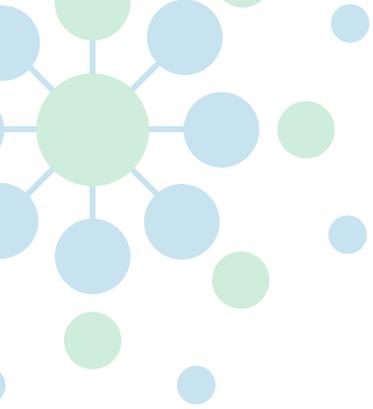


CERANOVUS[®] PRODUCTS

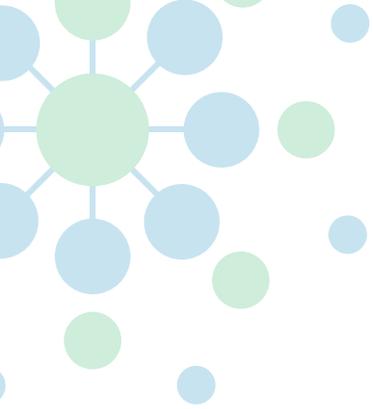
Waterproofing Underlayments & Membranes
for Roofing Applications



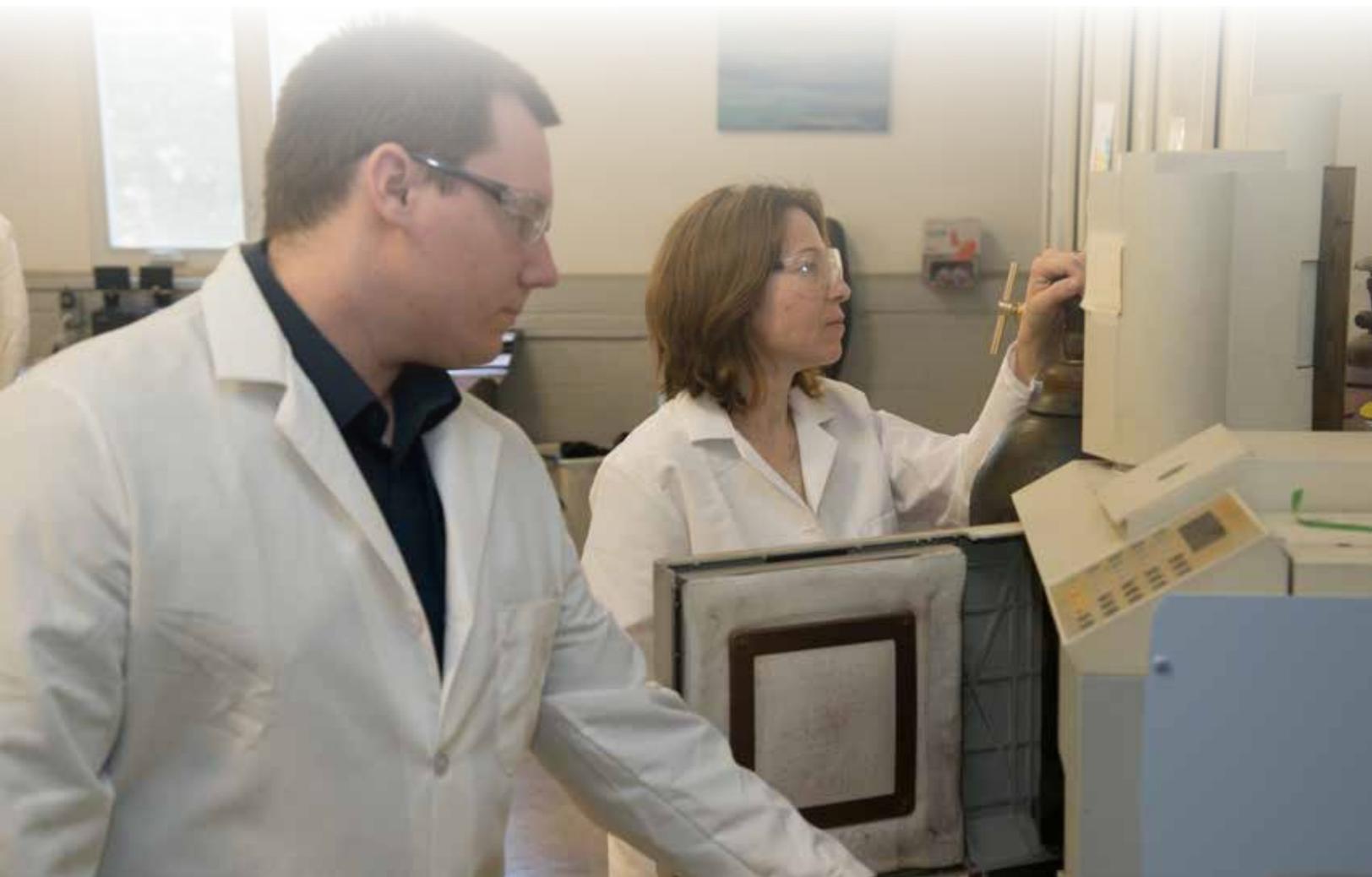
GreenMantra® Ceranovus® Additives Enable Better Performance in Waterproofing underlayments and membranes

