Latest developments in TPO stabilization for Automotive applications

ANTEC  
MAY 8-10TH 2017  
ANAHEIM, CA
ATR Segment sub-segmentation applications

Requirements

Exterior
- LS
- Paintability
- LTHS
- Non-blooming
- Aesthetics

Interior
- Low VOCs
- Low discoloration
- LS
- LTHS
- Non-blooming
- Aesthetics

Under the Hood
- Low VOCs
- LTHS
- Non-blooming
- Aesthetics
ATR sub-segmentation
Featured AddWorks solutions

- **AddWorks LXR 355** for LS of PP
- **AddWorks LXR 568** for LTHS of PP
- **AddWorks ATR 945** for LS of PP
- **AddWorks ATR 146** for LS and LTHS of PP
what is precious to you?
Interior

PP – ADDWORKS ATR 945

what is precious to you?
AddWorks ATR 945

- AddWorks ATR 945 - Main features

- Light stability acc. OEMs Automotive interior standards

- Oven ageing at 150°C
AddWorks ATR 945
MAIN FEATURES

what is precious to you?
AddWorks ATR 945 for PP Compounds

AddWorks ATR 945 is a low molecular weight hindered amine light stabilizers (LMW HALS) solution specially developed to provide outstanding UV protection to PP compounds

**AddWorks ATR 945:**

- Outstanding UV protection
- High stabilization efficiency thanks to its high compatibility with non-polar polymer substrates
- Lowers side effects like blooming, migration and VOC (volatile organic compounds) emission from PP compounds
- Reduced odor
- High resistance to extraction by water or detergent solutions
- Exceptional handling form
AddWorks ATR 945
Color & Appearance before and after storage

After 1 day stored in oven 50C
AddWorks ATR 945
Compatibility in PP / Solubility in n-Heptane

Solubility of Samples in n-Heptane

Solubility (g/100 ml)

Equilibration time (days)

AddWorks ATR 945 Pills: 0.238 g/100 ml
AddWorks ATR 945 Micropills: 0.231 g/100 ml
LS 3853 PP: 0.015 g/100 ml

Solubility in n-Heptane (at 25 ºC)
AddWorks ATR 945 – Pills: 0.238 g/100 ml
AddWorks ATR 945 – Micropills: 0.231 g/100 ml
LS 3853 PP: 0.015 g/100 ml
AddWorks ATR 945
LIGHT STABILITY
ACCORDING OEMS
AUTOMOTIVE INTERIOR
STANDARDS

✓ SAE J-1885
✓ Toyota Std
✓ PSA D 47 1431
✓ PV 1303

what is precious to you?
AddWorks ATR 945
Light stabilization according SAE J 1885 std.

Light stability acc. SAE J1885

Delta E

Dark grey - 0.25% LS 3853
Dark grey - 0.25% ATR 945
Dark grey - 0.15% ATR 945

300 hr 600 hr 791 hr 1000 hr
AddWorks ATR 945
Light stabilization according Toyota Std

ΔE of samples after ageing according to Toyota standard - TSM0501G

Medium gray PP impact copolymer
AddWorks ATR 945
Light stabilization according **PSA D 47 1431**

**Delta-E of PP plaques (black) after WOM ageing 900 hours**

PP + 14% talc - black
AddWorks ATR 945
Light stabilization according **PV 1303**

![Gray scale of PP before and after PV 1303 test](image)

Black PP-EPDM-T20
Addition rate 0.2%
Tackiness properties evaluation
PV 1306 standard

**Tackiness**: By hands of the persons (average rating)

<table>
<thead>
<tr>
<th>Level</th>
<th>Tackiness properties</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>OK</td>
</tr>
<tr>
<td>S</td>
<td>Dull (exudation, but not tacky)</td>
</tr>
<tr>
<td>2</td>
<td>Slightly tacky</td>
</tr>
<tr>
<td>3</td>
<td>Tacky</td>
</tr>
<tr>
<td>4</td>
<td>Very tacky</td>
</tr>
<tr>
<td>H</td>
<td>Resinified</td>
</tr>
<tr>
<td>W</td>
<td>Waxy</td>
</tr>
<tr>
<td>X</td>
<td>Test cancel, specimens crack</td>
</tr>
</tbody>
</table>

