

Improved Weather Resistance of Modified Bitumen Products Using Reflective Acrylic Elastomeric Roof Coatings

By Joseph Rokowski

INTRODUCTION

Low-slope roofing involves a variety of materials typically not used in steep-slope applications and certainly different from concrete roof tiles. A large percentage of low-slope roofing substrates involves asphaltic-type materials. Asphalt, a residue

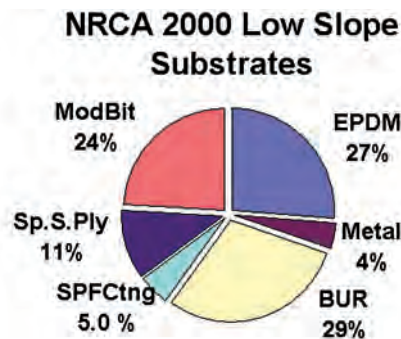


Figure 1 - Low-slope substrate market by square foot, NRCA.

of the crude oil distillation process, is an ancient material that has been available for centuries. Asphalt is the predominant material in hot mopping of built-up roofing. But there are many variations of asphaltic roofing products. These include asphalt cutback (asphalt + solvent), asphalt emulsion (asphalt + water), aluminized asphalt, cap-sheet (granulated modified bitumen), and the increasingly popular smooth-surface modified bitumen. How often is

modified bitumen used, and why is it so important to the roofing industry?

From the pie chart (Figure 1), one can observe that for the year 2000, figures from the National Roofing Contractors Association, based on square footage, show that 24% of low-slope roofing was composed of modified bitumen. Several decades ago, built-up roofing (including coal tar type systems), comprised over 80% of the roofing market. The advance of technology does indeed change the variety of roofing substrates. One can also observe the increase in use of EPDM rubber membranes as well as other single-ply membranes, such as TPO (thermoplastic polyolefin), PVC (poly vinyl chloride), and Hypalon. Because modified bitumen represents such a large portion of market share, it is helpful to understand the composition, failure method, and opportunities to extend the life of such roofs.

What is modified bitumen?

Modified bitumen is a roll roofing product used in commercial low-slope roofing applications. From a practical aspect, modified bitumen has advantages over conventional built-up roofs due to ease of application, lower labor/installation costs, and reduced likelihood of fire in the absence of hot asphalt kettles. In addition, the "modification" is done with relatively low levels of a

polymer – usually about 15-25%. There are two types of polymers used for modification. One is APP, which is Atactic PolyPropylene, a plastic-like material. The other is SBS, which is Styrene-Butadiene-Styrene (SBS) copolymer, a rubber-like material. The polymer modification increases the performance properties for weathering, durability, and toughness. All of these roll goods have an internal fiberglass or polyester scrim for added tensile strength and puncture resistance.

The APP type membranes are generally a little stiffer than the SBS types. Why?

Mostly because APP is a stiff, plastic-like polymer, which translates into a stiffer membrane. SBS has a more flexible, rubber-like component in butadiene, the “B” component of SBS. As a result, SBS membranes are generally softer, more flexible, and can be installed with greater ease in lower temperature climates or during fringe seasons such as late fall or early spring.

The asphalt component that is used in modified bitumen is typically processed minimally (usually to Type III asphalt) by blowing oxygen into the mixture, thus oxidatively increasing molecular weight and

increasing melt temperature. During the melt process, the APP or SBS polymeric modifiers are added and mixed homogeneously into the asphalt. In addition to the asphalt, polymer modifier, and scrim components, inorganic fillers are used to add bulk and sometimes fire retardancy to the sheet. Other processing agents used in the asphalt mixture include the use of low molecular weight, asphalt-compatible oils and sometimes waxes, which aid in the flexibility of the mod-bit. These oils tend to be very asphalt compatible but can migrate out of the film along with other asphaltic fractions and cause staining or prevent efficient adhesion of an aqueous, elastomeric roof coating. The migration of oils is more prevalent in APP modified bitumen than in SBS modified bitumen. Why? These oils are less soluble in the APP polymer component of APP modified bitumen, so they have a greater tendency to migrate out of the membrane. With SBS modified bitumen, the oils are much more soluble in the SBS polymer component and take longer to migrate out of the modified bitumen.