Roofing manufacturers are always on the lookout for raw materials to make higher performing, longer-lasting asphalt roofing products—without raising costs. Waterproofing underlayments and membranes are a type of adhesive asphalt sheeting applied to plywood under shingles, at roof edges and inside corners—leak-prone areas subject to snow and water buildup. This application accounts for approximately 16% of residential roofing business and requires materials resistant to climatic extremes and mechanical stress. GreenMantra Technologies, a leading-edge North American specialty chemical manufacturer, has developed new products that can enhance the roofing membrane performance and processing, while maintaining or reducing costs compared with conventional formulations.





Through a proprietary process, GreenMantra has developed a series of asphalt additives designed for various applications including waterproofing underlayments and membranes. Third party testing shows that these Ceranovus® A Series polyethylene and polypropylene additives can improve multiple performance parameters of a typical SBS modified formulation. Because waterproofing membrane products are applied under asphalt roofing and other roofing products, high temperatures play a large role. Manufacturers need products that can withstand high heat without sagging or deformation. In waterproofing membrane or underlayment, Ceranovus additives can improve adhesion while maintaining flexibility at both high and low temperatures. They can increase the softening point for greater high temperature stability, reduce penetration for less deformation, lower viscosity for easier processing and greater formulating freedom, and decrease separation—which may mean greater stability during shipping and storage. These specially designed products have a positive impact on performance and are sustainably made with 100% recycled plastics.



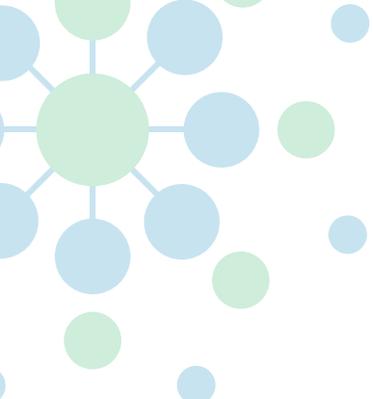


WORKING TOWARD A **CLEANER ENVIRONMENT**

Of the **300 million tons** of plastic produced globally each year, only about 10 percent is recycled. We are committed to the cost-effective transformation of plastic waste into high value products, improving the environment and creating a more circular economy for plastics.

Furthermore, sourcing feedstocks from recycled plastic materials means GreenMantra's products lessen the challenges associated with petroleum-based products, such as constrained supply and cost volatility.





Summary of Benefits

Results of application testing are detailed below, but here is a brief overview of the benefits to be gained from partial (~30%) substitution of SBS with GreenMantra’s Ceranovus additives in waterproofing underlayment or membrane formulations.



Properties of Ceranovus A Series Additives for Waterproofing Underlayment or Membrane Applications

Ceranovus A Series performance additives are delivered as dark, 2-3 millimeter pastilles. Properties of the two standard products we tested for this application are listed in Table 1.

