Coatings based on Trilene® EPDM Rubber

Technology and Applications

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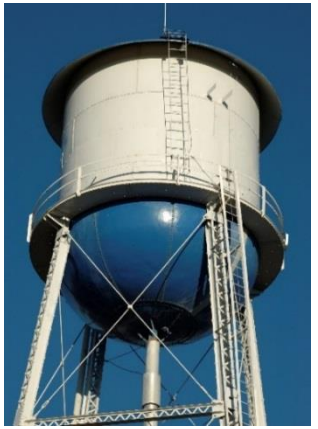
Trilene® in Coatings Outline

- What is EPDM Rubber and Where is it Used
- Advantages of Coatings from EPDM Rubber
- Technology & Applications
- Water-dispersed EPDM Coating Technology Development
- EPDM Grades for Powder Coating
- Wrap-up



Lion Elastomers is a leading manufacturer of synthetic rubber products. Our products represent the highest performing, highest quality EPDM and SBR rubber materials available anywhere in the world. The company operates world-class EPDM and SBR manufacturing facilities in Geismar, Louisiana and Port Neches, Texas.

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EPDM Rubber Key End Markets and Applications

EPDM					
	Automotive	**Polymer Modification**	**Construction**	**Wire & Cable**	**Mechanical Rubber Goods**
					
Applications	➢ Door/window seals ➢ Hoses, belts, gaskets and brake components ➢ Body side moldings and bumpers ➢ Airbag systems, instrument and door panels, and steering wheel ➢ Covers and sleeves ➢ Tires	➢ EP/EPDM elastomers used in thermoplastic polyolefins (TPO and TPV) • TPO and TPV are used in a variety of automotive, roofing, and consumer goods applications	➢ Single-ply roofing membranes ➢ Geomembranes ➢ In-window seals ➢ Drainage and tunnel seals ➢ Pond liners	➢ Increased use for wire and cable insulation ➢ Cable jacketing lead-in wire for residential and commercial buildings, building wire, mine cable, nuclear plant wire, automobile ignition wire, control and signal wire, power cable and medium voltage insulation, low voltage insulation, connectors and cable filler	➢ Appliance parts such as hoses, agitator boots and gaskets that come in contact with detergents and hot water ➢ Household appliances (dryers, dishwashers, refrigerators, vacuum cleaners, coffee makers, blenders and juicers). ➢ Belts and conveyors

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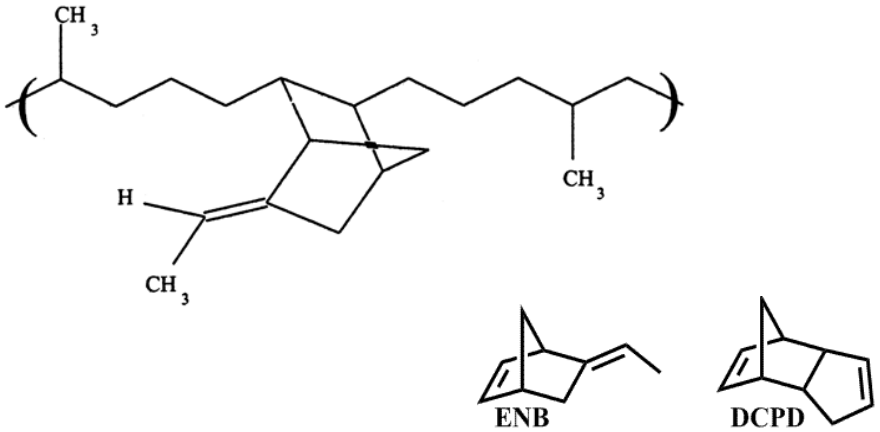
General Description & Application for EPDM

EPDM (Ethylene Propylene Diene Terpolymer*)



Compared with other rubbers, many special properties of EPDM are derived from the saturated backbone structure. Primary application areas for EPDM include Automotive, Building & Construction, Wire & Cable, and Consumer Products.