The samples were exposed on the side of smooth surface and evaluated on color change, grey scale assessment, gloss and tackiness as well as surface cracking after 4 cycles or 56 MJ or 384 hrs and 6 cycles or 84 MJ or 576 hrs.
AddWorks ATR 945
Light aging for tackiness test

Gray scale of PP before and after PV 1306 test

Formulations

LS 3808
AddWorks ATR 945

Black PP-EPDM-T20, smooth surface
Addition rate 0.2%
AddWorks ATR 945
Tackiness results after light treatment (PV 1306 test)

<table>
<thead>
<tr>
<th>Time</th>
<th>Tackiness rating after PV 1306 test</th>
<th>Reference</th>
<th>AddWorks ATR 945</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial</td>
<td>1 (OK)</td>
<td>1 (OK)</td>
<td></td>
</tr>
<tr>
<td>4 cycles</td>
<td>1 (OK)</td>
<td>1 (OK)</td>
<td></td>
</tr>
<tr>
<td>6 cycles</td>
<td>1 (OK)</td>
<td>1 (OK)</td>
<td></td>
</tr>
</tbody>
</table>
AddWorks ATR 945
HEAT STABILITY AT 150°C

what is precious to you?
AddWorks ATR 945
Heat ageing test at 150°C

Delta E of PP plaque (grey) after oven ageing at 150 °C for 750 hours

*Samples burned and brittled after 750 hr (Stopped exposing)
AddWorks ATR 945 Conclusion

– AddWorks ATR 945 is a light stabilizer solution designed as highly compatible and efficient for PP compounds to meet specific requirements of automotive applications.

– AddWorks ATR 945 brings PP compounds to pass OEMs standards for light stabilization of PP Automotive Interior compounds.

– AddWorks ATR 945 enhances heat stabilization of PP Automotive Interior compounds at 150°C till 600 hours.

– AddWorks ATR 945 is available in special handling forms – beads and micro-pills – to allow an ideal distribution in the compound.
Interior
PP – ADDWORKS ATR 146

what is precious to you?
AddWorks ATR 146

– AddWorks ATR 146 - Main features

– Light stabilization according PV 1303 exposure

– Oven ageing at 150°C
AddWorks ATR 146

MAIN FEATURES

what is precious to you?
AddWorks ATR 146
Heat and Light stabilizer for Latest Automotive PP
Interior challenges

– AddWorks ATR 146 allows to fulfil the most stringent Automotive interior requirements, especially on long term heat stabilization

– No surface cracking after 700 hours @ 150 °C

– Contains no sulfur-based co-stabilizer

– Outstanding UV protection

– Reduced VOC emissions

– Very low blooming

– High compatibility with PP

– High resistance to extraction media like water or detergents

– Ready-to-use, granulated free flowing form

NB: The whole study was conducted on a PP interior grade, medium gray colored, 20% talc filled.
AddWorks ATR 146
LIGHT STABILITY
ACCORDING AUTOMOTIVE INTERIOR STANDARD

✓ PV 1303

what is precious to you?
AddWorks ATR 146
Light stabilization according PV 1303
AddWorks ATR 146
Light stabilization according **PV 1303**

AddWorks ATR 146 provides similar performance on color stability, gloss retention and surface protection in PP interior than LS 3808 after 10 cycles of PV 1303 test.
AddWorks ATR 146
LONG TERM HEAT STABILIZATION AT 150°C
## AddWorks ATR 146
**Surface appearance at 150°C after 700 hr**

<table>
<thead>
<tr>
<th>Material</th>
<th>Formulation (0.3%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No stab.</td>
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<tr>
<td><strong>Samples</strong></td>
<td></td>
</tr>
<tr>
<td>Surface Cracking</td>
<td></td>
</tr>
<tr>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>Britteness</td>
<td></td>
</tr>
<tr>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>Blooming</td>
<td></td>
</tr>
<tr>
<td>NO</td>
<td>NO</td>
</tr>
</tbody>
</table>
AddWorks ATR 146
Appearance after oven ageing at 150°C