- **Performance benefits**
 - 2x improvement in plywood adhesion
 - Decreased penetration by 10-15 dmm
 - Increase in softening point by 10-22°C
 - Low temperature flexibility and thermal stability maintained
- **Manufacturing benefits**
 - Formulation viscosity decreased by approximately 55-65%, resulting in easier processing
 - Improved separation values suggest certain A Series products may act as compatibilizers, possibly increasing stability during shipping and storage
- **Greater sustainability**
 - Replacing a proportion of virgin-sourced synthetic rubber-modified bitumen with non-virgin-sourced wax contributes to a circular economy product design

Table 1: Properties of Ceranovus A Product Series additives for waterproofing underlayment and membrane applications

	DENSITY (g/cm ³) ASTM D1298	DROP POINT (°C) ASTM D3954	NEEDLE PENETRATION @ 25°C (dmm) ASTM D1321	VISCOSITY CPS @ 140°C BROOKFIELD
Ceranovus Waxes				
A120	0.93	122	2	700
A155	0.91	155	2	75

Third Party Application Testing

To quantify the performance effects of modifying asphalt in waterproofing membrane formulations with incorporating GreenMantra Ceranovus additives, we engaged PRI Asphalt Technologies, Inc. for third party testing and evaluation.

Components of the test formulations are shown in Table 2.

Table 2: Components of waterproofing underlayment and membrane formulations tested

Component	Grade
Base Asphalt	PG 64 - 22
Asphalt Extender	REOB
SBS	Linear SBS
Cross Linking Agent	Sulfur
Dolomite Filler	# 80 mesh (dried)
PE Wax	Ceranovus A120
PP Wax 2	Ceranovus A155

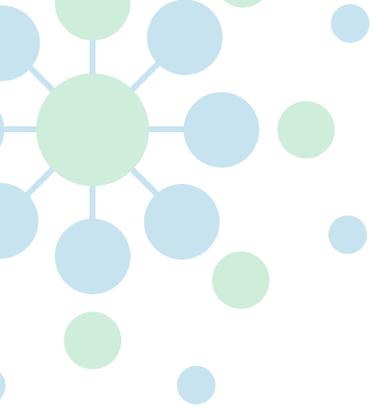
SBS is styrene-butadiene-styrene; PE is polyethylene; PP is polypropylene; REOB is re-refined engine oil bottoms

Formulations tested (Table 3) included a typical self adhered waterproofing membrane formulation with no additives, as a control; two formulations in which different additives—Ceranovus A120 and Ceranovus A155—replaced around 30% of the SBS; and one formulation in which Ceranovus A155 additive was added while the original SBS content was preserved.

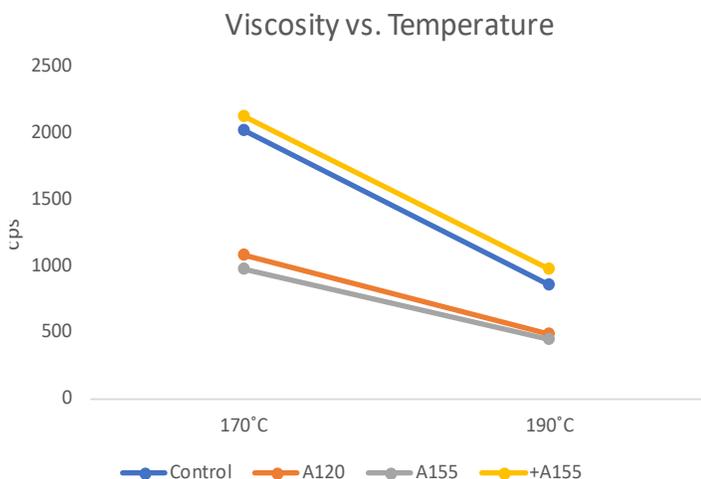
Table 3: Test waterproofing underlayment and membrane formulations

Formulations	Control wt. %	A120 wt. %	A155 wt. %	+ A155 wt. %
Asphalt (64-22 asphalt / extender, 3:1)	72.5	72.5	72.5	70.5
SBS	7.5	5.5	5.5	7.5
Cross linking agent	0.188	0.138	0.138	0.188
Ceranovus A120	0	2	0	0
Ceranovus A155	0	0	2	2
Filler	20	20	20	20

Tests were performed on all formulations after cross-linking, and both before and after the dolomite filler was added.



