EFFECT OF PHOTOCATALYTIC COATINGS ON THE WEATHERING OF ELASTOMERIC ROOFING MEMBRANE

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abstract

A continuing problem associated with reflective roofing membranes, particularly those installed in the southeast section of the US, is the gradual loss of reflectivity due to the accumulation of algal species on its outer surface. The Florida Solar Energy Center, in collaboration with Firestone Building Products Company, has been investigating the use of photocatalytic coatings to resist the growth of algae, particularly those from the genus *Gloeocapsa*. This is an environmentally friendly approach that could potentially replace paint and membrane additives whose biocidal effectiveness eventually wears out and whose toxicity may represent a problem to the surrounding area. Results of a two-year test where square-foot pieces of roofing membrane were modified with photocatalyst and mounted on a rooftop test stand showed that reflectivity for TPO and PVC membranes remained higher than untreated membranes throughout the test period.

INTRODUCTION

Reflective roofing membranes based on any of several elastomeric polymers have been a cost-effective means of covering rooftops of commercial buildings for many years. One problem that affects this and other roofing envelope technologies is the successive growth of algal species on the outer surface. In particular for Florida and the humid Southeast, the growth of *Gloeocapsa* on roofing membrane eventually converts an originally bright white surface to a dark gray, greatly reducing its reflective properties.

In Figure 1, newly installed roofing membrane in the foreground contrasts greatly with the same material further back that had been installed a couple years earlier. A typical initial reflectance value for a new installation would be on order of 78-79%. However, once exposed to the elements, most membrane formulations rapidly decay into the 50% range.

Figure 2 shows a close-up of how an initially bright white material rapidly succumbs to a discontinuous overlayer of black spots on order of several mm in diameter. An as yet not fully understood effect is the extra heavy infestation occurring along a seam.

Cognizant of this problem, many building envelope products contain antifungal agents, or biocides, in their formulations. These biocides, commonly metallic salts, are leached out of the paint or membrane surface with age and successive rainfalls. The biocide is absorbed by the microorganism attempting to attach to the surface, resulting in cell death. This process is effective as long as there is biocide available to be leached out of the paint or membrane surface. Once that reserve is depleted, the surface is no longer protected from the action of nuisance microorganisms.

Figure 1. New and Aged Samples of Installed Roofing Membrane.

The Florida Solar Energy Center, in collaboration with Firestone Building Products Company, has been investigating the use of photocatalytic coatings to resist the accumulation and growth of microorganisms on roofing membrane [1-4]. The photocatalysts are specialized metal oxide coatings, commonly based on TiO_2 or WO_3, which exhibit semiconducting properties. Their use in solar-driven hydrogen production from water [5], water detoxification, and removal of volatile organics from gas streams has been well established [6]. This is an environmentally friendly approach that could potentially replace paint and membrane additives whose biocidal effectiveness eventually wears out and whose toxicity may represent a problem.

Figure 2. Close-up of Roofing Membrane Affected by Heavy Algae Growth.

EXPERIMENTAL

A variety of photocatalyst formulations were affixed to 929 cm^2 (1.0 square foot) membrane surfaces at a loading of approximately 1 mg/cm^2, or 10 g/m^2. These samples were taken to Environmental Testing Laboratories in Homestead, Florida, where they were mounted on one of several rooftop test stands. The mountings were done using normal thermoplastic welding, but welded weakly to a dissimilar base membrane. A photograph of test and control samples is shown in Figure 3.

Reflectance measurements were taken at approximate 6-month intervals with a Devices & Services Company Solar Spectrum Reflectometer Model SSR-ER Version 5.0. Readings were reported relative to zero and 100% of a calibrated Glazed Ceramic #A92 working standard. A discussion of solar reflectance measurement methods can be found in reference 7. The TPO test ran for 24 months. A subsequent set of PVC (polyvinyl chloride) samples was installed and observed for 18 months.

Figure 3. Experimental Installation in Homestead, FL. left: sample with photocatalytic coating; right: control; above: 9 months-aged inoculation membrane.

RESULTS

Reflectance values for modified and unmodified TPO roofing membranes are shown in Figure 4. Not all samples were studied over the full 24-month period. The test period starting February 2004 included two full summer seasons of thunderstorms, not to mention the edges of several hurricanes in 2004 (Charley, Frances, and Jeanne) and a direct hit by Wilma in 2005. Consequently, some samples were blown off the test stand. Those which were subsequently recovered were remounted (Sample 5); thus the last data bar for #5 Other samples were lost altogether (Samples 2 and 8); even so, the data collected up to that point are still valid.

Nearly all the samples showed some measure of reflectance decay. Samples 6 and 8, and to some extent 5, actually showed an increase over time, but that trend probably had more to do with the fact that they were colored samples, so that the reflectance rise was most likely due to loss of photocatalyst pigment, exposing the reflective white underside.

Samples 1,3,4, and 7 were white photocatalyst application that maintained higher reflectance than the control throughout the test period. Even though the control sample appears to have held steady at 70%, numerous control sample measurements at other field tests put the initial reflectance at 79%. Two of the samples were TPV's, special formulations whose exact composition was proprietary. While their rate of reflectance decay was highest, they nevertheless held onto higher reflectance at the end of the 2-year period, because their initial reflectance values were highest.