Importantly, at the end of the roll forming process, materials are applied to the modified bitumen surface to allow smooth rolling and unrolling of the modified bitumen membrane and to prevent the formation of a giant “log” of asphalt. These processing aids are all release agents of some type and are usually 1) surfactants, 2) powdery inorganic extender pigments like mica or talc, or 3) solid particulate extender materials like sand. It is these release agents and the drying oils that cause the most problems for coatings on top of modified bitumen.

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**“The big difference
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coating comes
in protection of
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component from
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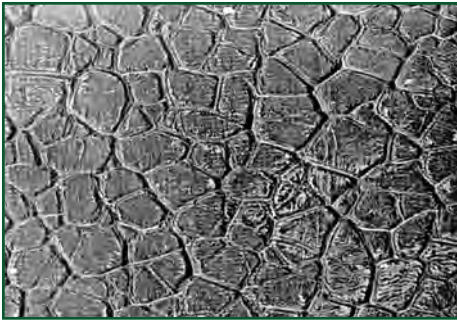


Figure 2 - Weathered APP modified bitumen, five years' exposure.

Asphalt Failure Mechanism

To understand the ability of acrylic elastomeric roof coatings to increase the life of bituminous roof products, the mechanism of asphalt degradation must first be understood. Asphalt is a complex mixture of literally hundreds of aliphatic and aromatic hydrocarbons. As it weathers, it breaks down chemically by absorbing UV radiation from the sun. The UV energy causes molecular vibrations and debonding, which is ultimately observed as cracking and chalking of the asphalt (Figure 2). Heat greatly increases the reaction rates and is one of the main causes for asphalt degradation.

An additional weathering component is the exudation of low molecular weight fractions or oils from the asphalt, which act as plasticizers to improve the flexibility of the roofing material. Because they are water soluble, this exudate can be seen on recently installed modified bitumen roofs where ponding is evident. The readily observed black-brown residue is typically called "tobacco staining." Its loss further contributes to degradation by reducing the long-term flexibility of the modified bitumen

membrane. Heat greatly increases the migration and loss of oil from modified bitumen products.

Asphaltic Analysis: Unweathered, Weathered, and Coated

To understand the effects of weathering of asphaltic materials, Rohm and Haas has performed chemical analysis on exposed, unexposed, and coated asphaltic built-up systems. To set up the experiment, samples of built-up roof were exposed outside, uncoated as well as coated with elastomeric roof coating. An identical but unexposed sample was kept in the lab. After six years' exposure, the samples were removed and analysis was performed on the unexposed, weathered/uncoated, and the weathered/coated material.

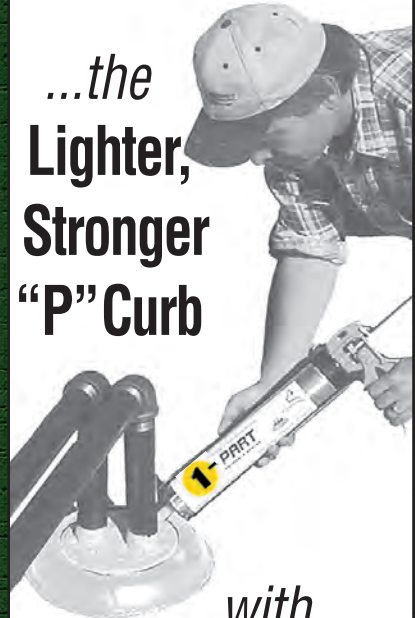
The components of the asphalt - before and after weathering - were separated using both filtration and solvent extraction, weighed, and compared to the control samples. Asphalt fractions are soluble in different solvents. Asphalt components soluble in aliphatic hydrocarbons such as heptane are called "maltenes." Asphalt components soluble in aromatic solvents like THF (i.e., tetrahydrofuran) are called "asphaltenes." Neither solvent affected the acrylic coating. Weight loss measurements (Figure 3) show that UV degradation reduces the weight of the hexane-soluble or low MW plasticizing component, which we would expect to cause embrittlement and cracking. Analysis of the acrylic coated material shows that all weathering involves some loss of heptane solubles. The THF soluble component was much higher for the uncoated sample than the coated sample. Scrim weight and inorganic filler content remain similar.

| Parameter | Uncoated/ Unweathered | Uncoated/ Weathered | Acrylic Coated/ Weathered |
|--------------------------------------------|--------------------------|------------------------|------------------------------|
| Initial weight in grams/2.5cm ² | 2.79 | 2.84 | 3.51 |
| Grams heptane-soluble | 1.24 | 1.10 | 1.19 |
| Grams THF-soluble | 1.16 | 1.62 | 1.17 |
| Grams Mat | 0.24 | 0.23 | 0.24 |
| Grams fines | 0.28 | 0.28 | 0.26 |
| Grams/2.5cm ² recovered | 2.40 | 2.72 | 3.43 |
| Wt % heptane-soluble in asphalt | 51.7 | 40.8 | 51.2 |

Figure 3 - Asphaltic built-up roof analysis.

