

1 K Sunshine Cure Polyurethane Dispersion Deck Coatings

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Introduction

Coatings formulated with UV-curable polyurethane dispersions (UV-PUDs) have become well established in the wood and furniture market over the last 10 years. Their high productivity, extremely low VOC and excellent performance have made them the standard by which other water-based coatings systems are measured. Bayer MaterialScience has now taken this concept into the exterior wood site-applied decking market. By having UV energy from the sun cross linking these low functional, high molecular weight products are possible.

This paper will compare the performance of sunshine cure semi-transparent and opaque coatings at different field sites. In addition, this paper will compare sunshine curing to curing by full spectrum UV and UVA artificial light sources. These results will show that sunshine provides enough energy to crosslink UV-cure PUD that will provide several years of performance on exterior decking.

Wood Decking Market

Traditional wood decks are fabricated using southern yellow pine treated with CCA (chromate copper arsenate) to prevent destruction of the wood over deck's life. A multitude of techniques have been developed to give the deck better appearance, and these treatments include stains, and short-term coatings, and long term coatings. Depending on the needs, the predominate technique is short-term coating application that will last anywhere from six months to a year. On large wood decks, the labor cost alone can be quite expensive.

Demand for the U.S. wood decking market is forecasted to increase 2.6% per year to \$6.0B in 2013. A rebound in the housing market would promote growth, and a recent market survey by Residential Design & Build Magazine identified outdoor living spaces as the second most requested room feature.¹

The residential market accounted for 61% of total decking demand in 2008; 60% of new homes come with a deck; 4% of all households add a deck each year; totaling 3.6 billion linear feet by 2013.

In exterior applications, maintenance coatings demand will continue to increase, along with environmental concerns with these coating. New VOC and HAPS regulations are driving the market to water based coatings. Wood decking will continue to account for the majority of exterior coatings in volume.

Composites, although expensive, offer new choices with the promise of less maintenance. Demand for wood-plastic composite decking is forecasted to rise 9.5% per year until 2013. Composite decking gives “environmentally friendly” material perception. They are highly durable and ideal for public parks, commercial spaces, dockyards and marinas. However, current reports have shown that the composite decking market may have issues that were not foreseen when these products were first introduced. Some of these issues include but are not limited to the following:

Earlier composite decking did not contain a broad spectrum micro biocide. It had a tendency to chalk and was not supplied in many colors.

Wood decking stains are available in many different colors and, the issue with stains is their durable. Some stains last less than two years, and requiring you to stain your deck more frequently. The sunshine cured PUD appears to have durability as compared to conventional deck coatings as shown in Figure 1. This finish has been down for over 30 months with very little change in gloss or loss in adhesion. The properties of the UV system make it better than a commercial 1K system.



Figure 1 deck after 30 months outdoor exposure in Pittsburgh PA

Characteristics and Properties

The formulated sunshine cure system has shown that it has the following characteristics and properties:

- Physically drying
- Aliphatic Polyurethane Dispersion
- Fast water drying
- Application by brush, roller and spray
- Viscosity ~ 400 cps
- Less than 1.0 lb/gal VOC
- Ca. 30% solids
- Excellent adhesion properties
- Good mechanical properties (flexibility, abrasion) and chemical resistance after UV curing
- Good storage stability

Since wood deck finishing is available in many different varieties, it is important to show the differences. In figure 2 it is obvious that the sealer coat/color coat of this deck is opaque and that the protective coating on top is a clear coat. In general, this is the preferred way to coat southern yellow pine that has been pressure treated with CCA.



Figure 2: CCA pressure treated southern yellow pine with opaque sealer coat and UV PUD Sunshine PUD

The more traditional method for coating CCA pressure treated southern yellow pine is a one coat system that is semi-transparent. In Figure 3 you will note that a coating allows the true wood grain to be seen. By far this is the most popular and economical method for deck refinishing. An advantage

of the one coat system is its ability to be removed with a conventional power washer. The conventional coating seen in Figure 2 would have issues with removal using a conventional power washer.



