SOLAR GUARD COATINGS

Can acrylic coatings save your next roof?

This research paper explains the process of asphalt degradation over time and reveals the performance of acrylic maintenance coatings, site-aged for six to 10 years, over both BUR and shingle roofs.

The application of roof coatings—to protect new systems and preserve existing membranes—has become an important part of the services the professional roofing provides to the building owner. But how effective are these products, particularly in the area of maintenance?
The results of current weathering research published here may help the industry answer this question.

MALTENE + SUNLIGHT + HEAT + OXYGEN ------> ASLPHALTENE
Like most reactions, the presence of heat will greatly increase its rate. A second reaction caused by weathering is the chain scission of the higher molecular weight fractions. This is also caused by the UV component of sunlight.
An additional weathering component is the exudation of low molecular weight fractions from the asphalt. These fractions are present in fresh asphalt and act as plasticizers to improve the flexibility of the roofing material. This exudate is most easily observed on freshly installed modified bitumen roofs as a residue collecting in shallow depressions or ponds. Its loss further contributes to asphalt degradation.

Experiments performed
In 1982, two separate experiments were initiated, designed to demonstrate the durability enhancement and life-cycle extension potential for elastomeric 100 percent acrylic roof coatings applied over asphaltic roofing substrates.
The experiment involved coating a Built-up asphalt roof with a 20 dry mil (.51-mm) acrylic coating. The coating formulation contained the polymer, titanium dioxide ($TiO2$), and zinc oxide (ZnO) pigments, calcium carbonate ($CaCO3$) extender, poly-phosphate and polyacrylic dispersants, an isothiazilone mildewcide and cellulosic thickener.
The polymer was based on 100 percent acrylic monomers and had a glass transition temperature, Tg, of -35 C.
After seven years of additional exposure in Spring House, PA, the roof was examined. The coated section clearly exhibited virtually no change in appearance, while the uncoated section was severely degraded.
The results of the coated built-up asphalt roof showed virtually no change while, the uncoated section was severely degraded.
And now, a more fundamental explanation of the asphalt degradation process and the inhibiting effect of 100 percent acrylic coatings.

Built-up roofing study
A controlled study was conducted, evaluating the weathering effects on glass-reinforced asphalt built-up roofing (BUR). In this experiment, a 20-mil (.51-mm) elastomeric acrylic coating was applied prior to weathering and exposed at the Rohm and Haas Research Exposure facility at Spring House, PA. The results again show the loss of heptane solubles on weathering.

All measurements show that weathering involves some loss of heptane solubles from the asphalt. It is noteworthy that the mat in these three samples is very similar in weight and morphology but was different in the shingle experiment.

The level of fines, including inorganic filler is also relatively constant. This is due in part to the relative short duration of this study and to the increased tensile strength of the glass versus the cellulosic (organic) mat in the shingle experiment.

Scanning Electron Microscopy (SEM) and optical microscopy (OM) were used to investigate the differences in the structure of the asphalt roof shingles studied in the previous section. The same designations were used as protected, coated and weathered. All SEM was done on the Joel 840 using a 10KeV beam. Samples were sputter coated with palladium/gold (Pd/Au) to provide a conductive surface necessary for this type of analysis. Images were taken in the normal (secondary) mode where higher atomic number and/or rougher materials appear brighter in contrast. For ex ample, the shingle granules will appear bright, while the asphalt will appear dark in most of the images.

Environmental Scanning Electron Microscopy (ESEM) was used to obtain images of the materials that were otherwise difficult to obtain. These samples were examined without the need for sputter coating. The OM was done on the Wild Heerbrugg stereo microscope, in conjunction with a Sony image analyzer.

Closer examination of the different layers in the cross section reveals the effect of weathering in these three materials. By comparing the granules and asphalt layers in the different samples, a general decrease in the amount of asphalt coating of the granules is observed.

The weathered asphalt micrographs show significant degradation of the asphalt used to embed the mineral granules. Moreover, the granules are only adhered on the underside and deep fissures and cracks have propagated to the mat or scrim-reinforced asphalt.

Simply stated, weathering reduces the amount of asphalt binding the granules. Further comparison of the cross sections indicate a general delamination between the asphalt and mat containing layers, as well as delamination in the mat itself. The protected areas show some degree of degradation, but appear to be holding the granules more completely.

