

CERANOVUS[®] PRODUCTS

Polymer Additives for
Roofing Applications

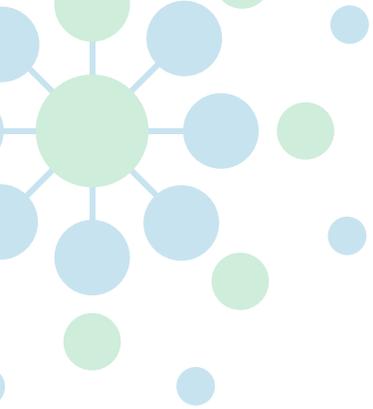


***GreenMantra® Ceranovus® A Series Synthetic Additive Products,
Made With 100% Recycled Content, Improves Roofing Asphalt Performance***

Today's roofing manufacturers are searching for raw materials to make higher performing, longer-lasting asphalt roofing products with the best cost/performance ratio possible. Using bitumen asphalts modified with styrene-butadiene-styrene (SBS) or atactic polypropylene polymers (APP) for commercial roll or shingle is one strategy for producing roofing materials resistant to climatic extremes and mechanical stress. But GreenMantra Technologies, a leading-edge North American specialty chemical manufacturer, offers a product that can further enhance roofing asphalt performance while lowering costs.

Through a proprietary process, GreenMantra is producing a series of asphalt additives made with 100% recycled materials and designed for all asphalt roofing applications. When combined with either modified or unmodified asphalt, these Ceranovus® A Series polyethylene and polypropylene additives improve the asphalt's application and performance characteristics in roofing applications. In asphalt flux, GreenMantra's additives can improve heat stability, increase softening point, and lower viscosity for faster processing. In SBS or APP modified bitumen (MB), they can also hasten polymer dispersion and reduce mixing times.

Sourcing from recycled polyolefin plastics means GreenMantra's additives offer competitive pricing and also address many of the challenges associated with petroleum-based products, such as constrained supply and cost volatility. It also supports Leadership in Environmental Energy and Design (LEED) building material qualification.



Summary of Benefits

Results of application testing are detailed below, but here is a brief overview of the benefits gained from adding GreenMantra's additives to roofing asphalt formulations.

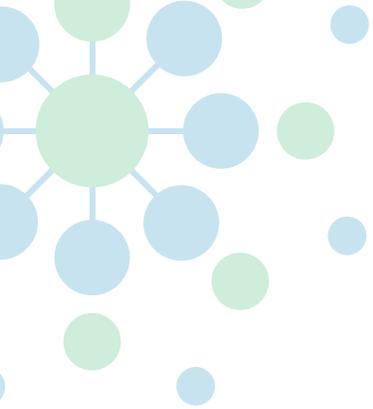
- **Faster production for lowered costs**
 - Decreases asphalt viscosity at process temperatures for faster line speeds
 - Reduces the mixing time necessary to achieve optimum polymer dispersion (phase inversion) in SBS or APP modified bitumen by up to 30%
 - Customizable properties depending upon process requirements
 - Increase filler percentages while maintaining or improving performance
- **Improved product performance**
 - Better heat stability with significantly improved energy of deformation (force ductility), meaning less warpage during storage, transport and use
 - Increased softening point and decreased penetration at various temperatures, without impact on cold temperature performance
 - No color migration or staining
 - Complements effects of SBS or APP modification, or oxidation
- **LEED credit**
 - Certified Recycled Content product
 - Roofing/siding or insulation containing Ceranovus A Series additives support various environmental credits
 - Cost-competitive, unlike many materials with recycled content

Properties of Ceranovus A Series Additives for Roofing Applications

Ceranovus A Series additives are delivered as dark, 2-3 millimeter pastilles. The standard products listed cover a range of densities, melting points, and viscosities (melt flow at various temperatures) as shown in Table 1. Depending upon manufacturing requirements, custom additives can also be supplied if necessary.

