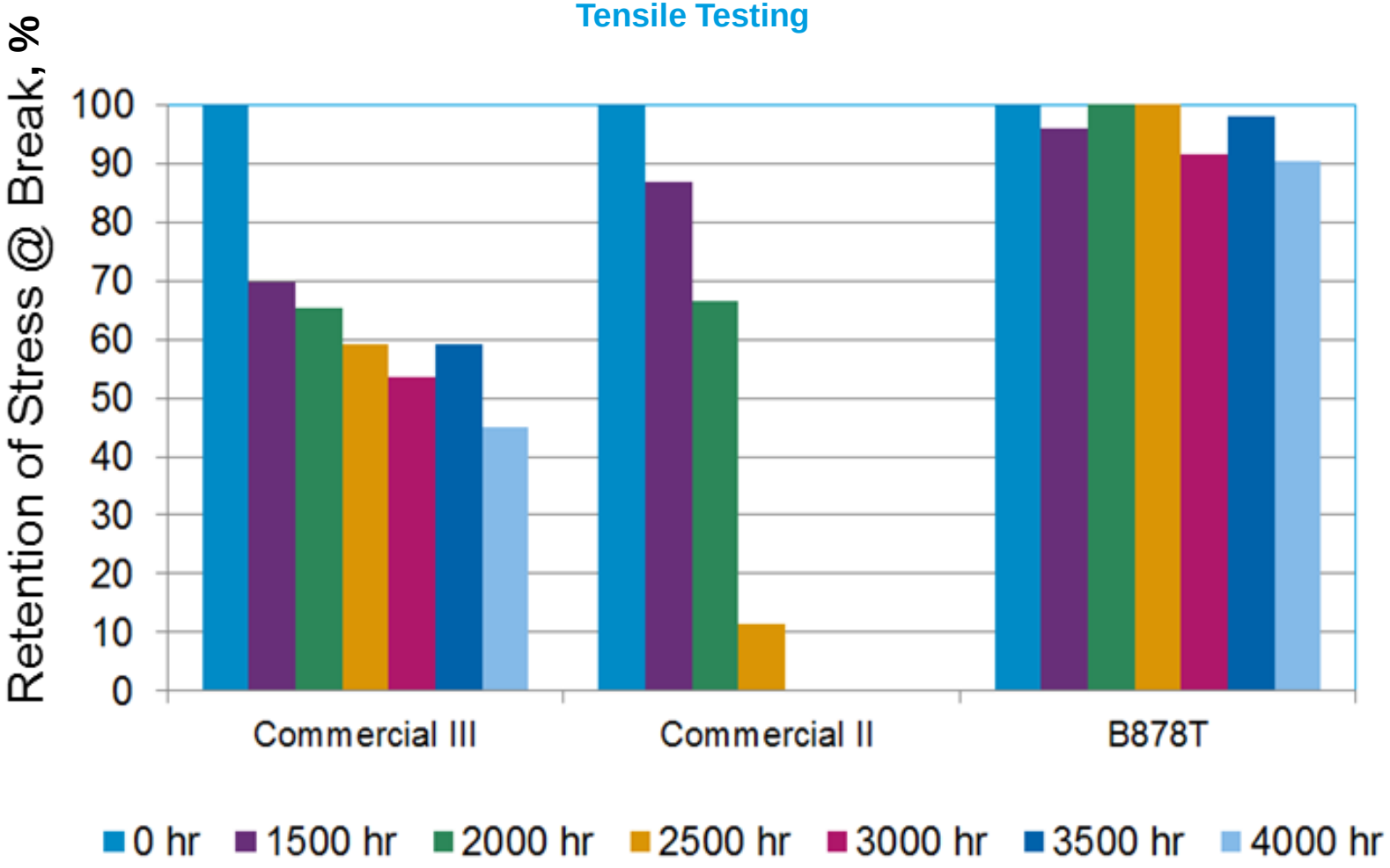
B878T maintains over 70% retention of strain at break after 7,500 hours of 116°C thermal aging