Graph 1: Adding Ceranovus additives to waterproofing underlayment and membrane formulations affects viscosity over a range of temperatures



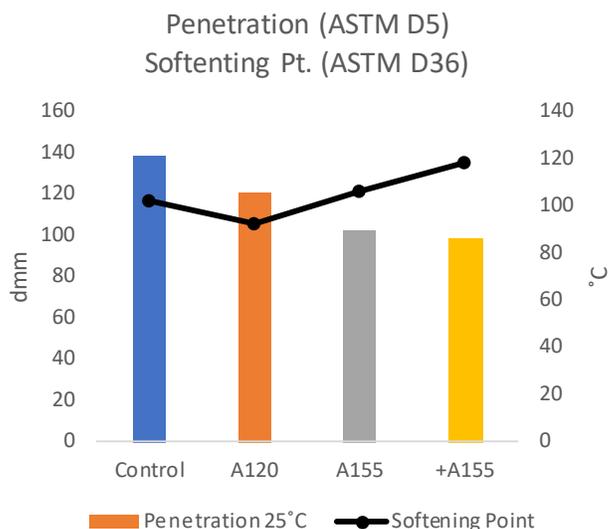
Results after cross-linking and adding Ceranovus Additive (unfilled)

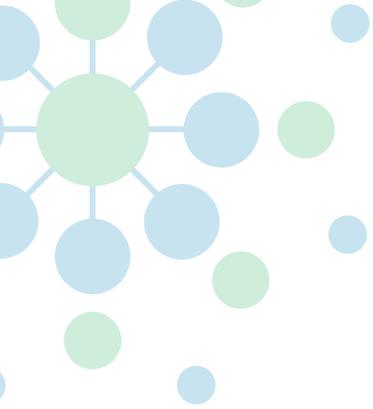
The impact of Ceranovus additives on penetration and softening points of the test formulations is shown in Figure 1. Both additives—especially A155—reduced penetration, compared with the control. This change is an improvement because greater stiffness should result in less deformation with mechanical stresses, such as foot traffic on the product during installation of the membrane.

The softening point of the unfilled compounds remained in the 92°C High Temperature (HT) compound range of most commercial products. In fact, Ceranovus A155 actually increased the softening point, an indicator of improved temperature stability. A higher softening point means less sagging and deformation at higher temperatures—another performance improvement over the baseline formulation.

Lowering the waterproofing membrane formulation’s viscosity offers a number of manufacturing benefits. First, a less viscous formulation flows more freely, for better penetration into the substrate mat and easier, smoother, faster, energy-saving manufacturing. A lower-viscosity formulation also offers greater formulating flexibility. For example, more filler could be added, which could save on cost or increase fire resistance in the final product. Figure 2 shows how substituting either Ceranovus A120 or A155 for about a third of the SBS lowers viscosity significantly—by 55 to 65%—over a range of temperatures.

Graph 2: Penetration at 25°C and softening points of the unfilled test formulations





Separation is a measure of a formulation’s stability. The closer testing of the physical properties from samples taken from the top and bottom of a stored product behave, the less separation has occurred and the more stable the product is. The effect on separation of adding Ceranovus A Series additives to waterproofing underlayment and membrane formulations is shown in Table 4.

Table 4: How adding Ceranovus additives to waterproofing underlayment and membrane formulations affects separation before the addition of dolomite filler

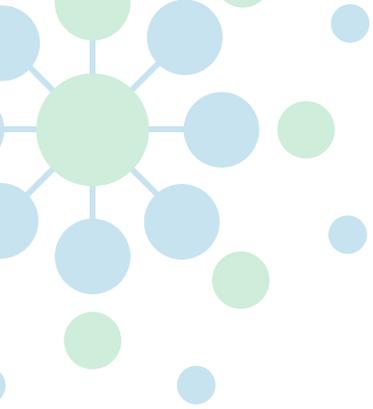
Properties		Method	Control	A120	A155	+A155
Separation, via Softening pt. (°C)	Top 1/3	D7173	109	104	108	115
	Bottom 1/3		87	81	115	123
	Difference		22	23	7	8

While the test formulation with added A120 behaves similarly to the control, both formulations that incorporate A155 exhibit much less separation. This improvement suggests the Ceranovus additives may be acting as a compatibilizer. If so, there may be a significant logistical advantage for manufacturers, since the formulation should remain stable longer during storage and shipping. Further testing is underway to explore this possibility.