Table 1: Properties of Ceranovus A Series additives for roofing asphalt

| | DENSITY (g/cm ³) ASTM D1298 | DROP POINT (°C) ASTM D3954 | NEEDLE PENETRATION @ 25°C (dmm) ASTM D1321 | VISCOSITY CPS @ 140°C BROOKFIELD |
|--------------------|--|---|---|---|
| Ceranovus PE Waxes | | | | |
| A115L | 0.92 | 116 | 2 | 225 |
| A120 | 0.93 | 122 | 2 | 700 |
| A125 | 0.94 | 126 | 1 | 2025 |
| | DENSITY (g/cm ³) ASTM D1298 | DROP POINT (°C) ASTM D3954 | NEEDLE PENETRATION @ 25°C (dmm) ASTM D1321 | VISCOSITY CPS @ 190°C BROOKFIELD |
| Ceranovus PP Waxes | | | | |
| A155 | 0.90 | 155 | 2 | 75 |



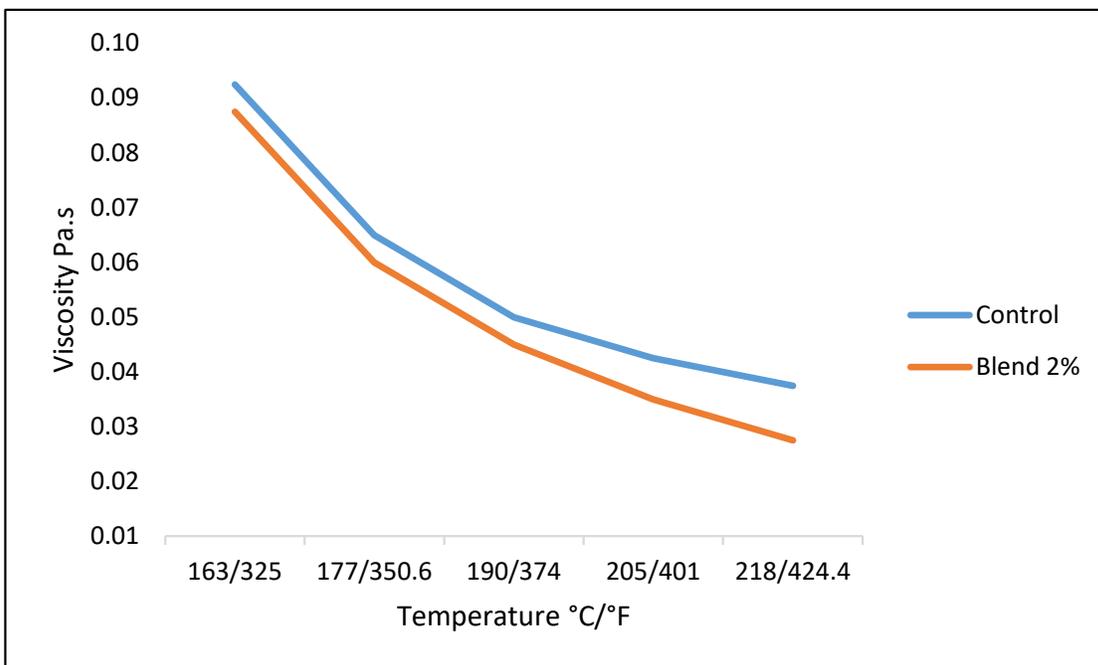
Application Testing

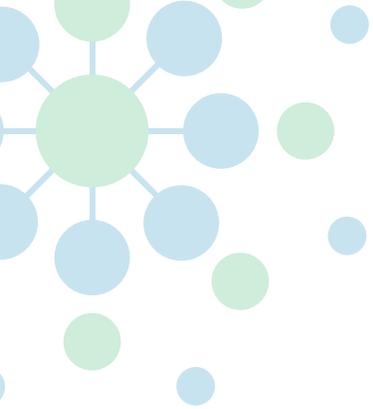
To examine the effect of modifying asphalt by incorporating a GreenMantra Ceranovus additive, we engaged PRI Asphalt Technologies, Inc. for third party testing and evaluation. The first formulation tested consisted of 150/200 penetration grade asphalt with 10 % KRATON® SBS linear block copolymer, 20% limestone filler, and 0.5-4% Ceranovus A Series additives. The test asphalt's performance was compared with that of a control formulation without any additive present.