Figure 3: Treated southern yellow pine coated with one coat of a semi-transparent Sunshine PUD

Experimental

To evaluate the same formulation utilizing several UV light sources determine what impact the different energies of each light source has on curing. The physical properties that were evaluated were: hardness, chemical resistance, and weathering. The three different light sources that were used, H&S Auto Shot, Fusion Hg bulb, and the sun.

UV curing parameters were low intensity UVA lamp at 4 minutes 10 inches from substrate (see Figure 4)². Figure 4 shows a picture of curing a clearcoat in a body-shop environment, 2) high intensity full spectrum H bulb ca. 20 feet/minute system as shown in Figure 5 and the sun panel ever left out for 24 hours as show in figure 6.



Figure 4: H&S Auto Shot 400W UVA



Figure 5: Fusion full spectrum UV Oven



Figure 6: The sun in Pittsburgh PA

Chemical Resistance:

After determining that the system will cure under all light sources, chemical resistance evaluation against common household chemicals. Table 1 shows there was no difference in chemical resistance between the three light sources.

Reagents	4 hours	96 hours
Motor Oil	no effect	no effect
Transmission fluid (red)	no effect	no effect
Anti freeze fluid (50/50 with tap water)	no effect	no effect
Detergent (50/50 with tap water)	no effect	no effect
Brake fluid	slight soft.	slight soft.
Gas (* both test times spots are covered)	slight soft.	slight soft.

Table 1 Uncovered chemical spot test

Hardness

In this section we will demonstrate how the different curing sources affect the hardness and abrasion. The system was tested using two different methods, (Pendulum Hardness and Micro Hardness). Figure 3 displays the results of the pendulum hardness over 14 days. The pendulum hardness tests the surface of the coating. Figure 4 displays the results of the bulk hardness over the 14 days. Both the Micro Hardness³ and the Pendulum Hardness⁴ show a change in hardness at the seventh day on the sunshine cure. The high intensity and low intensity cured systems show that the coatings are identical to each other based on surface hardness. In the case of bulk hardness, the high intensity develops its properties immediately compared to the low intensity. The sunshine cure films increases in both hardness tests after the seventh day. The sun cured coating shows its bulk hardness does not develop as rapidly as we attribute the sun cure's slower bulk hardness development to the low temperature during curing; assuming that some amount of water is still in the film and is released slower.⁵

