Polyaspartic Coatings That Perform as Well as Polyurethane Coatings

Andrew Smith[1], Beth Eng[2]

Abstract

Polyaspartic coatings can offer excellent performance characteristics typically expected of SSPC Specification Number 36, Level 3, for Aliphatic Polyurethane Topcoats. In addition, polyaspartates will pass an industry standard for corrosion protection in medium corrosivity environments direct to metal. These features offer the typical industrial maintenance customer high performance for gloss and color retention, while reducing application time and costs.

Introduction

Polyaspartic coatings have been commercially available since the early to mid 90's. Quick cures, high solids, good corrosion resistance, and overall good performance properties have fueled the industrial maintenance market's acceptance of this chemistry. This group of coatings is classified as aliphatic polyureas (1). End use applications include wind towers, propane tanks, etc (Figures 1 and 2).

Polyaspartates often compete with typical aliphatic polyurethanes. In addition to the properties noted above, color and gloss retention that are the hallmarks of aliphatic polyurethanes can also be features of polyaspartic coatings.

Many in the industry use SSPC Paint Specification No.36, "Two Component Weatherable Aliphatic Polyurethane Topcoat, Performance Based" as a guideline and reference for high performing polyurethane coatings/applications.

ISO 12944 is an international and European standard commonly used in the industry. It is designed for use by engineers who have some technical knowledge in the area of protection, as well as knowledge of other relevant specifications (2, 3). It covers durability ranges for different environments. "C3" is used to designate a medium service environment typically found in urban and industrial sites. This would include areas with moderate S02 pollution or moderate coastal conditions. One coat of epoxy or one coat of epoxy with a light stable topcoat is typically used in C3 environments. "C5" indicates a very high service environment typically found in industrial areas with high humidity and/or aggressive atmosphere. Corrosion protection is normally provided for C5 by a minimum of two coats, sometimes three.

[1] Chemist - International Paint LLC - Houston, Texas USA
[2] Chemist - International Paint LLC - Houston, Texas USA

It would be interesting to use the above standards to compare and contrast the performance of a polyaspartic coating with aliphatic (acrylic) polyurethane. Potential new growth areas could be suggested.

Experiment and Discussions

Coating Preparation:

Test panels for both formulations in this study were applied via air spray with a DeVilbis MBC 510 gun, E tip and needle, 704 aircap. The line pressure was 40 psi and pot pressure 10-15 psi. Applications with a 1/8" nap roller, 6" China bristle brush, and airless spray (68:1 pump, 3000 psi, 20' ft hose, 517" tip) were also done for potlife determinations.

Cure time before testing was 2 weeks at ambient laboratory conditions (approximately 78°F, 60% relative humidity).

Panels used for corrosion related and adhesion testing were 3" X 6" X 1/8" hot rolled carbon steel, prepared with a SSPC-SP10(Near white metal blast) finish, 2.0-3.0 mil profile.

Miscellaneous testing such as impact and solvent resistance were performed with coatings applied on 4" X 8" X .032" polished hot rolled steel panels.

Polyaspartic coating: the polyaspartic coating was formulated with polyaspartic esters and cured with a polyisocyanate trimer of HDI(hexamethylene diisocyanate). The dry film thickness of the coating was 6 mils. The formulation was a basic white color, with an initial gloss of 90%.

Commercially available polyurethane: the commercially available polyurethane tested is typically sold as meeting SSPC 36, Level 3 requirements for aliphatic urethane topcoats. It is composed of an acrylic type polyol reacted with a polyisocyanate trimer of HDI. The polyurethane is normally recommended at 2-3 mils as part of a 2 coat system with an epoxy primer for C3 environments, but applied at 6 mils in a single coat in this investigation for direct comparison with the polyaspartate. The formulation was a basic white color, with an initial gloss of 92%.

Coating Performance:

Weathering resistance

SSPC Paint Specification No.36, "Two Component Weatherable Aliphatic Polyurethane Topcoat, Performance Based" outlines two methods to determine weathering performance. ASTM D 1014 "Standard Practice for Conducting Exterior Exposure Tests of Paints and Coatings on Metal Substrates", 45° South exposure, is the preferred method. However, the end user may accept ASTM D 4587 "Standard Practice for Fluorescent UV-Condensation Exposures of Paint and Related Coatings" if they prefer.

In this study, ASTM D 4587 was chosen to obtain results for evaluation as soon as possible. The testing cycle used was 2(B) which consists of 4 hours of UV at 60°C, then 4 hours of CON(condensation) at 50°C.