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* *In ASTM nomenclature system, M designates a saturated polymer backbone. In contrast, R designates polymers that contain unsaturated backbone, e.g. NR, SBR.*

EPDM Properties Desired in Coating Applications

- ✓ Oxidation, UV and Ozone resistant
- ✓ Hydrophobic and water proof
- ✓ Low moisture permeability
- ✓ Flexibility, especially at low temperature
- ✓ Excellent electrical properties

- ✓ Adhesion to a wide variety of surfaces

Grades	E/P Ratio	Wt. % Diene	M_w*	Viscosity**
Trilene® 65	50/50	10.0 DCPD	47,000	177,000
Trilene 67	46/54	9.5 ENB	39,000	128,000
Trilene 77	74/26	10.5 ENB	27,000	102,000

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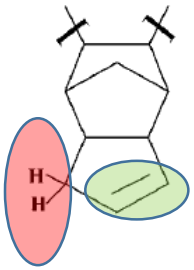
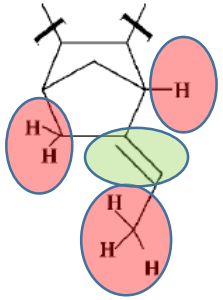
* Molecular weight derived from kinematic viscosity measurements. M_w is weight average molecular weight.
** Viscosity is Brookfield (cP) at 100˚C.

Curing of Trilene® Polymer: Free Radical Curing

Peroxide Curing

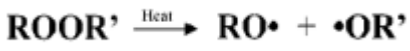


Dicyclopentadiene
(DCPD)



Ethylidene Norbornene
(ENB)

1) **Thermal decomposition of peroxide**

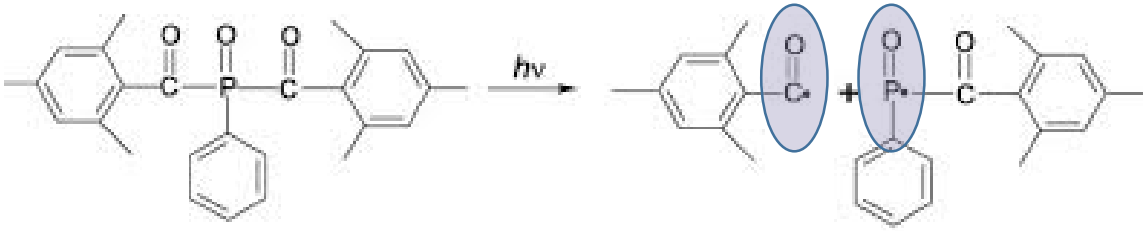


2) **Hydrogen abstraction from polymer**

3) **Crosslink formation (coupling)**

Curing of EPDM relies on free radical crosslinking chemistry. Peroxide generates polymer free radicals either by adding to a double bond or through the abstraction of Hydrogen atoms, often adjacent to the double bond (α-H). Curing through UV follows the same free radical crosslinking chemistry. The only difference is the source of free radicals. Omnirad® 819 (BAPO), for example, has the best absorption of natural sunshine and allows curing.

UV Curing



BAPO: Bis-Acyl-Phosphine Oxide, Omnirad® 819, Peak adsorption 371, 400 nm, CAS# 162881-26-7