- **Viscosity reduced**

The viscosities of both samples were compared over a range of temperatures between 163-218°C (Figure 1). Including Ceranovus additives in the formulation decreased the asphalt's viscosity at all temperatures tested. This drop in viscosity can correlate to faster line speeds in roll or shingle production.

Graph 1: Viscosity in relation to temperature of control asphalt and asphalt modified with 2% Ceranovus A115L additive; the additive blend's viscosity is lower throughout the temperature range





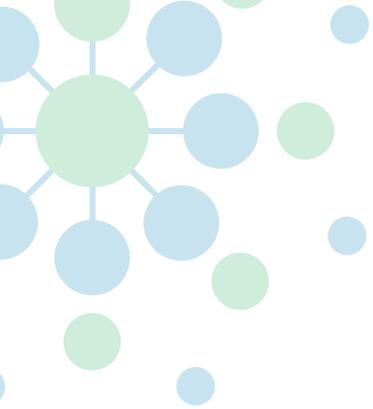
- **Mixing times decreased by 30%**

Test asphalt samples were prepared as above using SBS modified bitumen with 2% of either GreenMantra Ceranovus A115L or A125 additives. Fluorescence microscopy results for these samples were compared with results for control polymer-modified asphalt, without Ceranovus additives present. Results are shown in Table 2.

Table 2: Summary of mix times to achieve full dispersion in three modified asphalt formulations, two containing Ceranovus additives, and one control; note faster dispersion with Ceranovus additives

| Time | Control | 10% SBS + A115 | 10% SBS + A125 |
|------------|---------|----------------|----------------|
| 2 Hours | | | |
| 3 Hours | | | |
| 5 Hours | | | |
| 7 Hours | | | |
| 8 Hours | | N/A | N/A |
| 10.5 Hours | | N/A | N/A |

This test demonstrates the efficacy of the additives in reducing the mixing time necessary to achieve optimum polymer dispersion and phase inversion. Over 30% improvement in mixing time is seen compared to the control modified asphalt—an important processing economy.



- **Improved structural and thermal stability for modified bitumen**

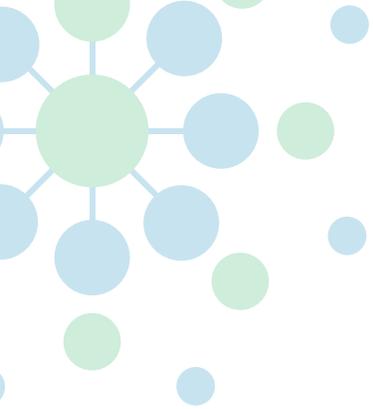
Dimensional integrity under mechanical strain and in extreme temperature conditions is a crucial aspect of roofing material performance. The impact of adding 2% Ceranovus additives to the structural integrity of asphalt modified with SBS is shown in Table 3 and Figure 1. Dimensional heat stability improves significantly, as does force ductility.

Table 3: Impact of two Ceranovus modifiers on SBS-modified asphalt properties; note improvement in dimensional heat stability and force ductility while low temperature behavior remains unchanged

| Ceranovus Waxes | CTMB Fail Temperature (°C) ASTM D5147M | HEAT STABILITY Dimensional Stability (% change) ASTM D5147/D1204 | | FORCE DUCTILITY @25°C AASHTO T300M | |
|-----------------|--|--|-----------------|---|--|
| | | Transverse | Parallel | Force Ratio (f1/f2) | Deformation Energy (J/cm ²) |
| Control | -23.9 | +10 | +6.4 | 0.37 | 3.2 |
| A125 | -23.9 | +2 | +1.2 | 0.52 | 6 |
| A115L | -23.9 | +1.2 | +1.6 | 0.54 | 5.4 |

Figure 1: Dimensional heat stability at 80°C (ASTM D1204) of rolled asphalt sheets made with and without additives





- **Higher softening point, lower penetration**

Raising the softening point of the asphalt component and making it stiffer by co-modification of sbs with Ceranovus additives can raise the performance and durability of roofing materials. This is true for materials as seen in Table 4.