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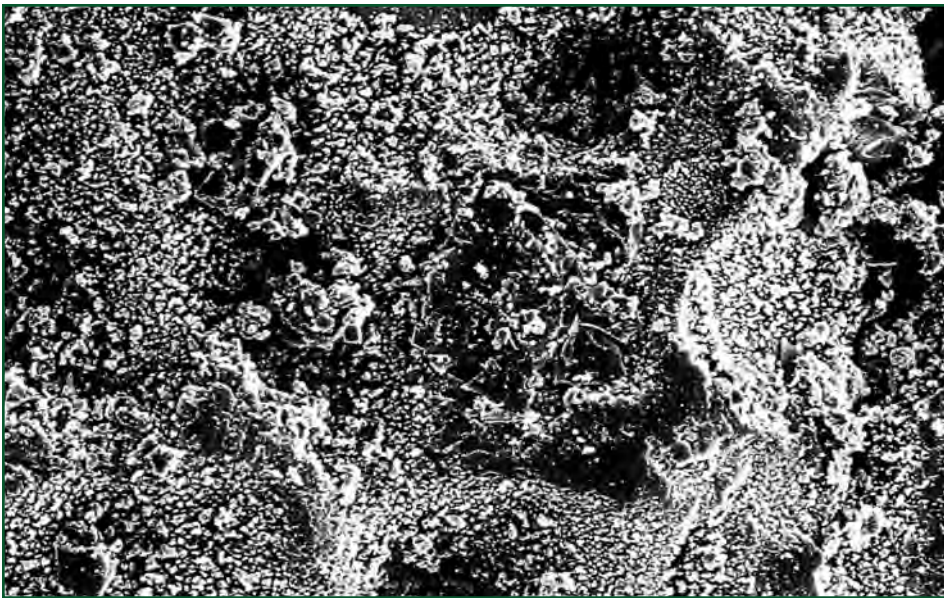


Figure 4 - 300 X magnification of uncoated, weathered BUR surface.

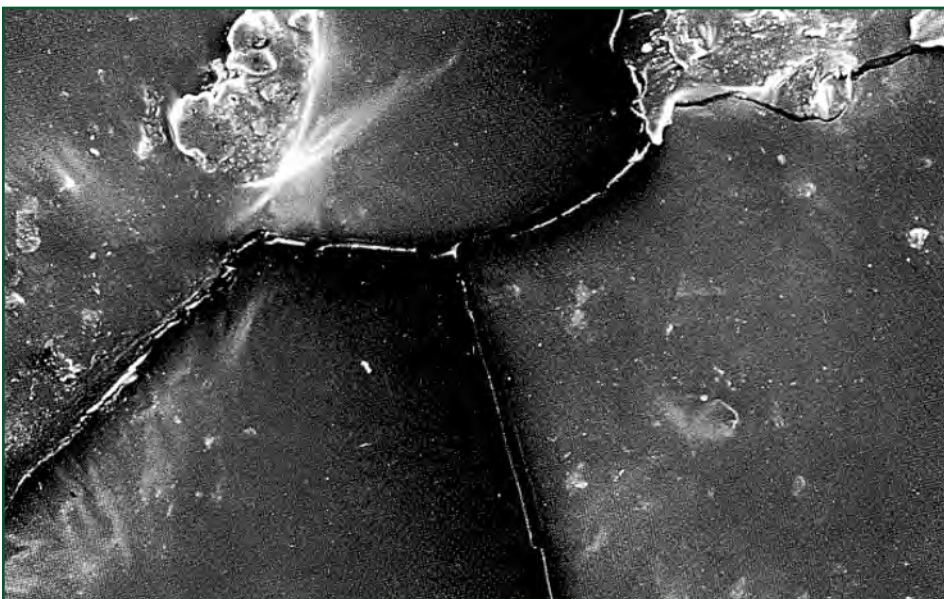


Figure 5 - 300 X magnification of coated, weathered BUR surface.

