Use of Fluoroethylene Vinyl Ether Resins in Coatings

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Fluoroethylene vinyl ether (FEVE) resins add many attributes to coatings. This article describes the development of FEVE coatings, gives examples of their use, and explains their resistance to ultraviolet exposure, wind, and extreme temperatures. Cost factors associated with their use are also shown.

When architects designed Ferrari† World in Abu Dhabi, United Arab Emirates, they included an aluminum roof that featured the company logo and comprised enough metal to cover ~17,000 Ferrari automobiles. That's a lot of metal to protect from the corrosion and elements that are a constant assault on the world's largest indoor theme park (Figure 1). Thanks to new coating chemistries, this roof has a protective coating that resists corrosion and provides a longer functional life than traditional fluoropolymer or polyurethane (PUR) coatings while preserving color and gloss. This facility is among many buildings, bridges, and outdoor structures protected by fluoroethylene vinyl ether (FEVE) resins formulated into protective coatings.

FEVE resins impart the same protection against corrosion, dirt, ultraviolet (UV) rays, wind, rain, and chemicals as traditional fluoropolymers and PURs, and provide additional benefits that include the following:

- Greater durability
- Color retention
- Gloss retention
- Reduced maintenance costs

†Trade name.

Because FEVE resins do not require heat curing, they can be integrated into products that can be applied either in the factory or the field. When formulated into topcoats, these products can help prevent corrosion longer than traditional industrial coatings, which significantly prolongs the functional lifespan of public infrastructure such as water towers and tanks, bridges, piers, and shipping docks.

The Effects of Corrosion

Corrosion can be caused by a variety of environmental factors that can mar the physical appearance of the coated object or, worse, cause structural damage that can increase maintenance costs and ultimately shorten the object's lifespan.

Bridges are highly susceptible to corrosion based on both their function and location. Daily exposure to UV light, wind, extreme and fluctuating temperatures, and (in many cases) salt water takes a heavy toll on these structures. Maintenance and upkeep are imperative for safety and to reduce the negative impact on civil transportation (Figure 2).

Private and public buildings and other federal-, state-, and municipality-owned infrastructure are affected by the same environmental factors at varying levels based on materials of construction, location, and use. Corrosion is also a substantial concern for the military, which must maintain both structures and fleets of planes and specialty craft at locations around the world.

According to the cost of corrosion study[1] initiated by NACE International, the financial impact of corrosion in the United States in 2002 was $276 billion, nearly 3.1%

of the gross domestic product (GDP). This total includes an estimated $29.7 billion in the transportation sector and $20 billion in the defense sector.

Coating Chemistries

Fluoropolymer Resins

Introduced to the coatings industry in the 1960s, fluoropolymers have been used in coatings because of their outstanding resistance to weather, chemicals, heat, water, and petroleum products. These qualities have made them useful in a variety of other industries, from paper and plastics to textiles and oil and gas.

Traditional fluoropolymer resins used in coatings have three shortcomings in their applications. They have poor solubility in conventional solvents, they require heat to cure, and the low surface energy that makes them water- and chemical-resistant limits their adhesion to metals and other substrates.

Polyurethane Resins

PURs were introduced in the 1940s and are the most widely used element in topcoat formulations where high gloss is required. While standard PUR-based coatings are much less expensive on initial purchase, the cost advantage is lost over the life of the coated structure because these formulations do not have the long-term weatherability of coatings that are based on fluoropolymer resin technology.

Fluoroethylene Vinyl Ether Resins

FEVE resins, developed in the 1980s, offer the same outstanding weatherability and durability as traditional fluoropolymers, but are soluble in solvents and are also available as water-based emulsions. FEVE resins traditionally were used for coatings for aesthetic reasons because of their ability to retain high gloss. Their anticorrosive benefits, however, have made FEVE-based coatings suitable for outdoor applications where weather-induced corrosion is high.

FEVE resins comprise alternating segments of fluoroethylene and vinyl ether. They are synthesized with reactive hydroxyl groups and can be cross-linked with standard aliphatic isocyanates to make fluorourethane coatings that offer extreme durability.

UV radiation, a contributor to corrosion, breaks down traditional coatings by generating free radicals that affect weaker bonds and linkages in polymer structures. FEVE resins impart excellent resistance to UV exposure because of the high energy of the carbon-fluorine bond. These products have a low permeability to oxygen, water, and chloride. This quality makes them highly effective on both inland and oceanic bridges. Coating systems utilizing FEVE-based topcoats are more effective against corrosion than coating systems using alkyds, chlorinated rubber, and acrylics.