CYASORB CYNERGY SOLUTIONS® B878T Stabilizer

138°C Oven Thermal Aging

Single Ply TPO Sheets

Tensile Testing



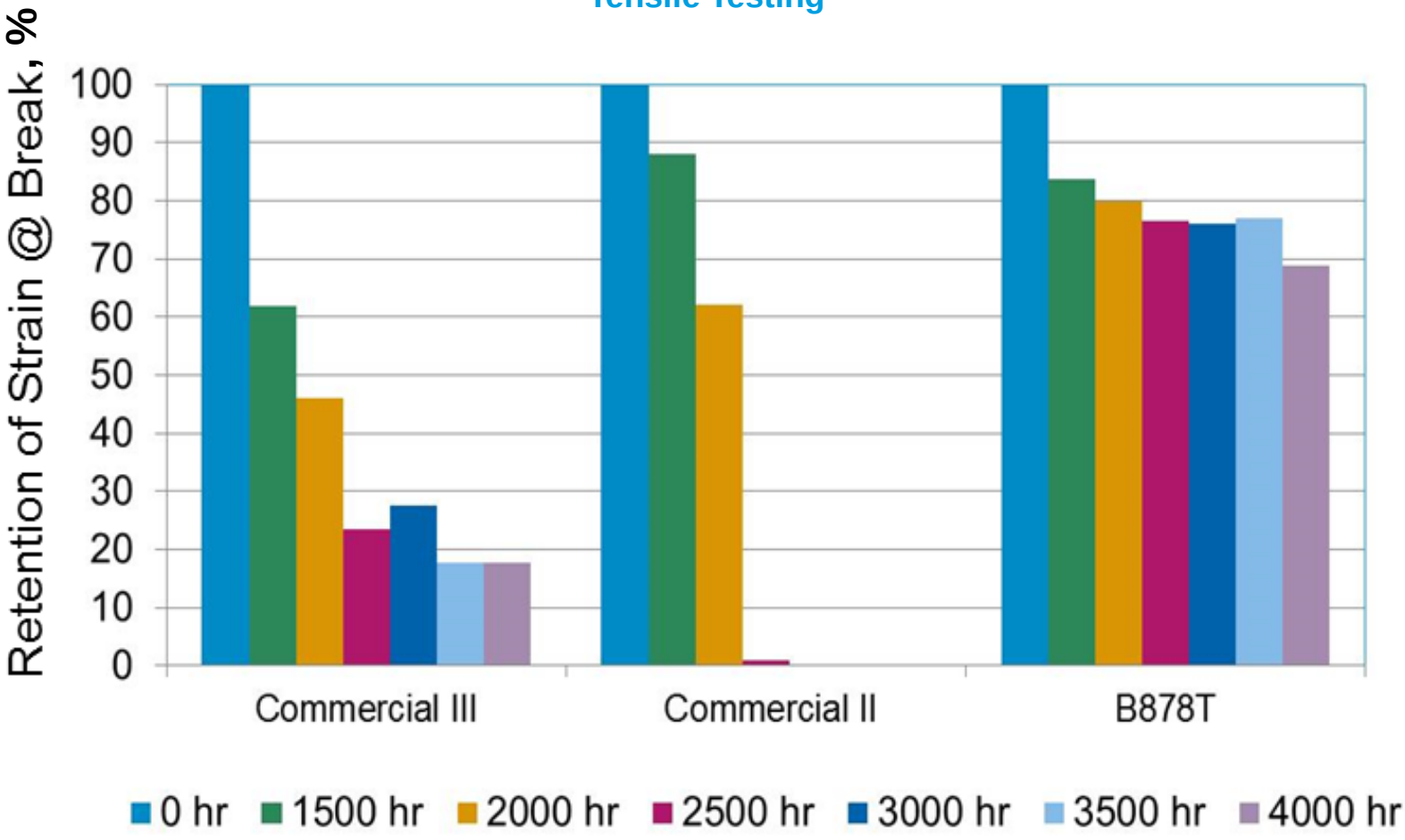
B878T maintains over 90% retention of stress at break after 4,000 hours of 138°C thermal aging

CYASORB CYNERGY SOLUTIONS® B878T Stabilizer

138°C Oven Thermal Aging

Single Ply TPO Sheets

Tensile Testing



B878T maintains 70% retention of strain at break after 4,000 hours of 138°C thermal aging

CYASORB CYNERGY SOLUTIONS® B878T Stabilizer

Features & Benefits

- Surpasses specifications for weathering and high temperature thermal exposure
- Protects physical properties with outstanding crack resistance on UV exposure
- Excellent thermal protection at elevated temperatures
- Discoloration resistant
- Available in dust free, non sticking pellet form

Applications

- TPO roofing
- Polyolefin roofing tiles
- Polyolefin roofing shakes
- Solar shingles
- Siding
- Shutters
- Geomembranes
- Sport Tiles

B878T is suitable for B&C applications requiring extreme weathering and thermal protection

Conclusions

- CYASORB CYNERGY SOLUTIONS M535® Stabilizer has been demonstrated to deliver equal performance at reduced concentrations over competitive stabilizers in PE injection molding applications

- CYASORB CYNERGY SOLUTIONS B878T® Stabilizer has shown good performance in stabilizing building & construction materials in both UV exposure and long term heat aging

Thank You For Your Kind Attention

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