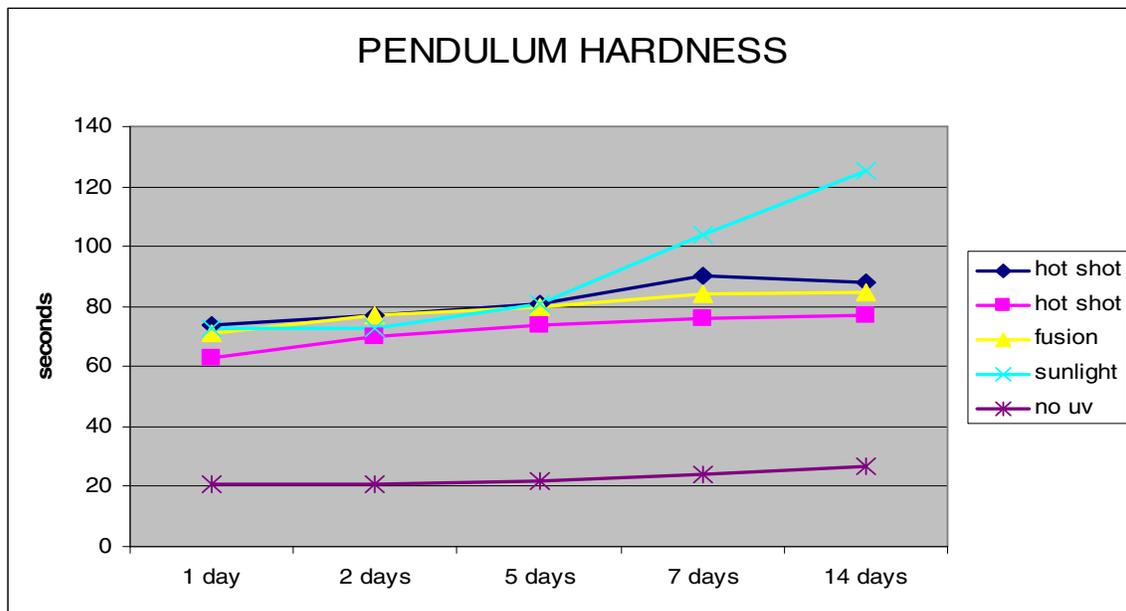


Figure3 After UV curing surface hardness testing over days

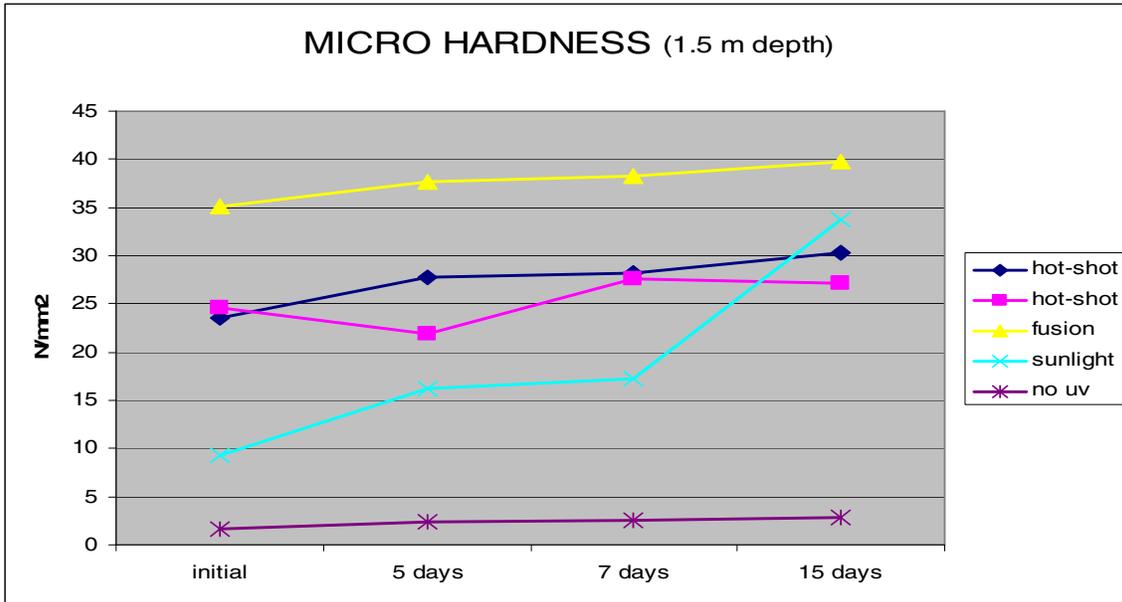


Figure 4 After UV curing bulk hardness over days

Abrasion Resistance

The Taber abrasion resistance as shown in Figure 5: These panels were evaluated the next day after curing. After the hardness results, we believe there is post curing or water release still taking place. In the presentation we will show data that supports the time vs. abrasion. The curing conditions of the system were evaluated using ASTM D 4060 – 95 CS10 wheels.⁶ The abrasion results showed that the high intensity and low intensity have comparable properties and sun cured exhibits twice the amount of mg loss.