Table 4: Impact of modifiers on penetration and softening point in SBS-modified asphalt

| Ceranovus Waxes | SOFTENING POINT (°C) ASTM D36 | PENETRATION (dmm) ASTM D5 | | |
|-----------------|--|--|-------|-------|
| | | @4°C | @25°C | @46°C |
| Control | 93.6 | 41 | 50 | 90 |
| A125 | 106 | 35 | 39 | 55 |
| A115L | 102 | 34 | 40 | 60 |

- **No color migration**

To ensure that the addition of Ceranovus additives to asphalt shingle does not lead to discoloration, asphalt samples containing A115L & A125 products were stain-indexed. In one sample, the additives were added before the SBS. In the other sample, the additives were added after the SBS. There was no bleeding or color staining in either test sample.

Figure 2: Stain index of two SBS-modified asphalt blends including Ceranovus A115L wax (1-wax added before SBS, 2-wax added after SBS); no staining has occurred



- **Lower formulation cost, and better performance through co-modification of SBS**

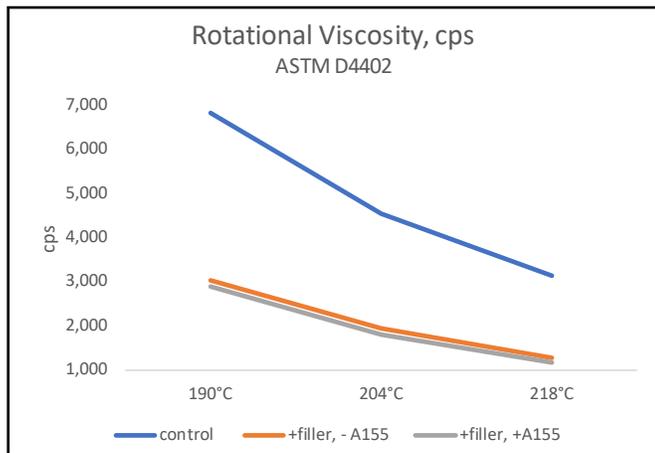
The ability to incorporate 1-5% added filler into a polymer modified commercial formulation can have a significant impact to both a manufactures formulation cost and the performance of the final roofing product. One major constraint behind this minor increase in filler is the negative impact it typically has on the viscosity of the formulation, making it more difficult to process. As with the work on the previous pages GreenMantra utilized third party testing to evaluate a generic commercial formulation, and determine the impact Ceranovus A155 has on the ability to increase filler percentages and offset 25% of the SBS content.

Table 5: Components and test formulations for polymer modified commercial membranes

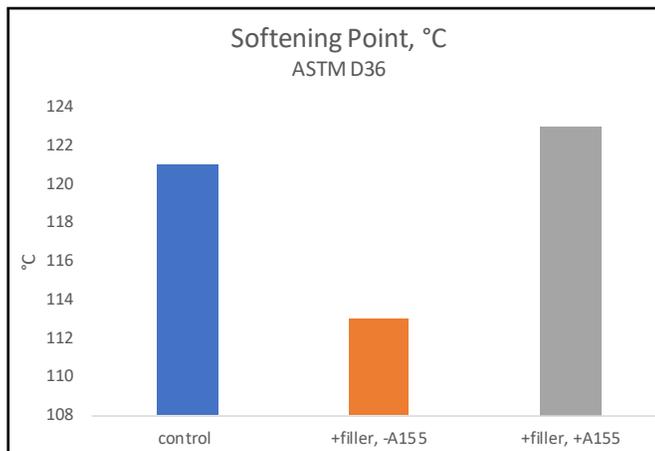
| Formulations | Control wt. % | Control (-wax + filler) | A155 (+wax, +filler) |
|----------------|---------------|-------------------------|----------------------|
| Asphalt | 60 | 57.15 | 56 |
| SBS | 8 | 6.15 | 6 |
| Ceranovus A155 | 0 | 0 | 2 |
| Filler | 32 | 36.7 | 36 |

