



Case Study

TPO Roofing with Excellent Weathering Performance

Fulfilling the revised ASTM D 6878 standard (thermoplastic polyolefin-based sheet roofing)

The ASTM D 6878 standard for thermoplastic polyolefin (TPO) roofing formulations has been revised to address concerns of prolonged exposure in extreme heat climates. The heat aging exposure at 116°C was extended from 670 hours to 5,400 hours (32 weeks). To meet these requirements, it is critical for TPO roofing formulations to contain high quality resins combined with tailored stabilization, flame retardants, and membrane design.

The Dow Chemical Company (Dow) and BASF conducted a joint study to test various TPO roofing formulations against the revised ASTM D 6878 requirements. These tests were conducted at Dow’s R&D laboratories in Horgen, Switzerland and BASF’s in Basel, Switzerland using elastomers from Dow in combination with BASF processing and long-term stabilizer packages.

The results show that TPO roofing membranes produced with the right polymer formulation and stabilization can perform in some of the most extreme climate conditions and fulfill current roofing and waterproofing standards like ASTM D 6878 or EN 13956 (flexible sheets for waterproofing). ASTM D 6878 heat aging, along with a Xenon arc weatherometer (WOM) test based on ASTM G 26A, demonstrates UV-resistance⁽¹⁾ and long-term weathering behavior. Depending on the climate zone, 1.5 mm membranes may last up to 25 years or more.



TPO Formulations and Longevity

TPO formulations based upon Dow’s thermoplastic polyolefin elastomers help ensure that important membrane properties such as processability, welding, elasticity, and physical strength are met. To protect against degradation during membrane production and end-use, several other elements are needed, including:

- Phenolic process stabilizers and hindered amine light stabilizers (HALS)
- Flame retardants such as aluminum trihydrate or magnesium hydroxide for fire safety⁽²⁾
- Titanium dioxide or carbon black for additional UV protection
- Calcium carbonate to help improve economics and fine tune performance properties

Table 1: Dow-BASF TPO Formulation

Parts per Hundred (Phr)	Component Description	Commercial Product
70	Polyolefinic elastomer	VERIFIFY™ 2300 Plastomer
30	Impact copolymer polypropylene	INSPIRE ⁽³⁾ 137 Performance Polymer
0.3	Phenolic process stabilizer system	Irganox ⁽⁴⁾ B 225
0.75	Hindered amine light stabilizer	Chimassorb ⁽⁴⁾ 2020
3	Titanium dioxide	KRONOS ⁽⁵⁾ 2220
64	Precipitated magnesium hydroxide	MAGNIFIN ⁽⁶⁾ H-5

⁽¹⁾The addition of a UV stabilizer to a resin does not completely eliminate the effects of UV exposure. These effects may include color shift (yellowing, darkening, or bleaching), decreased ductility, decreased impact resistance, decreased mechanical properties, decreased surface gloss, and/or increased haze. The purpose of a UV stabilization package is to slow down the rate at which these effects occur. Actual results may vary depending on application and other factors such as resin color, transparency, and additives. Therefore, actual end-use testing is recommended.

⁽²⁾Resins containing ignition-resistant additives do not readily support ignition. However, they will burn under the right conditions of heat and oxygen supply. The resins should not be exposed to direct flame or extreme heat. Results of small-scale flammability tests on these or any other materials are not to be considered indicative of the behavior of these materials under actual fire conditions.

⁽³⁾Trademark of Braskem S.A. ⁽⁴⁾Trademark of BASF ⁽⁵⁾Trademark of Kronos Titan GmbH ⁽⁶⁾Trademark of Albemarle

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The quality of these formulation components can also significantly impact the UV-resistance and weatherability performance.

For the purposes of this study, BASF's latest stabilization was used in a state-of-the-art European TPO formulation (Table 1, previous page). This formulation meets the requirements of ASTM D 6878 and EN 13956.

Sample Preparation and Testing

Compounds were produced on a PR 46 Buss-Co-kneader and extruded into 0.5 and 1.0 mm thick sheets on a 40 mm Colin single screw extrusion line.

Oven Aging: The sheets were exposed to 120°C in a circulating air oven for 155 days. The mechanical properties were tested over this period.