“...Titanium dioxide and zinc oxide are the two most important hiding and UV-blocking pigments in the formulation.”

The big difference in acrylic coating versus no coating comes in protection of the asphaltic component from ultraviolet rays. Microscopy photographs (Figures 4 and 5) show that uncoated/weathered asphaltics have craters and significant surface pitting. When the acrylic coating is carefully peeled away from the coated, weathered BUR sample, the asphalt surface appears smooth with some surface cracking but without craters and pitting.

Mechanism of Coating Protection

Acrylic coatings' ability to protect the asphaltic substrate and extend service life of the roof are based on two mechanisms.

The first is that the acrylic polymer, because of its non-aromatic molecular structure, does not absorb ultraviolet rays, so is very durable in exterior applications. In contrast, asphalt contains aromatic components that are susceptible to UV damage. Since the acrylic polymer is not UV damaged, it is very durable on the roof when exposed to sunlight. Clearly, if the polymer is UV-transparent, something in the coating must be UV blocking to the substrate in order for the coating to protect the asphalt. The coating's formulation is composed of materials that do block UV from penetrating to the substrate. These ingredients are titanium dioxide and zinc oxide, the two most important hiding and UV-blocking pigments in the formulation.

The second is that the acrylic coating provides a water-resistant barrier over asphaltic surfaces. Acrylic coatings resist penetration of liquid water but allow the permeation of water vapor; hence, they are called “breathers.” One benefit of the water resistance is to minimize solubilization of the low molecular weight asphalt components and subsequent migration out of the modified bitumen and into the coating. In addition, when the pigmented white coating is applied over black asphaltic materials, the surface temperature is significantly lowered, by up to 50 degrees F (28 degrees C). The temperature reduction will further minimize chemical reactions and asphalt degradation and extend the life of the roof.

Rohm and Haas often conducts lab and field work to understand the failure mechanism of coatings applied to asphaltic-type roofing products. The modified bitumen release agents have a tendency to inhibit the adhesion of waterborne coatings, as does the composition of the asphalt and modifier (APP and SBS). Asphalt is a very hydrophobic and oily substrate to begin with and is difficult to “wet-out” with a hydrophilic (water loving) roof coating. In addition, the surfactant, which adheres to the modified bitumen surface and is used to prevent sticking of the roll, can also prevent the coating from getting a good “bite” to the modified bitumen. This simply means that the coating is trying to adhere to an oily surface (i.e., modified bitumen), but before it can do so, it must try to adhere to a slippery, surfactant layer on smooth modified bitumen.

Acrylic roof coatings have been around for quite some time and have primarily been used over SPF, metal, aged BUR, or modi-

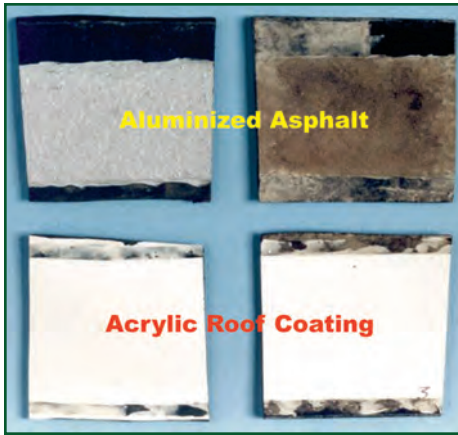


Figure 6 - Acrylic vs. aluminized asphalt on fresh APP modified bitumen: unweathered vs. weathered.

fied bitumen. So what is different about the acrylic coating for fresh asphaltics? In order for the acrylic coating to be hydrophobic enough to coat and adhere to fresh asphaltic, the polymer needed to be modified so that it was more “asphalt-like.” This means that one of the components of the polymer had to be very hydrophobic or oil-loving, like asphalt. This was achieved through a monomer that has a string of 12 to 14 carbons on it versus the normal one-carbon-side chain, making it very oil-like. Because of this, it is quite compatible with the substrate and also very water resistant. In fact, many of the coatings based on this polymer have very low permeability values (i.e., 1 to 4 perms) as compared to 20 to 35 perms for a typical acrylic roof coating. This helps improve the adhesion by preventing water from reaching the asphaltic-to-coating interface.