0.3% AddWorks ATR 146

0.3% LS 3808

Exposure was stopped due to breaking of sample
AddWorks ATR 146
Surface cracking after oven ageing at 150°C

0.3% AddWorks ATR 146

0.3% LS 3808

AddWorks ATR 146 provides better performance on surface protection in PP interior than LS 3808 after 700 hr oven ageing at 150°C.
AddWorks ATR 146
Discoloration (ΔE) of PP plate after oven ageing at 150°C

AddWorks ATR 146 provides better performance on color stability in PP interior than LS 3808 after 700 hr oven ageing at 150°C.
AddWorks ATR 146
Surface quality after oven ageing at 150°C

AddWorks ATR 146 provides better performance on surface quality in PP interior than LS 3808 after 700 hr oven ageing at 150°C.
Conclusion ATR 146

- AddWorks ATR 146, all-in-one, complies with most stringent OEM requirements in heat and light stability and beyond:
  - Outstanding color retention under UV test
  - Exceptional heat resistance at 150°C (700 hours+)
  - 10 % lower total carbon emissions from PP parts when compared to best alternative
- Sulfur-free product
- Low VOC emissions
- Long lasting surface aesthetics
Under the Hood

what is precious to you?

Public

Emilie Meddah
Clariant BU Additives
Technical Marketing Polymer Additives
24.01.2017
Under the Hood
PP – ADDWORKS LXR 568
AddWorks LXR 568

- AddWorks LXR 568 – LTHS 140°C

- AddWorks LXR 568 – LTHS 150°C
AddWorks LXR 568
LONG TERM HEAT STABILIZATION AT 140°C
AddWorks LXR 568 - Oven ageing at 140°C
Surface Appearance of PP plates according PS class

AddWorks LXR 568 allows better surface protection under oven ageing test at 140°C compared to other PS classes materials.

BS: PP + 0.1% AO 1010 + 0.1% PS + 0.2% Hostanox SE 4 (DSTDP) + 20% Talc
AddWorks LXR 568
Surface quality of PP plates under oven ageing at 140°C

Formulation: PP + 0.1% PS + 0.1% AO 1010 + 0.2% Hostanox SE 4 + 20% Talc
AddWorks LXR 568
LONG TERM HEAT STABILIZATION AT 150°C
AddWorks LXR 568 - Oven ageing at 150°C
Surface Appearance of PP plates according PS class

<table>
<thead>
<tr>
<th>No PS</th>
<th>PS 168</th>
<th>PS 626</th>
<th>PS 9228</th>
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<tbody>
<tr>
<td><img src="image1" alt="Initial" /></td>
<td><img src="image2" alt="600 hours" /></td>
<td><img src="image3" alt="600 hours" /></td>
<td><img src="image4" alt="600 hours" /></td>
</tr>
<tr>
<td><img src="image1" alt="Initial" /></td>
<td><img src="image2" alt="600 hours" /></td>
<td><img src="image3" alt="600 hours" /></td>
<td><img src="image4" alt="600 hours" /></td>
</tr>
</tbody>
</table>

Samples were broken before 720 hours

AddWorks LXR 568 allows better surface protection under oven ageing test at 150°C compared to other PS classes materials.

BS: PP + 0.1% AO 1010 + 0.1% PS + 0.2% Hostanox SE 4 (DSTDP) + 20% Talc
Color retention of PP plates before and after oven ageing at 150°C

Formulation: PP + 0.1% PS + 0.1% AO 1010 + 0.2% Hostanox SE 4 + 20% Talc
AddWorks LXR 568
Mechanical properties retention at 150°C

Strength at break of PP plates before and after oven ageing at 150°C

With LXR 568, still >50% retention after 600 hours

Sample was broken before 600 hours

Formulation: PP + 0.1% PS + 0.1% AO 1010 + 0.2% Hostanox SE 4 + 20% Talc
AddWorks LXR 568
Conclusion

- **AddWorks LXR 568** show superior performance on color stability and mechanical properties retention in PP compound vs most common processing stabilizers in long term heat stabilization of talc filled PP compounds.

