High-Performance Polyimide Powder Coatings

Corrosion Control

Much of the infrastructure at Kennedy Space Center and other NASA sites has been subjected to outside weathering effects for more than 40 years. Because much of this infrastructure has metallic surfaces, considerable effort is continually devoted to developing methods to minimize the effects of corrosion on these surfaces. These efforts are especially intense at KSC, where offshore salt spray and exhaust from Solid Rocket Boosters accelerate corrosion. Coatings of various types have traditionally been the choice for minimizing corrosion, and improved corrosion control methods are constantly being researched.

Recent work at KSC on developing an improved method for repairing Kapton (polyimide)-based electrical wire insulation has identified polyimides with much lower melting points than traditional polyimides used for insulation. These lower melting points and the many other outstanding physical properties of polyimides (thermal stability, chemical resistance, and electrical properties) led us to investigate whether they could be used in powder coatings. In Phase 1 of our research, we found that polyimides have the potential to perform effectively as coatings. Physical-property testing of panels coated with an experimental polyimide formulation indicated that the resulting surfaces were hard and durable, with excellent impact resistance, adhesion, and flexibility. Salt fog corrosion testing revealed that this formulation performed very well on aluminum substrates but exhibited corrosion and lost adhesion on steel panels. All panels coated with this formulation developed, upon baking, a number of small craters or pin holes, randomly distributed across the coated surface, which we concluded reduced the formulation's corrosion performance on steel.

In Phase 2, we worked toward developing an effective polyimide powder coating resin. Research began with the goal of significantly improving the soak test adhesion and wetting of a polyimide-based powder coating. To soak-test the coating in the laboratory, we immersed the coated coupon in a 3-percent sodium chloride solution and observed the progress of delamination and corrosion over time. We identified significant improvements in polyimide powder coating resin performance through this screen test. The table shows one powder control and six polyimide formulations tested. Items 5 through 7 showed improved adhesion over the controls, and Item 2 was the best formulation identified through Phase 1 research.

A 1,000-hr salt fog test of Items 5 through 7 revealed significant corrosion resistance over the Phase 1 polyimide formula. Figures 1 and 2 highlight this improvement.

Results of adhesion and wetting tests.

Item	Formulation	Adhesion	Wetting	Comments
1	DuPont Clear Epoxy	3.5	5.0	
2	Phase 1 Polyimide Formula	2.0	4.5	Phase 1 Salt Fog Delamination begins > 14 days
3	Phase 2 Polyimide Resin A	5.0	3.0	
4	Phase 2 Polyimide Crosslinker	1.0	4.0	
5	3/4/Epoxy resin/PL 545 (8:1:0.7:0.3)w	5.0	4.5	"Formula 1"
6	3/4/PL 545 (9:0.7:0.3)w 3/polyester resin/PL 545	5.0	4.5	"Formula 2," all polyimide
7	(9.2:0.5:0.3)w	4.5	4.5	"Formula 3"; no methylacrylic acid (MAA)
0: Very poor; 5: Excellent		PL 545: flow/leveling aid		

Close examination of the corrosion spots on steel panels, shown in Figure 2, revealed that these corrosion spots began where small craters existed after coating. No corrosion was found where these craters were not present. No corrosion was noted on aluminum, even with the presence of small craters.

In conclusion, this research developed polyimide resins with good melt properties suitable for coatings. The results of a 1,000-hr salt fog test for 1-mil polyimide on steel coatings were encouraging, and excellent salt fog results were achieved on aluminum panels. This novel technology led to the submission of two NASA New Technology Reports.

Contacts: Dr. Luz Marina Calle <Luz.M.Calle@nasa.gov>, NASA-KSC, (321) 867-3278; and Dr. David Trejo <Trejo@civilmail.tamu.edu>, Texas A&M University, (979) 845-2416

Participating Organizations: ASRC Aerospace (Dr. Scott T. Jolley and Lilliana Fitzpatrick) and University of Central Florida (Dr. Mary C. Whitten)

Figure 1. Steel, Item 4, Phase 1: 525-hour salt fog test.

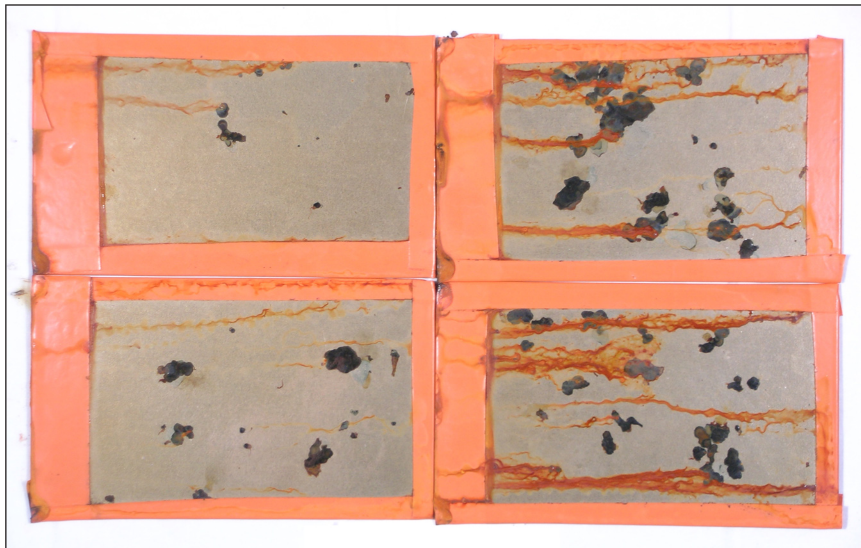

Figure 2. Steel, Item 7, Phase 2: 1,000-hour salt fog test.

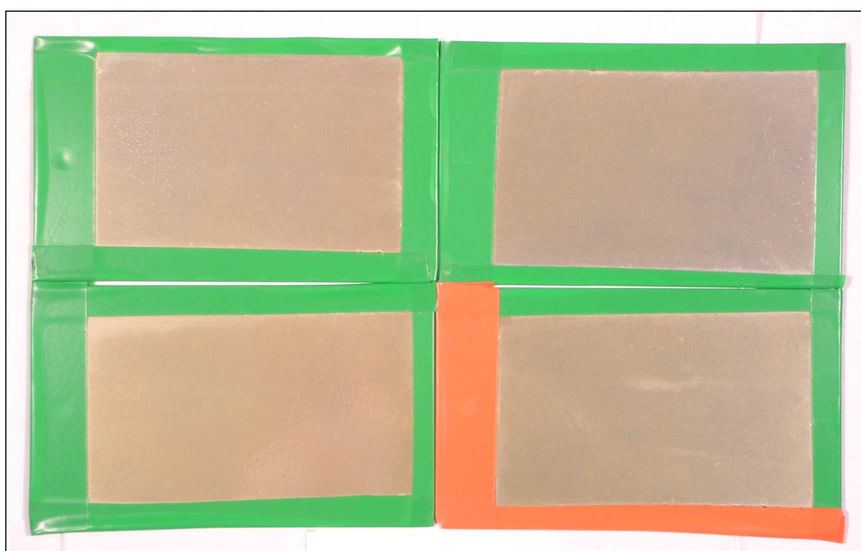

Figure 3. Aluminum, Item 4, Phase 2: 1,000-hour salt fog test.