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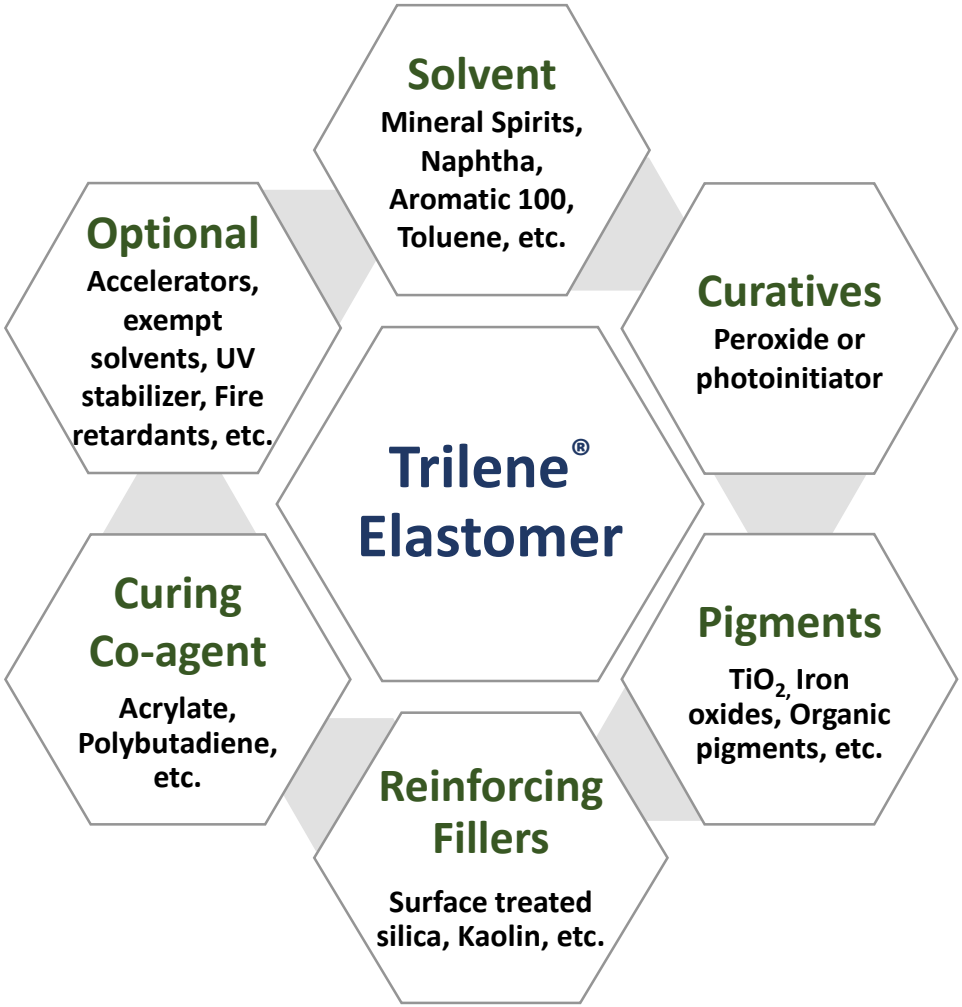
Typical Ingredients of Trilene® Solvent-based Coating



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Typical raw materials cost: US $18-22 / Gallon for roof coating formulation

Starting Formulations - Peroxide and UV Curing

Material	Function	Supplier	Peroxide	UV
Part A				
Trilene® 65	Function	Lion Elastomers	32.92	28.37
Ricon® 156	Co-agent	Cray Valley	2.74	2.36
SR-350	Co-agent	Sartomer	0.69	
Mineral Spirit	Solvent	Lard Oil	20.67	16.55
SIH6115.0	Exempted Solvent	Gelest	10.00	21.28
Disper BYK® 118	Dispersant	BYK	1.10	0.70
Ti-Pure® R-706	White Pigment	Chemours	8.23	9.46
Coupsil® 6508	Reinforcing Filler	Evonik		9.46
Ultrex® 96	Reinforcing Filler	BASF	16.46	
Omnirad® 819	Photoinitiator	IGM Resins		2.36
12% Co Ten-Cem	Catalyst	OMG	0.27	
18% Zn Ten-Cem	Catalyst	OMG	0.27	
Toluene	Co-solvent	Various		9.46
Part B				
Peroxan® PIN	Curative	Pergan	1.65	
Mineral Spirit	Solvent	Lard Oil	5.00	
Total			100	100
		Solid Content (w/w%)	64.3%	52.7%
		VOC (g/L)	243	247
		Brookfield Viscosity (cP)	4600	5400
		Specific Gravity	0.946	0.955

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Typical Performance Properties of Coatings