- **AddWorks LXR 568** shows better appearance than PS 168, PS 626 and PS 9228 after oven ageing at 140°C reaching 1500 hr.

- **AddWorks LXR 568** shows better appearance than PS 168, PS 626 and PS 9228 after oven ageing at 150°C reaching 600 hr.
what is precious to you?
Exterior

PP – ADDWORKS LXR 355
AddWorks LXR 355

- AddWorks LXR 355 - Light stabilization of PP compounds

- AddWorks LXR 355 - Heat stabilization of PP compounds
AddWorks LXR 355
LIGHT STABILIZATION OF PP COMPOUNDS
AddWorks LXR 355
Light Stabilization (Exposure acc. to Renault Ext. Std)

AddWorks LXR 355 reveals exceptional performance on color retention during light exposure tests, with grey scale still above 4 after 6000 hours of Exterior artificial weathering.

Study on black exterior PP exterior
AddWorks LXR 355
Light Stabilization (Exposure according to PV 1303)

Grey Scale before and after 10 period (2800 kj/m²) for WOM ageing

AddWorks LXR 355 reveals also excellent performance on color retention according most stringent interior artificial weathering tests.

Study on PP copolymer / 30% EPR, 20% talc, 0.4% CB, 0.4% AO 215, 0.3% LS
AddWorks LXR 355
HEAT STABILIZATION OF PP COMPOUNDS
AddWorks LXR 355
Oven ageing at 150°C - Color retention (Grey scale)

Study on PP copolymer / 30% EPR, 20% talc, 0.4% CB, 0.4% AO 215, 0.3% LS
AddWorks LXR 355
Oven ageing at 150°C - Color retention (Delta E)

![Graph showing ΔE* of PP before and after thermal ageing]

Study on PP copolymer / 30% EPR, 20% talc, 0.4% CB, 0.4% AO 215, 0.3% LS 3808

SPE ANTEC® Anaheim 2017 / 2158
AddWorks LXR 355
Oven ageing at 150°C - Surface appearance

LS 3808

AddWorks LXR 355

Initial

400 hours

Bending test (Brittleness test after 400 hr oven ageing at 150°C)

<table>
<thead>
<tr>
<th></th>
<th>Brittleness Test after 400 hr oven ageing at 150°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>LS 3808</td>
<td>Brittle</td>
</tr>
<tr>
<td>AddWorks LXR 355</td>
<td>OK</td>
</tr>
</tbody>
</table>
AddWorks LXR 355

Conclusion

– AddWorks LXR 355 reveals the best performance on color stability, surface cracking protection and mechanical stability after thermal treatment and also artificial weathering.

– Cracks and brittleness observed in sample stabilized with competitor LS 3808 system after 400 hours thermal treatment.

– AddWorks LXR 355 provides superior surface protection with no crack and no brittleness after both treatments, thermal and artificial weathering.

Clariant AddWorks LXR 355 provides superior light and thermal stability to fulfill market needs in Automotive Exterior PP compounds.
Conclusion

what is precious to you?
Potential benefits along the value chain with the right additives solution

**MB / Compounders**
- Flowability of highly filled compounds
- Better pigment dispersion

**Converters**
- Productivity
- Dimensional stability
- Energy saving
- Surface appearance

**OEMs**
- Light stabilization
- Durability
- Color stability
- Aesthetics
TOYOTA Interior parts  
TSM0501G

Instrument: Atlas Weathering O-meter (WOM), Model Ci65A (Xenon-arc Artificial Weathering Exposure Test)