The panels were checked for color changes after exposure using ASTM D2244 "Standard Practice for Calculation of Color Tolerances and Color Differences from Instrumentally

Measured Color Coordinates". The light used was D65 at a 45° angle; CIELAB was the method of color calculations. Exposed panels were also checked for gloss retention by ASTM D523 "Standard Test Method for Specular Gloss"; 60° was the angle of measurement. Gloss and color were checked every 500 hours. However, only the final interval of 2 000 hours is reported. The performances of the two coatings are similar and meet the Level 3 requirements of the specification (less than 2.0 delta E color change, and a maximum gloss reduction of 25%) (Figure 3).

Optional testing

In addition to the weathering requirement for SSPC Paint Specification No.36, optional testing is suggested for informational purposes. Typical values are suggested, but not required. The following optional testing was conducted.

Adhesion

Crosshatch adhesion was determined using ASTM D 3359 "Standard Test Methods for Measuring Adhesion by Tape Test". The polyurethane shows slightly less adhesion than the polyaspartic coating direct to steel. This may be a factor in the corrosion performance reviewed below. (Figure 4)

Direct Impact

Direct impact resistance was measured using ASTM D 2794 "Standard Test Method for Resistance of Organic Coatings to the Effects of Rapid Deformation (Impact)". The performances of the coatings are similar (Figure 4).

Solvent(MEK) resistance

ASTM D 5402 "Standard Practice for Assessing the Solvent Resistance of Organic Coatings Using Solvent Rubs" was used to check the solvent resistance of the coatings. The polyaspartic coating was significantly more resistant to MEK rubs than the polyurethane. The polyaspartics can exhibit a range of solvent resistances, depending on the formulation (4) (Figure 4).

Effect of household chemicals

A variety of chemicals were used to compare the performance of the two coatings, using ASTM D 1308 "Standard Test Method for Effect of Household Chemicals on Clear and Pigmented Organic Finishes". The time interval tested was 24 hours. The performance of the polyaspartic and polyurethane were similar (Figure 4).

Additional testing

Other testing was run above the SSPC Paint Specification No.36 requirements. Most of the testing consists of corrosion type testing. Notable physical property type testing such as cure, potlife, and VOC were also conducted.

Condensation

Humidity resistance was tested using ASTM D 4585 “Standard Practice for Testing Water Resistance of Coatings Using Controlled Condensation”. A 50 mm scribe was used on all panels. Evaluation of the panels after exposure was done using ISO standards 12944 Annex 1 for creepage, 4628-2 for blistering, and 4628-3 for rusting. The polyaspartic coating displayed much more blistering resistance than the acrylic polyurethane. The ISO 12944 standard requires that for a coating to be recommended in C3 environments, there can be no blistering, no more than 1 mm creep, and no rusting, cracking or flaking after 240 hours of condensation testing (in addition to other testing). The polyaspartic coating passes this criteria (Figure 5).

Salt Fog

Resistance to salt fog was checked using ASTM B 117 “Standard Practice for Operating Salt Spray (Fog) Apparatus”. A 50 mm scribe was used on all panels. Evaluation of the panels after exposure was done using ISO standards 12944 Annex 1 for creepage, 4628-2 for blistering, and 4628-3 for rusting. Again, the polyaspartic coating performed very well. The ISO 12944 standard requires that for a coating to be recommended in C3 environments, there can be no blistering, no more than 1 mm creep, and no rusting, cracking or flaking after 480 hours of salt fog testing(in addition to other testing). The polyaspartic coating passes this criterion. The corrosion protection found in this study suggests that a polyaspartic coating would be worth investigation for C5 environments with an appropriate primer (Figure 5)

Cyclic Weathering

ASTM D 5894 “Standard Practice for Cyclic Salt Fog/UV Exposure of Painted Metal, (Alternating Exposures in a Fog/Dry Cabinet and a UV/Condensation Cabinet)”. A 50 mm scribe was used on all panels. Evaluation of the panels after exposure was done using ISO standards 12944 Annex 1 for creepage, 4628-2 for blistering, and 4628-3 for rusting. After 10 cycles, the acrylic polyurethane did not perform as well as the polyaspartic coating (Figure 5).

Cure

The cure to handle time intervals were measured using ASTM D 1640 “Standard Test Methods for Drying, Curing, or Film Formation of Organic Coatings at Room Temperature”. The polyaspartic coating is significantly faster to cure than the acrylic polyurethane. This fast cure is an outstanding advantage for applicators looking for quick back to service intervals or through put in shop applications (1) (Figure 5).

Potlife

The potlife of the products were measured by actually applying the materials with the appropriate equipment and environmental conditions. The application properties(atomization, film appearance, etc) were noted at various time intervals. The shortest time interval with acceptable application properties was recorded as the potlife. Polyaspartic coatings can achieve up to 2 hours of potlife, depending on the exact formulation (5) (Figure 5).