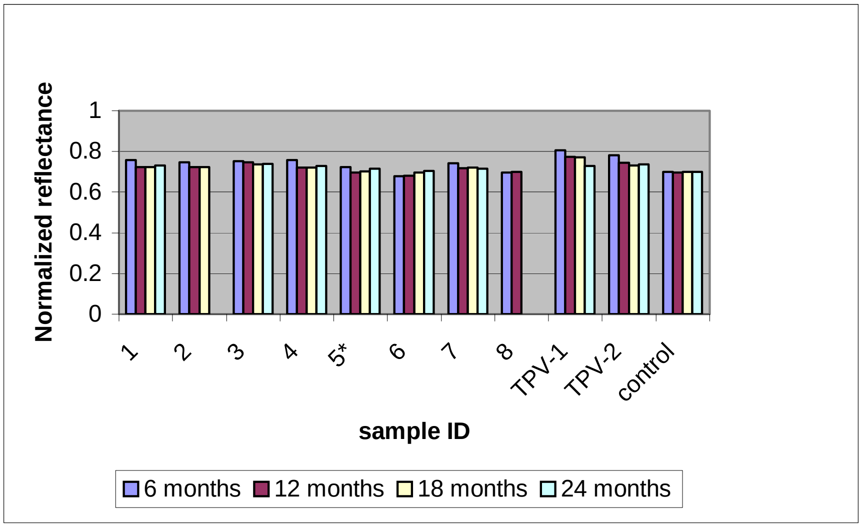

Figure 4. Reflectance Data for TPO Roofing Membrane Samples Modified by Photocatalyst.

Cumulative 18-month data for PVC membranes are shown in Figure 5. While none of the samples was specifically identified as an unmodified control sample, Samples 1-3 represent preliminary process steps in the photocatalyst application procedure, and so are essentially control samples. Samples 4-7 and 10-12 are white photocatalyst applications, while 8 and 9 are colored due to admixture with colored co-catalyst formulations.

Unfortunately, the PVC backing bonded poorly with the membrane mounted underneath. Samples 6,7,9, and 11 were blown off by Hurricane Wilma and had to be reattached; Samples 8, 10, and 12 were lost the previous year. Despite these experimental difficulties with the PVC field test, Samples 4 and 5 remained, and unambiguously demonstrated photocatalyst-related retention of reflective ability. Even samples 6 and 7 were clearly better than the effective controls after one year of exposure. The "innoc" sample was a reflectance reading of the surrounding membrane that had been installed without photocatalyst some 15 months before initiating the PVC test. At 52% reflectance, it was by far the lowest value measured for any of the samples.

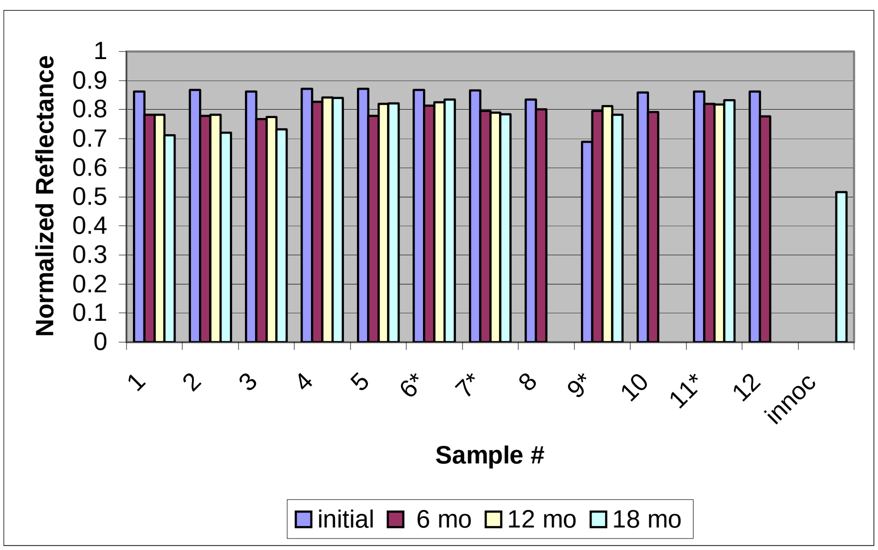

Figure 5. Reflectance Values for PVC Roofing Membrane Modified by Photocatalyst Formulations

CONCLUSION

A two-year test was conducted where pieces of reflective roofing membrane were modified with photocatalyst and mounted on a rooftop test stand. Results showed that reflectivity for photocatalyst-modified TPO and PVC membranes remained higher than untreated membranes throughout the test period. This has favorable implications in terms of lessening heat gain and lowering of cooling loads on industrialized housing.

REFERENCES

1. C.A. Linkous, G.J. Carter, D.B. Locuson, A.J. Ouellette, D.K. Slattery, and L.A. Smitha, "Photocatalytic Inhibition of Algae Growth Using TiO_2, WO_3, and Cocatalyst Modifications, Environ. Sci. Technol., 34 (2000) 4754-4758.
2. "Photocatalytic Nuisance Organism Inhibitor Agents," C.A. Linkous, U.S. patent No. 6,472,346, October 29, 2002; No. 6,455,467, September 24, 2002.
3. "Photocatalytic Surfacing Agents with Varying Oxides for Inhibiting Algae Growth," C.A. Linkous, U.S. patent #5,880,067; March 9, 1999.
4. "Photocatalytic Surfacing Agents for Inhibiting Algae Growth," C.A. Linkous, U.S. patent #5,518,992, May 21, 1996.
5. Bard, A.J. J. Phys. Chem. 86 (1982) 172-177.
6. Ollis, D.F. Environ. Sci. Technol. 19 (1985) 480-84.
7. T.W. Petrie, A.O. Desjarlais, R.H. Robertson, and D. Parker, Int. J. Thermophysics, 22 (2001) 1613-28.