Figure 6 demonstrates the long-term durability of white acrylic roof coating versus aluminized asphalt. The acrylic coating remains white – thus cooler – and prevents migration of asphalt stains from the substrate.

Blister Resistance of Acrylic Coatings over Asphalt Emulsion

Adhesion of coatings in ponded situations is sometimes a challenge for acrylic roof coatings. Asphalt emulsion is difficult to adhere to because of the variation in asphalt grade and emulsifiers. To simulate ponding water conditions, three waterborne coatings were applied to a one-week cured asphalt emulsion, dried two weeks, and immersed continuously in water for 12

days. Results in Figure 7 show that, indeed, the proprietary acrylic exhibits no blistering, while two other commercial products blister.

Energy Savings Through White Roof Coatings

Finally, the solar reflectivity and emis-

sivity of acrylic roof coatings versus aluminized asphalt were measured according to EPA’s EnergyStar® protocols. From the table on page 42, it is clear that the acrylic roof coating has higher solar reflectivity and emissivity than the aluminized asphalt coating.

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| Coating | Solar Reflectivity | Emissivity |
|---------------------|---------------------|------------|
| Proprietary Acrylic | 84% | 91% |
| Aluminized Asphalt | 55% | 53% |
| Target | 65% minimum initial | >80% |

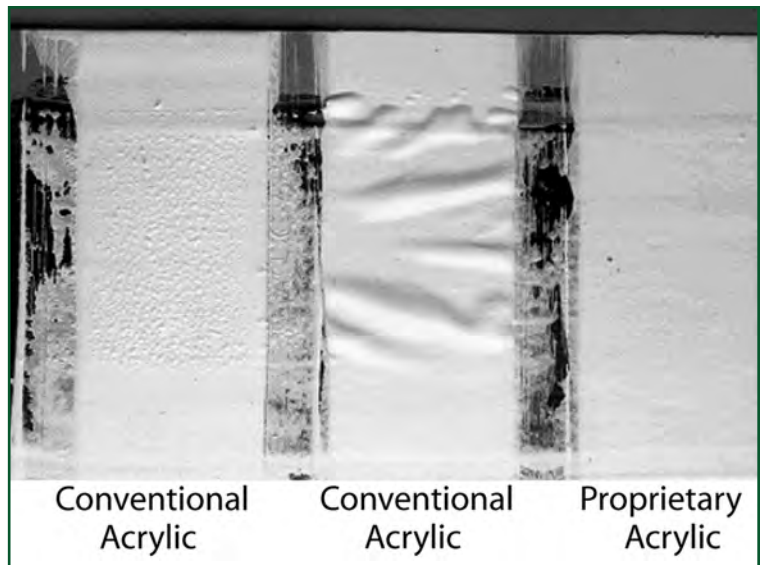
Summary

Asphalt roofing substrates fail by loss of low molecular weight fractions, heat-induced degradation, and fracturing. Aluminized asphalt coatings and acrylic elastomeric roof coatings have been used over modified bitumen roofs but sometimes fail in the areas of asphalt stain bleed-through or blistering in ponded water situations. In addition, aluminized asphalt coatings do not generally pass emissivity values recommended by the EPA. 

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Figure 7 - Asphalt emulsion coated with acrylic roof coating; 12-day water immersion.



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Joseph Rokowski is currently the technical service group leader in Functional Coatings/Elastomeric Roof Coatings at Rohm and Haas, where he has been employed for 20 years. His experience at Rohm and Haas in the Coatings, Industrial, and Building Products Departments includes exterior house-paints, primers, exterior clear coatings, and currently, roof coatings. Including past employment at Petrach Systems, Arco Chemical, and Wacker Polymer Systems, he has been awarded four patents and has held positions in research, technical service, sales service, market development, and sales. Rokowski received his B.S. in chemistry from St. Joseph's University in 1988.



HEFNER'S HOUSE?

Ron Dorszynski of Skyline Technical LLC, Mequon, WI, sent us this photo, noting, "I guess when you look at too many roofs for too many years, you start seeing things... strange things."

PDA LAUNCHES COURSE

The Polyurea Development Association (PDA) launched its first Spray Applicator Course on Sept. 23-26 in Kansas City, MO. The course was developed as a hands-on course covering all phases of hot spray polyurea application, including surface preparation, equipment setup, spraying techniques, troubleshooting, and final evaluation and testing. For more information, visit pda-online.org.

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