Characteristic	UV/Sunshine Cured	Peroxide Cured	Testing Standard
Solid Content	Up to 80 wt%	Up to 80 wt%	ASTM D3960
VOC	<250 g/L	<250 g/L	ASTM D3960
Specific Gravity	~0.94	~0.94	ASTM D1475
Brookfield Viscosity (25°C)	4000-9000 cP	3000-9000 cP	ASTM D2196
Tensile Strength	800-1200 psi	1200-1600 psi	ASTM D412
Elongation at Break	120-140 %	80-100 %	ASTM D412
Dry-to-Touch (25°C)	30-60 min	3-4 hours	ASTM D1640
Dry-to-Handle (25°C)	8 hours	16 hours	ASTM D1640
Paint Pot Life (25°C)	N/A	> 2 hours	
Adhesion to substrates	OK with aged EPDM, TPO, wood, metal, concrete, and typical acrylic or epoxy primers		ASTM D4541
Moisture Permeability	< 0.2 perm	< 0.2 perm	ASTM E96
Paint Shelf Life (25°C)	3 years	1 year	

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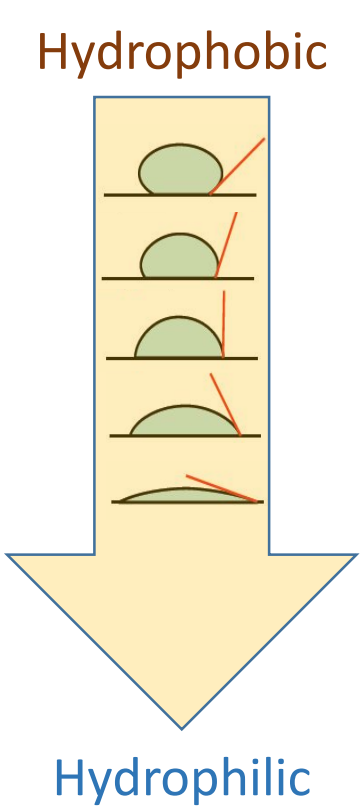
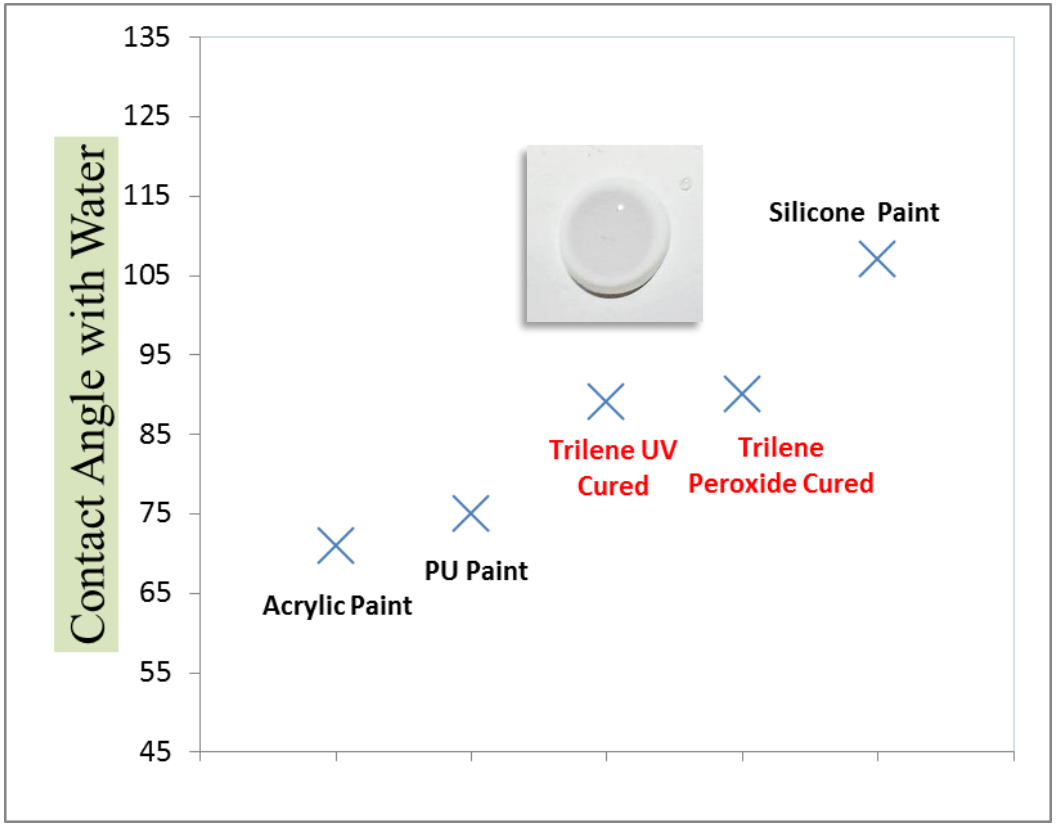
Hydrophobicity – Contact Angle Test
ASTM D7490





Trilene® based coatings are more hydrophobic than acrylic and polyurethane(PUR) paints.