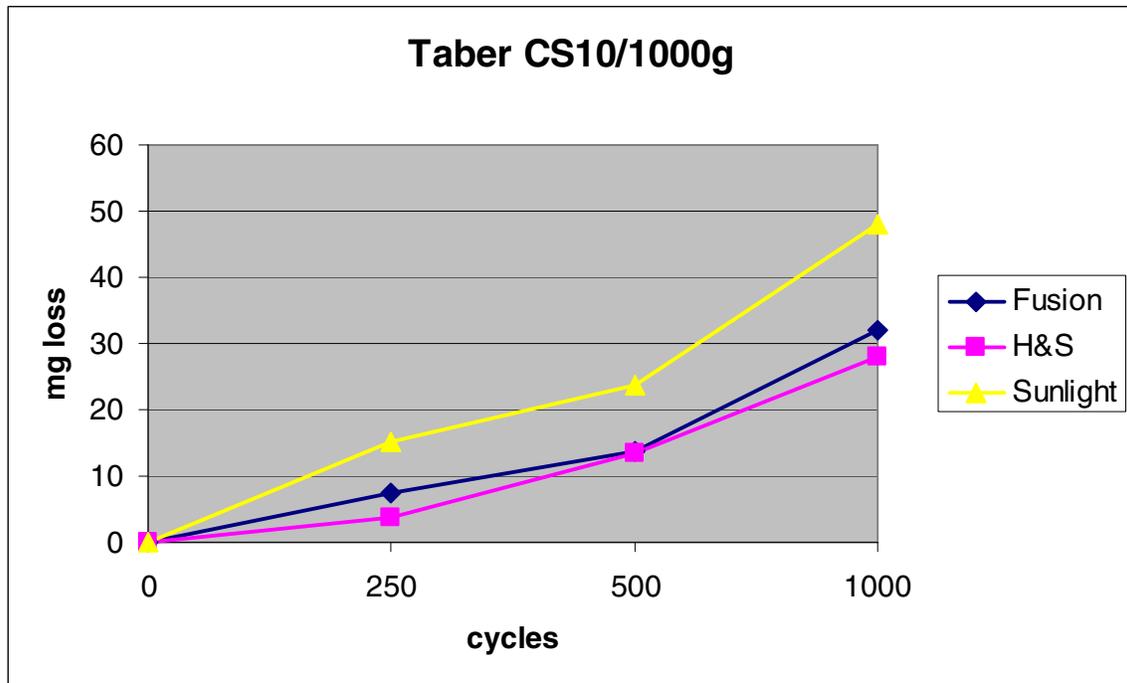


Figure 5: taber abrasion after UV cure

Weathering South Florida

Based on the data, and the time of year it was determined that the low intensity light would be sufficient for the evaluation of an Aliphatic UV PUD for outdoor durability. We will be sending system based on sun cure at a later time. Bayer has evaluated the aliphatic UV PUDs in pigment, clear and clear over commercial stain. These systems were sent to Florida for yellowing, gloss, cracking evaluation. These appearance properties would be one of the reasons a home owner would redo their deck. Southern yellow

pine CCA treated was the substrate used in the application. They were coated with one of 3 systems: white, a clear system over pine and a clear over commercial stain. These panels were sent to South Florida for testing (Direct / 45° / South / Open Back). The panels were evaluated every 3 months for color, gloss, and cracks for a total of 24 months. Figure 6 shows the 60 gloss retention over the 24 months in Florida. The gloss on all of the systems showed a change at month 18, this was not significant change that a homeowner would not redo their deck. The wood cracking and mildew for all systems were in the same 10 to 8 range. The scale is 10 to 1 with 10 being the best.⁷