Volume Solids

The test method used to measure the volume solids was ASTM D 2697 “Standard Guide for Determining Volatile and Nonvolatile Content of Paint and Related Coatings”. The products were mixed and placed in an oven at 110° C for 1 hour. (Figure 5)

VOC(Volatile Organic Content)

VOC was determined by ASTM D 3960 “Determining Volatile Organic Compound (VOC) Content of Paints and Related Coatings”. The products were mixed and left to cure 24 hours at ambient conditions before placing in an oven at 110° C for 1 hour. Polyaspartic chemistry allows the formulator to reach lower VOC’s much easier than many polyol/polyurethane type coatings (5, 6) (Figure 5).

Figure 1. Windtower - application of polyaspartic coating

Figure 2. Propane Tank - application of polyaspartic coating

Test	Standard	Criteria to pass level 3	Polyaspartic coating		Commercially available polyurethane	
			Gloss reduction	DE	Gloss reduction	DE
UV-A	ASTM D 4587 (Cycle 2)	2000 hrs, ≤ 25% gloss reduction of initial 60° gloss or ≤ 2.0 DE	17%	.13	21%	.20

Figure 3. Weathering resistance, accelerated weathering(UV-A) required for SSPC Paint 36, Level 3

Optional Testing						
Test	Standard	Typical values	Polyaspartic coating		Commercially available polyurethane coating	
Adhesion	ASTM D 3359	≥ 4B	5B		4B	
Direct Impact	ASTM D 2794	≥ 30 inch-lb	30		35	
MEK Resistance	ASTM D 5402	50-150 double rubs	100		60	
Effect of household chemicals	ASTM D 1308, 24 hours exposure	No visual effects	Distilled Water: 50% Ethyl Alcohol: Vinegar(3% acetic acid): 5% Sodium Hydroxide: 5% Hydrochloric Acid: Xylene:	All pass-no visible effect upon the coating	Distilled Water: 50% Ethyl Alcohol: Vinegar(3% acetic acid): 5% Sodium Hydroxide: 5% Hydrochloric Acid: Xylene:	All pass-no visible effect upon the coating

Figure 4. Optional testing suggested for SSPC paint 36, level 3

Other Testing

Test	Standard	Polyaspartic coating	Commercially available polyurethane
Condensation, 240 hours	ASTM D 4585*	Creepage from the scribe: 0 mm Blistering: 0 Rusting: Ri 0	Creepage from the scribe: ≥ 1 mm Blistering: 3 Rusting: Ri 0
Salt fog, 480 hours	ASTM B117*	Creepage from the scribe: ≤ 1 mm Blistering: 0 Rusting: Ri 0	Creepage from the scribe: ≤ 1 mm Blistering: 4 Rusting: Ri 2
Cyclic Weathering, 10 cycles	ASTM D 5894*	Creepage from the scribe: ≤ 1 mm Blistering: 0 Rusting: Ri 0	Creepage from the scribe: ≤ 1 mm Blistering: 1 Rusting: Ri 2
Cure to handle, hours @ 77°F	ASTM D 1640	1.5	12
Potlife, hours @ 77°F	**	1	3
Volume solids, %	ASTM D 2697	80	68
VOC, grams/liter	ASTM D 3960	195(1.62 #/gal)	327(2.73 #/gal)

*Performance evaluation: Blistering- ISO4628-2(0-5 best to worst)

Rusting- ISO4628-3(Ri 0-5 best to worst)

Creepage from scribe- ISO12944 Annex A, no more than 1 mm to pass

**Materials are applied via recommended application methods at various time intervals. Potlife is recorded as the last time that the product may be applied with recommended methods and have good appearance and properties

Figure 5. Other testing of interest for industrial maintenance coatings

Conclusions

Polyaspartic coatings can offer comparable or superior performance to acrylic polyurethanes for gloss and color retention, solvent resistance, and physical properties such as flexibility and adhesion. The cure times of the polyaspartic coatings are very fast, especially in comparison with typical acrylic polyurethane. Of particular note, the corrosion protection of polyaspartics direct to metal allows recommendations for service in C3 environments. C5 protection is a likely possibility if an appropriate primer is used. Typical aliphatic urethanes are not specified direct to metal due to poor corrosion protection. All of these properties add up to a coating that offers an industrial maintenance customer the high performance properties of a SSPC Specification Number 36, level 3 aliphatic polyurethane, with cost savings of a one coat application in many environments and higher productivity. Coupled with the low VOC potential, polyaspartics make an easy choice.

Bibliography References

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