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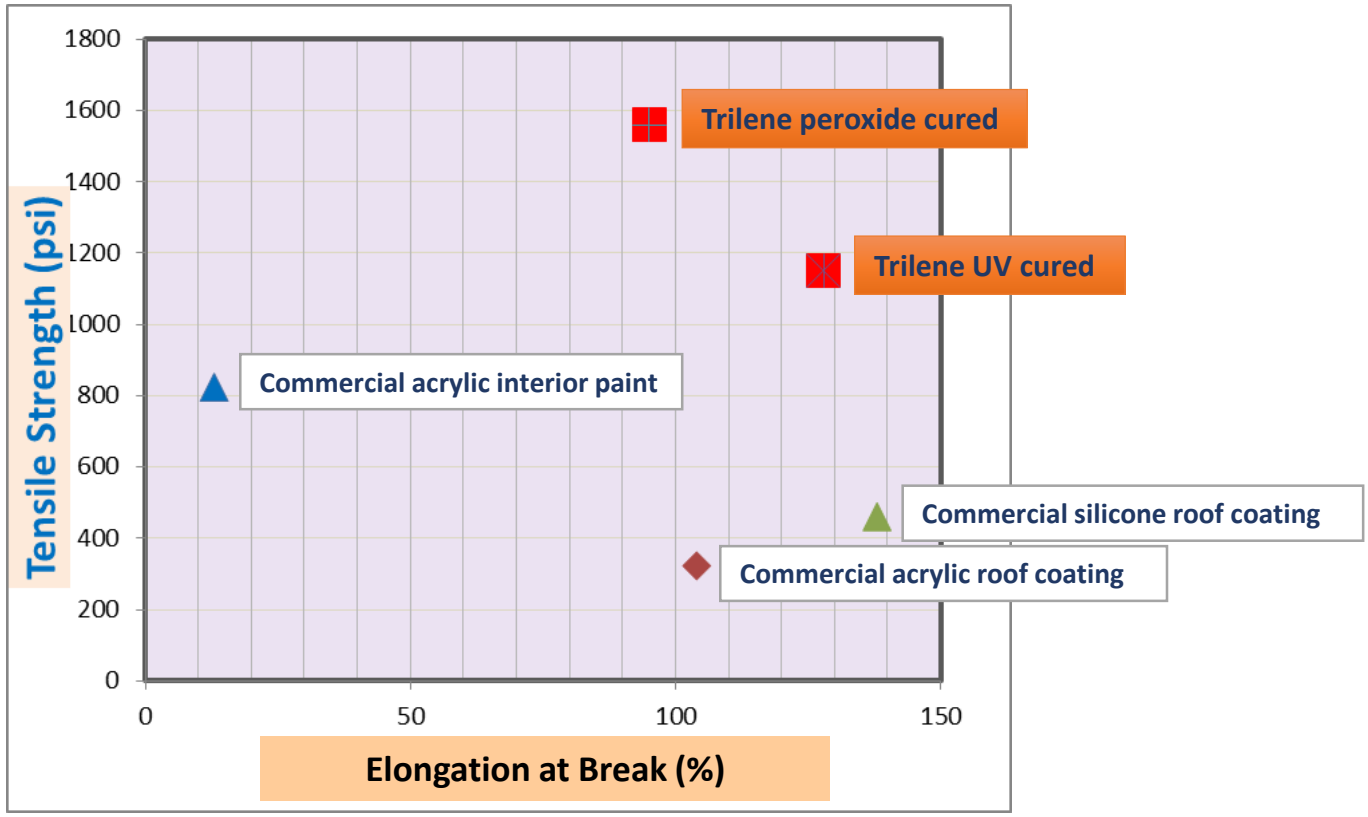
Mechanical Strength – Tensile Test
ASTM D412



** Comparison based on commercial products dried 7 days.*

Trilene® based coating showed better mechanical strength than alternative roof coatings.