Through the co-modification of SBS with A155 the challenges around viscosity are solved, with additional improvements to the asphalt softening point and penetration.

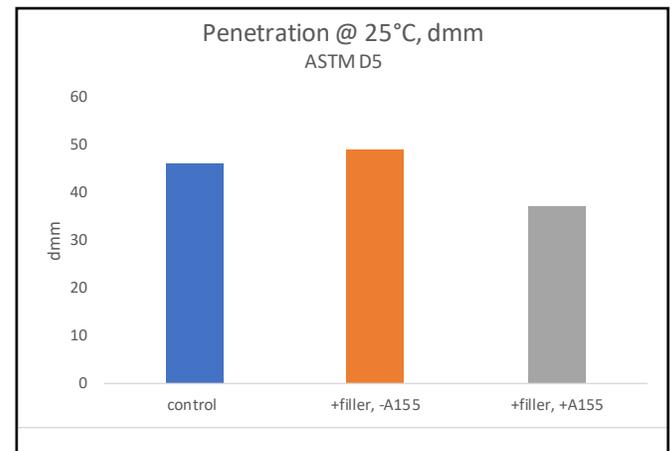
Graph 2: Higher fill %, with lower viscosity



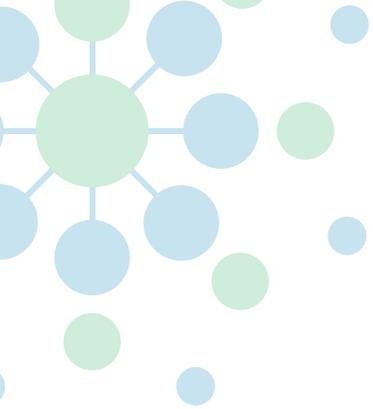
Graph 3: Softening points of control and trial formulations



Graph 4: Penetration of control and trial formulation



As shown in graphs 3 and 4, when reducing SBS loading without addition of co-modification with Ceranovus A155, the formulation viscosity reduces, but the asphalt becomes softer and loses almost 15°C in softening point, leading to poor product performance.



Certified Recycled Content & LEED qualification

GreenMantra's Ceranovus A Series additives are certified made with recycled content, providing roofing manufacturers products focused on the circular economy with transparent documentation and added support in qualifying for environmental product standard requirements and green building industry requirements such as U.S. Green Building Council's LEED certification.

Summary

Manufacturers of rolled asphalt roof sheets and shingles are looking to make their products stand out in the market place. Asphalt modified with GreenMantra's Ceranovus A Series additives can contribute to better performance and warranties, environmental suitability, and competitive pricing—all of which can signal innovation and differentiate your roofing product.

Ceranovus A Product Series offer time-, emissions- and cost-saving process benefits, such as decreased asphalt viscosity, faster dispersion of modifiers, and lowered requirements for other modifiers, such as SBS or APP, or oxidation. Performance benefits include increased durability through better thermal stability with higher softening points and less deformation. At the same time, despite improving warm weather performance, customizable Ceranovus brand additives do not adversely affect cold weather performance, nor do they bleed or stain.

Ceranovus A Series products are not only uniquely effective in improving the properties of asphalt for roofing applications, but GreenMantra is the only company making such a product from 100% certified recycled content. Use of this product will support LEED credits as well as help lower the cost of the roofing materials.



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

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