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Value</th>
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<tbody>
<tr>
<td>Radiation filter</td>
<td>340 nm</td>
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<tr>
<td>Light or Dark</td>
<td>Light</td>
</tr>
<tr>
<td>Irradiance</td>
<td>0.55 W/m²</td>
</tr>
<tr>
<td>Black Temperature</td>
<td>89 C</td>
</tr>
<tr>
<td>Chamber Temperature</td>
<td>62 C</td>
</tr>
<tr>
<td>Relative Humidity</td>
<td>50%</td>
</tr>
</tbody>
</table>

Exposure Time and Interval: Taking sample at 250, 500, 750 and 1043 hr (equivalent to 2065 KJ/m²).
VW PV 1303 - Non-Metallic Materials Exposure Test of Passenger Compartment Components

Instrument: Atlas Weathering O-meter (Xenon-arc Artificial Weathering Exposure Test)

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Value</th>
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<tbody>
<tr>
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<td>Light or Dark</td>
<td>Light</td>
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<tr>
<td>Irradiance</td>
<td>1.20 W/m²</td>
</tr>
<tr>
<td>Black Temperature</td>
<td>100 ± 3°C</td>
</tr>
<tr>
<td>Chamber Temperature</td>
<td>65 ± 3°C</td>
</tr>
<tr>
<td>Relative Humidity</td>
<td>20%</td>
</tr>
</tbody>
</table>

The samples were exposed on the side of grain surface and evaluated on color change and grey scale assessment as well as surface cracking after 3 cycles or 840 kJ/m² or 195 hrs and 5 cycles or 1400 kJ/m² or 325 hrs. Grey scale is permitted as per ISO105-A02 ≥4.0 and no cracks or holes may appear after 5 cycles.
PSA - Accelerated exposure for automotive interior materials

Instrument: Atlas weathering-o-meter (WOM), Model Ci 4000 (Artificial Weathering Exposure Test)

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>Radiation filter</td>
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<tr>
<td>Light or Dark</td>
<td>Light</td>
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<tr>
<td>Irradiance</td>
<td>1.20 W/m²</td>
</tr>
<tr>
<td>Black Temperature</td>
<td>100 ± 3°C</td>
</tr>
<tr>
<td>Chamber Temperature</td>
<td>66 ± 3°C</td>
</tr>
<tr>
<td>Relative Humidity</td>
<td>30%</td>
</tr>
</tbody>
</table>

Exposure time and interval: Every 150 hr until 600 hr
SAE J-1885 (Automotive Interior)

Instrument : Atlas Weathering O-meter, Model Ci 4000 (Xenon-arc Artificial Weathering Exposure Test)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value 1</th>
<th>Value 2</th>
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</thead>
<tbody>
<tr>
<td>Segment number</td>
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<td>2</td>
</tr>
<tr>
<td>Light or Dark</td>
<td>Light</td>
<td>Dark</td>
</tr>
<tr>
<td>Irradiance</td>
<td>0.55 W/m²</td>
<td>0 W/m²</td>
</tr>
<tr>
<td>Black Temperature</td>
<td>89°C</td>
<td>38°C</td>
</tr>
<tr>
<td>Chamber Temperature</td>
<td>62°C</td>
<td>38°C</td>
</tr>
<tr>
<td>Relative Humidity</td>
<td>50%</td>
<td>95%</td>
</tr>
</tbody>
</table>
RENAULT - D27 1911 (Exterior parts)

Instrument : Atlas Weathering O-meter (Xenon-arc Artificial Weathering Exposure Test)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value 1</th>
<th>Value 2</th>
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<tbody>
<tr>
<td>Segment number</td>
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<td>Light or Dark</td>
<td>Light</td>
<td>Dark</td>
</tr>
<tr>
<td>Irradiance</td>
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<td>0 W/m²</td>
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<tr>
<td>Black Temperature</td>
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<tr>
<td>Chamber Temperature</td>
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<td>50±2°C</td>
</tr>
<tr>
<td>Relative Humidity</td>
<td>50%</td>
<td>95%</td>
</tr>
</tbody>
</table>

The samples were evaluated on color change and grey scale assessment as well as surface cracking at 1500h, 2250h and 2750h and 3500 h