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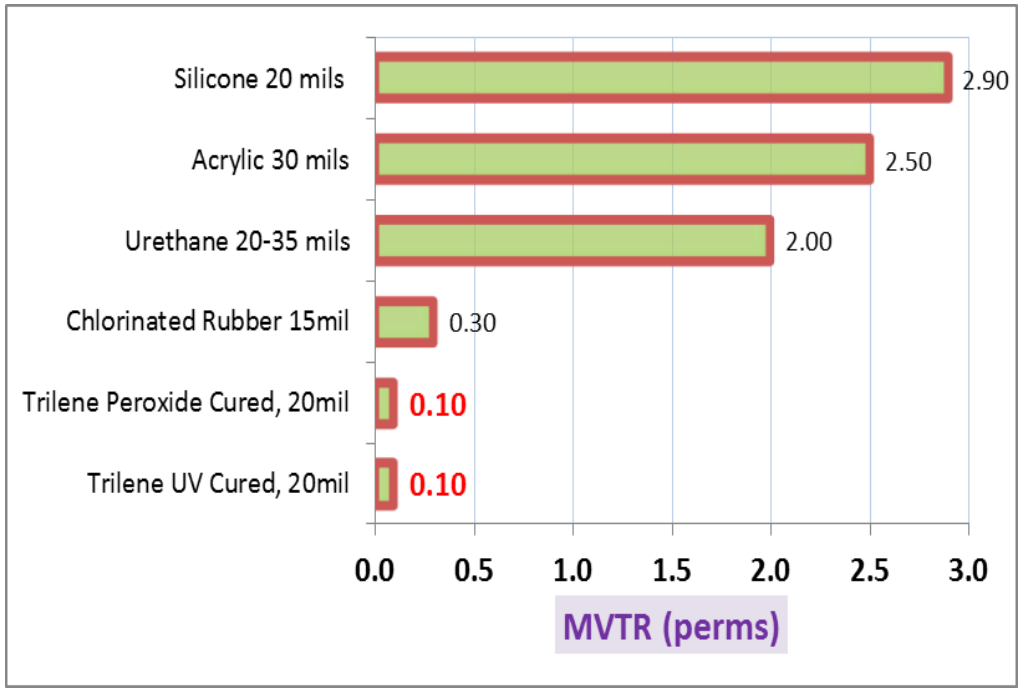
Water Moisture Vapor Resistance (MVTR)
ASTM E96



Trilene® based films have very low moisture vapor transmission rates compared with other materials. MVTR can be adjusted through formulation, if desired.

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Adhesion to Substrates and Primers
ASTM D4541

Substrate	ASTM D4541 Pulling Test (psi)	Results
Aged EPDM Sheet (pre-cleaned with NaOH)	2300	OK
Aged EPDM Sheet (No Pretreatment)	2150	OK
New TPO Sheet	1350	OK
Aluminum Panel (Q Panel)	1420	OK
Cold Rolled Steel	2200	OK
Wood Panel	1900	OK
Concrete Panel	1600	OK
Primer coatings		
Master Chem KILZ2	2100	OK
Master Chem KILZ Complete	2300	OK
Behr 436	2250	OK
Roman Rx35	2450	OK
Glidden Gripper	2000	OK
Zinsser B.I.N.	2240	OK
Zinsser 1.2.3	2260	OK