Table 5: Separation of waterproofing membrane control formulation and Ceranovus-modified samples, after the addition of dolomite filler

Properties		Method	Control	A120	A155	+A155
Separation, via Softening pt. (°C)	Top 1/3	D7173	111	104	112	117
	Bottom 1/3		130	84	125	139
	Difference		19	20	13	22

Even after the addition of dolomite filler, the separation advantage of substituting Ceranovus A155 for 2% of the SBS remains. (See Table 5.) This apparent increase in compatibility was unexpected and demands further study, since lower viscosities typically result in greater separation. A more stable compound would convey a significant logistical advantage.



Graph 3: Penetration and softening point—waterproofing membrane control formulation and Ceranovus-modified samples, after the addition of dolomite filler

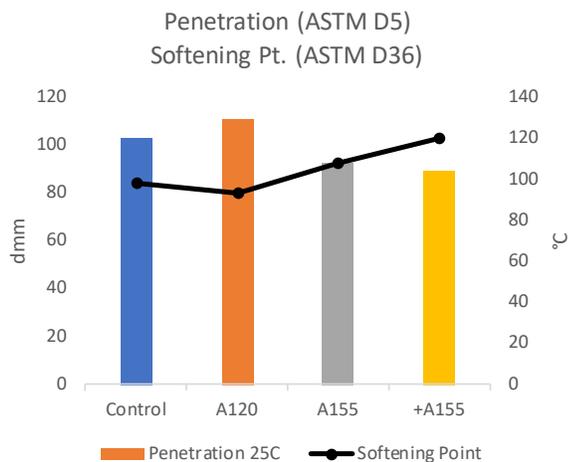


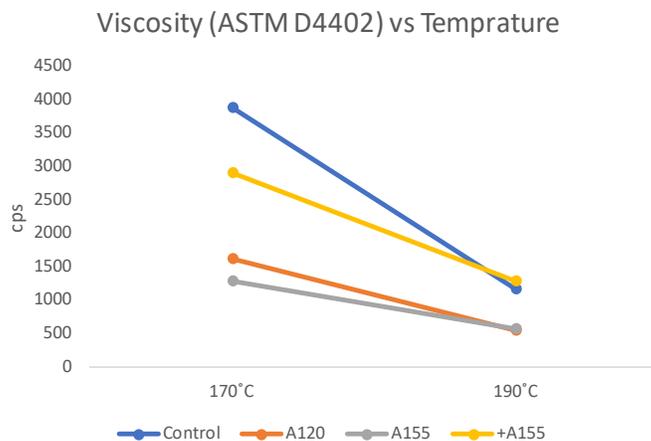
Figure 1: Image of dolomite filler.

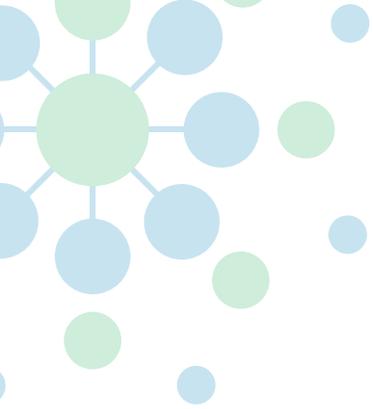


Formulation Flexibility

In our investigation, waterproofing membrane test formulation behavior once filler has been added, largely echoes that of its behavior without filler. A155 decreases penetration and increases the softening point. (See Graph 3) Replacement of ~30% of the SBS with either A120 or A155 additive lowers viscosity. (See Graph 4.)

Graph 4: Viscosity at various temperatures—waterproofing membrane control formulation and Ceranovus-modified samples, after the addition of dolomite filler