Artificial Weathering: The effect of UV exposure was examined on the 1 mm samples on the weatherometer at an irradiation of 0.35 W/m² at 340 nm, dry/wet cycle 102 min/18 min, 63°C black panel temperature (BPT). Surface inspection and mechanical testing were performed up to 20,000 hours of exposure.

Figure 1: Oven Aging of TPO Sheets at 120°C⁽¹⁾

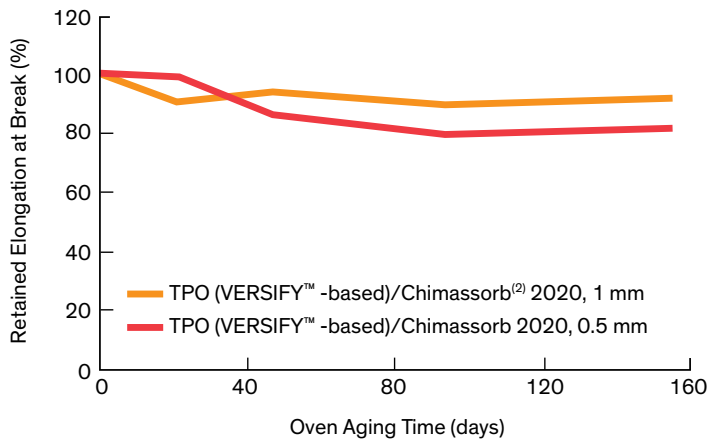


Table 2: Visual Assessment of TPO Sheet after UV Exposure in WOM⁽¹⁾

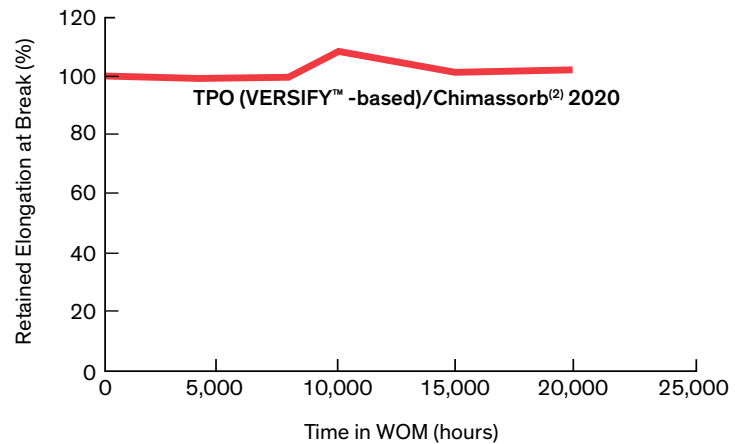
Formulation	Time to Microscopic Crack Formation (50x microscope) WOM: 0.35 W/m ² at 340 nm; 102/18 min dry/wet cycle; 63°C BPT
TPO (VERSIFY™-based)/Chimassorb ⁽²⁾ 2020	>20,000 hours

Results

Oven Aging: The TPO retained mechanical properties over the entire test period, as shown in Figure 1. The revised requirements of ASTM D 6878 can be fulfilled without impacting stabilization, resin, and formulation.

Artificial Weathering: Global roofing standards require no surface defects and more than 85 percent retention of mechanical properties after exposure to UV light with 5,040 kJ/m² (4,000 hours in WOM). Figure 2 and Table 2 show that these requirements were passed without loss of surface quality or mechanical strength up to 20,000 hours of testing (when the samples were used up). It is evident that state-of-the-art TPO formulations can be tailored for use in some extreme climate conditions. Depending on the climate zone, 1.5 mm membranes have a predicted potential lifetime of 25 years or more.

Figure 2: Mechanical Properties of 1 mm TPO Sheets after UV Exposure in WOM⁽¹⁾



For additional information regarding TPO roofing formulations designed to fulfill ASTM D 6878 or EN 13956, contact your Dow Technical Service & Development professional, your Dow Elastomers seller, or call the Dow Customer Information Group (CIG) at 1-800-441-4369 or 1-989-832-1426. Find out more about Dow Elastomers and Dow products for TPO roofing applications at www.dowelastomers.com.

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Published July, 2013.
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⁽¹⁾ Data per tests conducted by Dow. Test protocols and additional information available upon request. Properties shown are typical, not to be construed as specifications.

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