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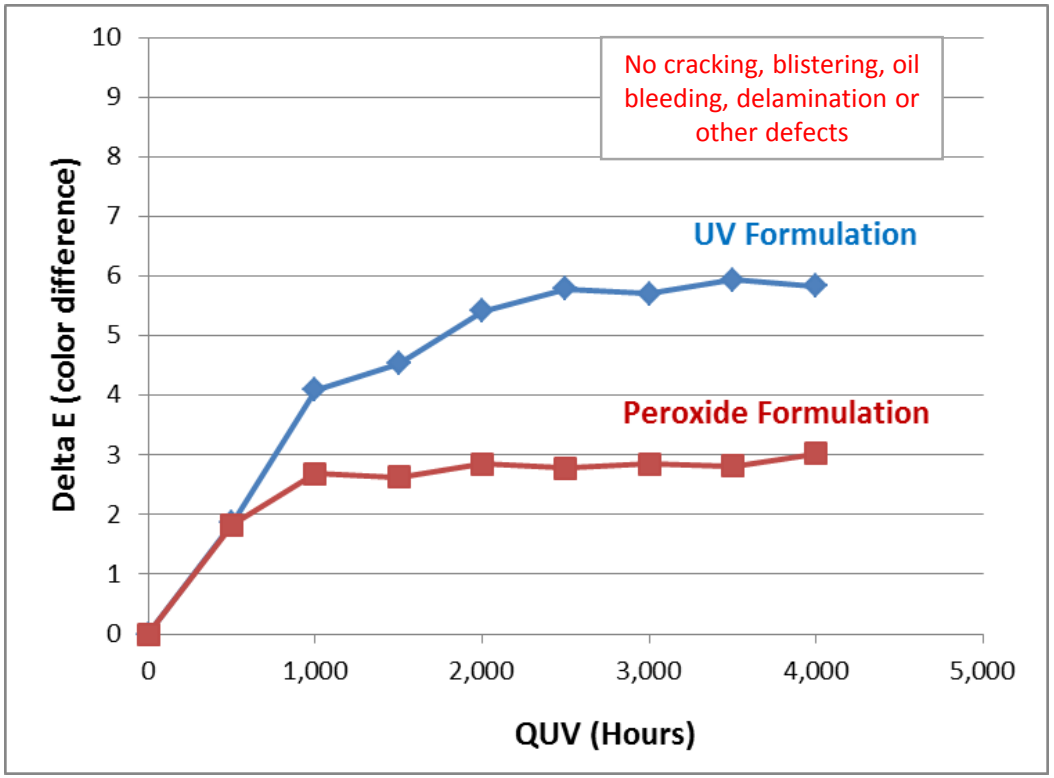
Weatherability – QUV Aging Test
ASTM D4587



* Based on Trilene-based roof coating peroxide formulation coated to 15 mil DFT. No UV absorbers used. QUV lamp peaks at 340nm with output of 0.89 w/m^2. Color was compared to a reference samples not exposed to QUV.

Trilene® based roof coatings showed good stability for >4000 hours under QUV accelerated aging.

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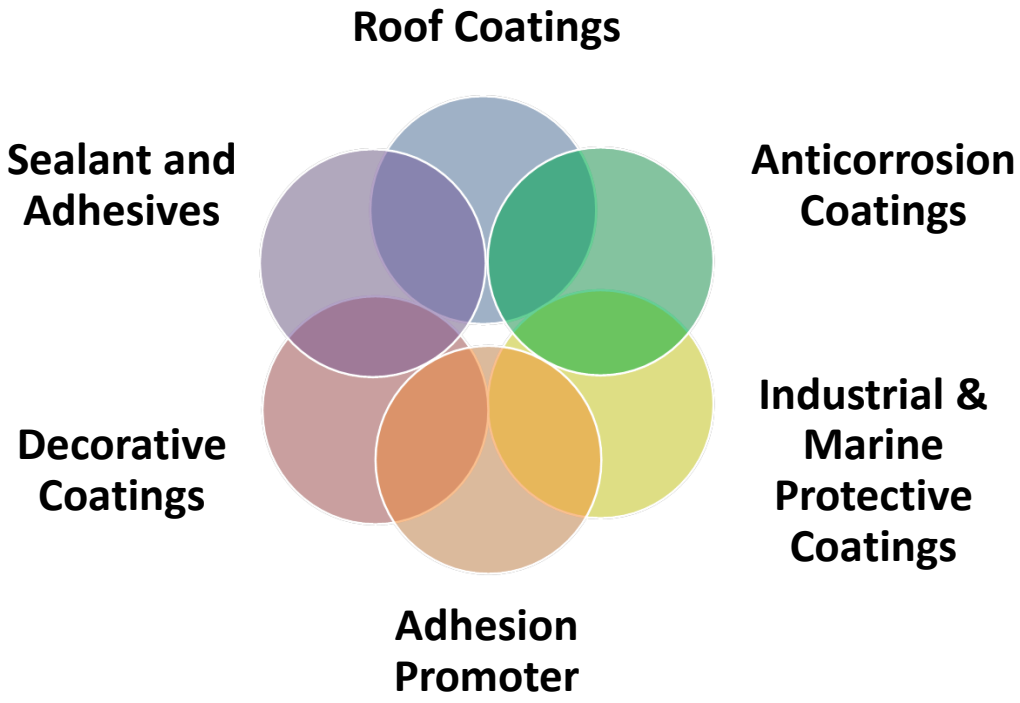
Potential Coating Applications