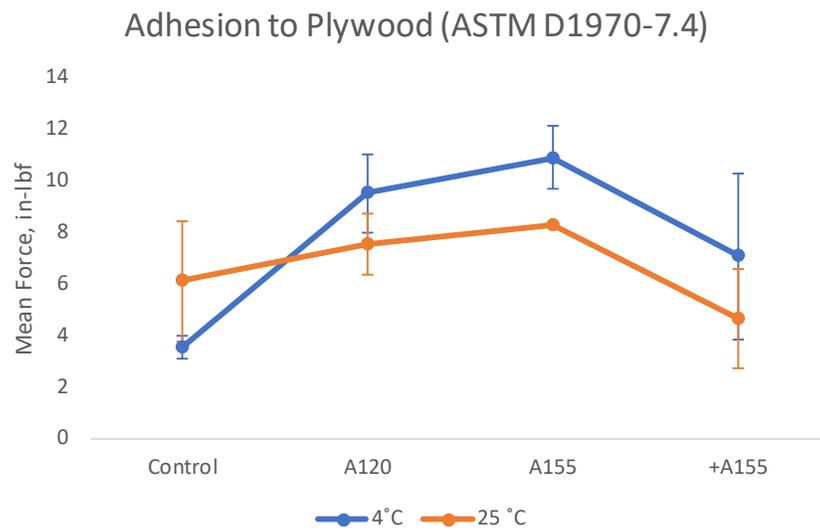


Adhesion and performance properties of Ceranovus-modified waterproofing membrane formulations

Substituting ~30% of the SBS with Ceranovus A120 or A155 in a self adhered waterproofing membrane formulation improves ASTM D1970’s key property, Adhesion to Plywood (see Figure 5). A120 exhibited a 20% improvement at 25°C and a 250% improvement at 4°C. A155 exhibited a 36% improvement at 25°C and a 300% improvement at 4°C.

The addition of 2% A155 without subtracting any of the SBS increased/improved the softening point and decreased/improved the viscosity while retaining flexibility. However, with this formulation, Adhesion to Plywood at 25°C was reduced by 23%, though a 200% improvement at 4°C for adhesion was seen compared to the control.

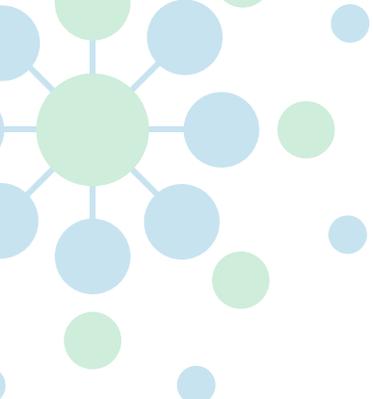
Graph 5: Adhesion performance at low and high temperatures: control and Ceranovus-modified self adhered waterproofing membrane formulations



How these formulations perform at both high and low temperatures is important. Better adhesion at low temperatures should improve durability with seasonal temperature fluctuations. While some formulations that adhere at low temperatures are brittle, all three of these Ceranovus-modified formulations remain flexible, as shown by ASTM D1970 flexibility testing (Table 6). The Ceranovus-modified formulations also pass standard thermal stability testing. Good flexibility and thermal stability are critical to prevent waterproofing membrane or underlayment products from sagging, peeling and bubbling over time.

Table 6: Performance properties

Properties	Method	Control	A120	A155	+A155
Thickness, mm @ 25°C	D5147	1.264	1.520	1.348	1.358
Flexibility, @ -28°C	D1970 - 7.6	Pass	Pass	Pass	Pass
Thermal Stability, @ 70°C	D1970 - 7.5	Pass	Pass	Pass	Pass



Design with the Circular Economy in Mind!

A more sustainable product

SBS is made from virgin sources. GreenMantra performance additives are a certified product made from 100% recycled materials. Substituting a proportion of the modified bitumen with a non-virgin product increases the sustainability of the formulation and contributes to a circular economy.

Summary

Manufacturers of waterproofing underlayment and membrane roofing materials want more durable, higher performing materials that are easy to process and don't raise costs. Formulations incorporating these novel additives made with 100% recycled materials can enhance performance and processing, while maintaining or reducing costs compared with conventional formulations.

When substituting for roughly one third of the SBS content, Ceranovus A Series polymers offer improved adhesion, especially at low temperatures; lower viscosity for easier processing; and better high temperature performance for less sagging and deformation. Compared with the control, flexibility is maintained. A significantly decreased separation can be found with the Ceranovus A155-modified formulations, suggesting that they may be acting as compatibilizers. In all, this combination of results points to a line of products designed to drive performance, quality, and sustainability in asphalt roofing formulations.





For additional information or to contact us, please visit **greenmantra.com** or email **info@greenmantra.com**

All statements and information provided herein are believed to be accurate and reliable, but are presented without guarantee warranty or responsibility of any kind, expressed or implied. User assumes all liability for use of the information and results obtained.



MADE WITH 100% RECYCLED CONTENT
POST CONSUMER



GREENMANTRA[®]
TECHNOLOGIES