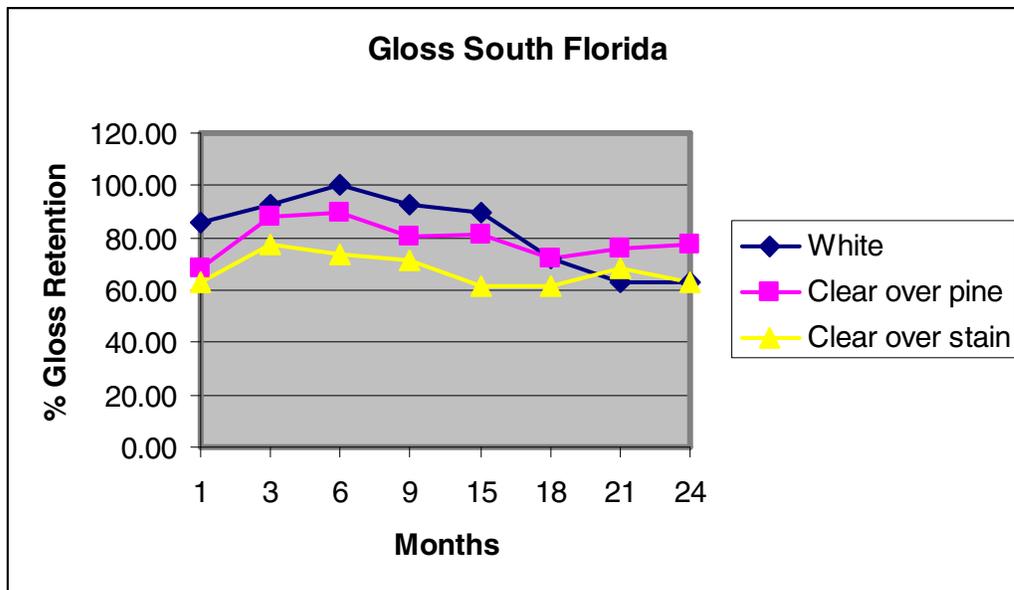


Figure 6 South Florida Weathering Gloss retention

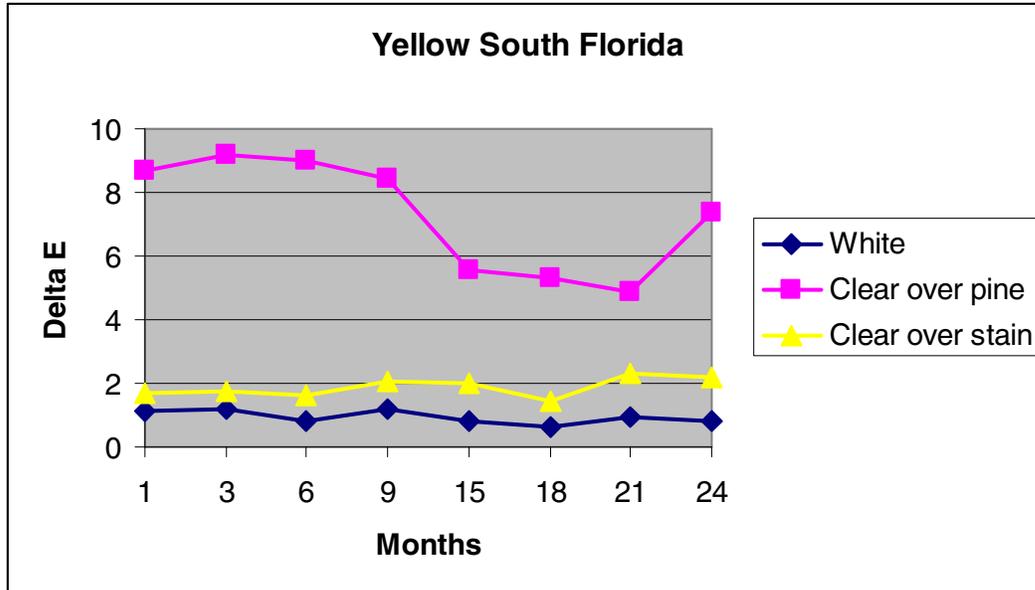


Figure 7 South Florida Weathering change in yellowing

Figure 8 is a deck application that was done 30 months ago. We evaluated a commercial stain then coated with the Sunshine PUD. Figure 9 is a driveway sealer application. This system has been on the driveway for 36 months and 2 winters.



Figure 8 Field trials basecoat a commercial stain and Sunshine UV PUD clear.



Figure 9 Concrete driveway sealer application

Conclusions:

The UV PUD technology lends itself to many market areas because of its low VOC and HAPS. For outdoor applications the sun gives sufficient curing compared to artificial light. This technology will be accepted into the decking market for several reasons but the primary reason is its ability to move from a contractor applied to the DIY market. This type of curing could be used in other outdoor applications provided the object is not located in the shadows.

References:

1 Freedomia, Wood Protection Coatings & Preservatives, July 2009

2 Acrylate Monomer Free/VOC Compliant UV-A Curable Technology for Automotive Refinish Clear Coat

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3 The Fischerscope® H100C measures Martens hardness according to DIN 14577.

4 The Current standards Pendulum Hardness document is ISO 1522.

5 Dvorchak, M.J., UV Cure Coatings Technology -New Markets, New UV Oligomers and New UV PUDs, Western Coatings Symposium, November 2009

6 ASTM D 4060 – 95 Standard test Method for abrasion Resistance of Organic Coatings by the Taber Abraser,

7 Accelerated Weathering of Wood Coatings by QUV-A with Direct Water Spray Bob Wade, Bayer MaterialScience LLC, Pittsburgh PA