Also, there is no evidence of the deep fissures observed in the weathered samples. The coated samples show less degradation than the weathered samples and the coating has formed a monolithic single-ply membrane formed in-situ on the shingle. Some small fissures in the asphalt present at the time of coating were actually filled by the coating, thus preventing further degradation of the shingle. These fissures would otherwise allow water to penetrate through the asphalt into the organic mat, causing the shingle to swell and subsequently shrink when dry. Additional stress would develop when the shingle would freeze and thaw. Ultimately, the shingle would leak and the roof would require replacing. The protected and weathered samples were then examined with SEM to determine finer changes in the top side of the asphalt surface morphology.

Cracks are difficult to detect in the asphalt of the weathered sample due to the roughness of its surface; however, there are crater-like indentations in addition to rough particulates, present both in and outside the craters. Further examination of the particulates at 10,000X shows their popcorn-like appearance. The cratering is probably due to the erosion and dislodgment of the inorganic filler, calcium carbonate ($CaCO_3$) found in the asphalt.

It was not possible to examine the asphalt under the acrylic coating for the presence of craters and roughness; however, it was hypothesized that the coating would conform to the irregularities, forming a type of negative mold of the asphalt morphology.

The coating containing the granules was isolated with heptane, as described above, and examined using SEM at 330X magnification. The back sides of the three asphalt shingles were examined for differences as a result of weathering. Interestingly, differences were observed visually so SEM studies were conducted. Magnification micrographs show the asphalt roughness increases in the following order: protected, coated and weathered. The same type of surface disruptions with aging are seen in the built-up roofing samples when examined by SEM. The coated, exposed BUR shows some cracking, but is smooth overall. The weathered BUR shows craters, but to a lesser degree than the shingles.

Extending roofing life

The experimental data from the roof exposures of both the asphalt shingle and built up roofs clearly show the life extension properties of the acrylic coating. **It is theorized that the acrylic coating increases the longevity by two separate mechanisms.**

First, while asphalt is subject to degradation by the UV radiation component of the sunlight, acrylic polymeric materials are transparent to UV radiation. As such, they do not absorb this intense radiation and are not subject to the polymeric degradation seen in less durable chemistries like aromatic urethanes and butyls.

However, **the acrylic material must be formulated with UV-blocking pigments in order to protect the substrate—in this case, the asphalt—from degradation. These pigments are usually titanium dioxide (TiO_2) and zinc oxide (ZnO),** as was the case in this study.

A second mechanism is the acrylic coating providing a water-resistant barrier over the existing asphalt shingle or built-up membrane.

While it is well known that acrylic coatings are "breathers," having a permeance rating of >1, and, when used alone, are not considered waterproofing barriers, they are able to resist penetration of bulk water. This analogy is similar to Gore-Tex5 fabric used in making breathable fabrics for cold-weather garments and camping equipment. The acrylic roof coating prevents contact of bulk water with the asphalt membrane, thus preventing low molecular weight asphalt fractions from leaching out of the asphalt.

Moreover, the coating prevents intimate contact of water with the membrane, and more importantly, the reinforcing mat, scrim or felt, thus eliminating the formation of ice and freeze/thaw-induced dimensional changes in the membrane. This is clearly evidenced by the fluffy, long-stranded appearance of the coated shingle mat versus the short length, more compact mat appearance of the uncoated shingle.

Water infusion into the organic felt would also cause degradation of the mat via biological attack. This problem would theoretically be eliminated by using glass felt as the mat for asphalt shingles.

The introduction described the generally accepted mechanism for asphalt degradation, citing the contribution of heat. When the acrylic coating is pigmented with white pigments, the color of the dried coating will reduce the temperature of the roofing assembly, and reduce the rate of the asphalt degradation. This will further prolong the life of the coated roof. Because the acrylic coating is applied at 20-30 mils (.51-.76mm), it acts more like a fully adhered functional membrane than merely a paint-type coating. The mechanical properties are approximately 300 percent elongation and 250 psi (1.72 N/mm^2) tensile strength at room temperature and 100 percent elongation and 600 psi (4.14 N/mm^2) at 0F (-17C.).

Studies conducted by Rohm and Haas have demonstrated over 80 percent retention of initial elongation properties even after five years exposure. As such, the coating actually provides reinforcement and structural integrity to the roofing material, similar to the reinforcing mat or scrim.

Conclusions

The results described in this paper clearly demonstrate the effectiveness of acrylic coatings in prolonging the life of asphaltic roofing materials used in low- and steep-slope roofing. The mechanisms elucidated show the actual degradation of asphalt is not merely due to changes in the maltene/asphaltene ratio, but is more complex and of a second dimension.

While the simple mechanism2 previously reported is acceptable to describe short-term or early weathering, the results presented herein more closely document the actual failure of the roofing material. The effects of the mat and reinforcing attributes of the coating are critical to the longevity of the roofing material.