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Roof Coating: Field Application

DURABILITY, FLEXIBILITY, AND WATER RESISTANCE

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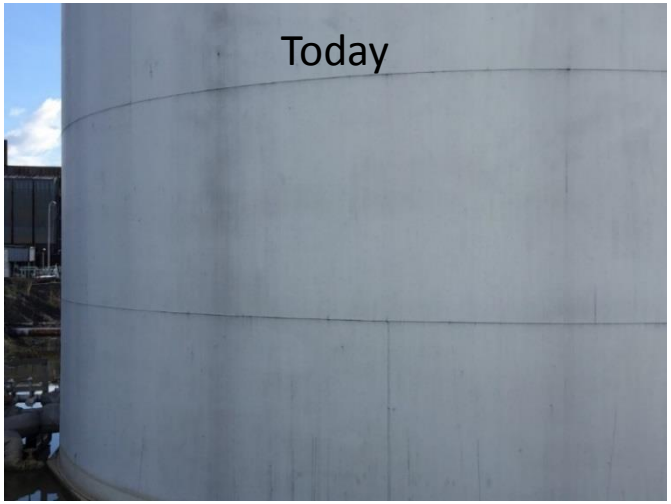
Protective Coating: Case Demonstration

Before Coating

After Coating



Demonstrating a Trilene® based protective coating. Coating still performing after 4-years in service.

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Water dispersed EPDM

- Solvent based coatings based on Trilene® EPDM have a relatively high VOC demand.
- Some applications require waterborne formulations for environmental and/or health concerns.

Solvent solution Neat

- A dispersion of Trilene EPDM in water has been developed. The dispersion provides an approach to a stand alone coating, or a unique additive to current latex products.
- Typical properties of the EPDM dispersion
  - 45-55% by weight solids content
  - Pourable viscosity at room temperature
  - Formulated with common ingredients
  - Water clean-up
  - Peroxide or UV curable
  - Compatible with other water-based resins

46% dispersed in water

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Trilene® Grades for Powder Coating

- A powder version (Freeflow®) is available for some grades;
- Freeflow version is achieved by adsorbing Trilene EPDM onto 30-32% silica filler (or other powder surface);
- Can be fast cured with temperature using a sulfur or peroxide system, thus a powder coating is achievable;
- A powder coating with flexibility is the major advantage.

Grades	Wt. % Diene	E/P Ratio	Density (g/cc)
Trilene 65 FF	10.0 DCPD	50/50	1.00
Trilene 67 FF	9.5 ENB	46/54	0.86

Trilene 65 C-30 is 30% active Trilene 65 adsorbed on Burgess KE silane-treated, calcined clay.

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Wrap-up

- ✓ Solvent-based coatings based on low molecular weight EPDM elastomer have been successfully developed using both peroxide and photoinitiator (UV) crosslinking.
- ✓ Properties and advantages of EPDM coatings have been demonstrated.
- ✓ EPDM Coatings offer potential in various coating applications, including roof, protective, and decorative coatings.
- ✓ Water dispersed EPDM technology has been developed.
- ✓ Grades for powder coatings are also available.

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Thank you.