FEVE solid resins can be used to formulate hazardous air pollutants (HAPs)-free, low-volatile organic compound (VOC), and South Coast Air Quality Management District (SCAQMD)-compliant industrial topcoats with outstanding aesthetic characteristics and superior corrosion resistance. These FEVE resins have varying molecular weights and hydroxyl values, which can allow for significant formulation latitude.

FIGURE 1 **Ferrari World in Abu Dhabi is protected by coatings formulated with FEVE resins.**

FEVE resins are also supplied in water as dispersions and emulsions. They can be formulated into products such as industrial maintenance coatings with VOCs <100 g/L. Accelerated weathering tests show that the dispersion-based fluorourethane weathers as well as the solvent-borne coating.

Replacing a standard PUR topcoat with a FEVE-based topcoat will increase the total cost of the coating application by 5 to

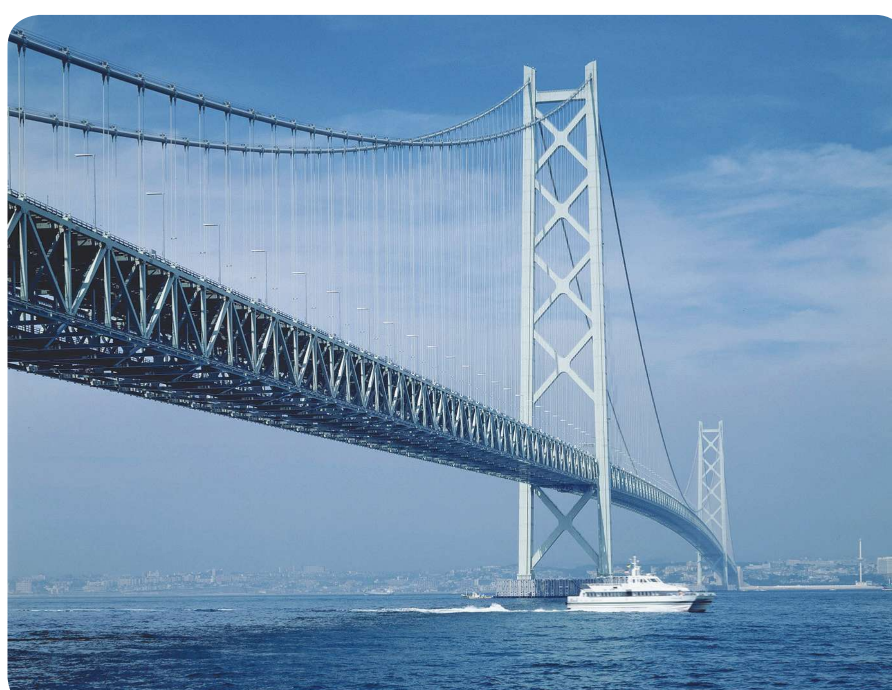

FIGURE 2 **Shown is the Akashi Stright Bridge in Kobe, Japan. Bridges like this are susceptible to corrosion from UV exposure, wind, and extreme and fluctuating temperatures. FEVE resins provide the needed protection.**

TABLE 1. LIFE CYCLE COSTS: ALKYD, PUR, AND FLUOROURETHANE COATING SYSTEMS

Coating System	Alkyd	PUR	Fluorourethane(A)	
Total repainting cost ($/m^2)	69.48	85.65	93.87	
Estimated coating life (years)	7	18	30	60
Total applied coating system cost ($/m^2/year)	9.93	4.76	3.13	1.56
Cost index	100	48	32	16

(A)A FEVE-based coating.

10%; however, the FEVE-based coating will last up to 30 years or longer depending on the substrate and environment.

When life cycle costs are taken into account, the FEVE-based coating system offers several cost advantages. The total applied cost of coatings with FEVE resins is one-third of the cost of alkyds and two-thirds of the cost of urethanes (Table 1).

Additionally, there are environmental advantages derived from the extended lifecycle of a FEVE-based coating. It eliminates waste generated by recoating, such as:

- Corroded parts that have been removed and replaced
- Waste water from power washing
- Solid debris from the removal of the old topcoat
- Disposable application accessories/tools used during recoating

Conclusions

Corrosion and UV degradation are the primary enemies of public infrastructure and large-scale, privately owned property. The cost of corrosion currently is nearly half a trillion dollars per year just in the United States. The inclusion of FEVE resins in topcoats will extend the lifetime of coating systems engineered to protect our public infrastructure while reducing the overall life cycle costs.

Reference

1 G.H. Koch, M.P.H. Brongers, N.G. Thompson, Y.P. Virmani, J.H. Payer, "Corrosion Costs and Preventive Strategies in the United States," FHWA-RD-01-156 (Washington, DC: FHWA, 2002).

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†Trade name.