Epoxy, Polyester, Acrylic — What's in a Name?

Powder coating resin systems are no longer distinct and easily categorized . . .

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Remember how simple it used to be to decide what type of hamburger to order? You basically had two choices, plain or with cheese. Now you walk into a restaurant and it takes at least five minutes to read all the variations that are available.

A similar situation is facing powder coating end users. When thermosetting powder coatings were introduced, the user could have any resin system as long as it was epoxy. Then, as powder coatings evolved, polyester and acrylic resins became available. By the early 1980's five basic systems were in use: epoxy, epoxy/polyester (hybrid), polyester urethane, TGIC polyester and acrylic urethane. Each of these resin systems had specific characteristics that made it easy to categorize.

Powder manufacturers and end users compared these resin systems. Table I reviews the advantages and disadvantages of each. This comparison became so common that whenever anyone involved in the powder coating industry mentioned one of the five resin systems, the listener would immediately picture a set of film properties. For example, polyester urethanes were thought of as thin-film, exterior-durable systems, while epoxy/polyester hybrids were identified as a low-cost, versatile binder where UV resistance was not required.

As powder technology advanced, these distinctions blurred. An outpouring of resins and crosslinkers changed the physical and chemical characteristics that had been associ-

TABLE I--Typical Properties of Thermosetting Powder Coatings

Properties	Epoxy	Epoxy/Polyester Hybrid	TGIC Polyester	Polyester Urethane	Acrylic Urethane
Application Thickness	1-20 mills	1-10 mils	1-10 mils	1-3.5 mils	1-3.5 mils
Cure Cycle (Metal Temperature)	450F-3 min 250F-30 min	450F-3 min 325F-25 min	400F-7 min 310F-20 min	400F-7 min 350F-17 min	400F-7 min 360F-25 min
Outdoor Weatherability	Poor	Poor	Excellent	Very Good	Very Good
Pencil Hardness	HB-5H	HB-2H	HB-2H	HB-3H	H-3H
Adhesion	Excellent	Excellent	Excellent	Excellent	Excellent
Chemical Resistance	Excellent	Very Good	Good	Good	Very Good

ated with the resin classes. Depending upon the type of polyester and crosslinker used, a polyester urethane could be formulated with poor UV resistance or with no flexibility, traits that are normally not associated with this binder system. Formulators also started to mix base resins in unusual combinations to achieve specific properties, such as the powder systems designed to replace porcelain in laundry applications.

The United States appliance industry, where powder has been successfully used for the last 25 years, provides an excellent example of how powder resin systems have evolved from epoxy only to the remaining basic five binders to special proprietary products that do not fit any classification system. Table II provides a chronological listing of resin evolution.

Due to the increase in formulation complexity, there has been a trend in recent years to refer to powder coatings by the generic classifications of epoxy, polyester and acrylic. Even these designations are no longer representative of the formulation variations that are available. Fluorocarbon and silicon modifications are just two examples of the new resins that powder formulators now incorporate into their product lines.

There is a new way to adapt to both the changing needs of the market place and the complexity of resin systems now available. Rather than try and describe a new binder system by resin type, a product line is designated, such as a polymer alloy line of powder coatings. The binder system in this example is tailored to meet individual customer requirements. Basic building blocks are manipulated by type and amount to produce a binder system that achieves specific results.

A review of Table II reveals that

TABLE II-Resin Chemistry in the Applicance Market

Period	Application	Chemistry
Early 70's	Refrigerator liners	Epoxy
	Water Heater	Epoxy
Mid 70's	Refrigerator racks	Epoxy
	Freezer liners	Epoxy
	Microwave cavities	Epoxy
	Dryer drums	Epoxy
	Exterior refrigerator & dishwasher	Acrylic-urethane
	Range side panels	Polyester-urethane
		Acrylic-urethane
Late 70's	Air conditioners, heating	Polyester TGIC
	Microwave trim	Polyester-urethane
	Washer control panels	Polyester-urethane
Early 80's	Refrigerator racks	Hybrid
	Exterior freezers	Acrylic-urethane
	Washer tops & lids	Proprietary polyester
Mid 80's	Washer wrappers	Proprietary polyester
	Dryer drums	Proprietary polyester
	Bulk heads	
Late 80's	Range door trim	Heat resistant polyester
	Range splash panels	Heat resistant polyester
	Spinner baskets	Proprietary polyester
Early 90's	Refrigerator doors and wrappers	Flexible polyester

polyester and acrylic urethanes have dominated the range and refrigeration markets. While they offer many outstanding properties, they normally contain three to four pct volatiles. While this amount is extremely low when compared to liquid coatings, it can still result in visible emissions from the cure oven. Also, the primary component of the three to four pct volatiles is e-caprolactam, which is identified as a hazardous air pollutant under the Clear Air Act Amendments (CAAA). In 1995 state agencies will enforce the requirements of CAAA.

The polymer alloy system used as an example is nearly 100-pct-applied solid that contains no hazardous air pollutants or SARA 313 materials. In addition, there are no unusual health and safety concerns. Because of the 100-pct-solid content, oven fouling is significantly reduced and color stability is increased. An additional benefit is a reduction in oven temperature. Polyester and acrylic urethanes

1. TRANSFER efficiency differences

normally require a metal temperature of 380F for 10 min in order to achieve full cure. The polymer alloy can obtain the same properties at 350F for 10 min.

Another weakness of urethane cured binders is application. While they are successfully applied in many large powder systems, they are not as user friendly as other powder chemistries. Figure 1 demonstrates the transfer efficiency differences between an appliance polyester urethane, a traditional epoxy polyester hybrid, and the polymer alloy example. In actual field trials the polymer alloy example has consistently resulted in a 25-35 pct improvement in transfer efficiency at reduced powder delivery rates. Fluidization and Faraday penetration have also been improved.

Since the example system customizes the basic building blocks, many properties can be achieved. For example, it is possible to combine hardness with excellent flexibility. Regardless of how the components are combined, excellent thin-film appearance and properties are obtained. Corrosion and chemical resistance are excellent. All of these benefits are achieved with a stable raw material base that is competitive with existing powder binder systems.

The "product line" concept is just one approach to meeting the increasing demands of today's end user. It is an example of the complexity of today's powder coating formulations. The old familiar designations of epoxy, polyester urethane and hybrid have lost their meaning. Combinations of specifically engineered resin systems can no longer be categorized by the chemical and physical properties of a single resin chemistry.

This inability to generalize resin properties also applies to compatibility between powder systems. It has always been dangerous to assume that two powder coatings were compatible just because they used the same resin chemistry. With the array of formula variations now available, it is impossible to generalize about powder types. The end user needs to evaluate, at different levels, what effect the blending of two powder coatings has upon finished film appearance.

The growing complexity of powder coating formulations is leading to better communication between the powder supplier and the end user. Rather than telling a powder manufacturer that he wants a specific resin system, the end user can now detail his specific finishing requirements and allow the formulator to create a special product. With this approach the powder producer and end user work together as a team to engineer the best cost/performance system.

The names of the powder coating resin systems may have changed, and the formulations have become more complex, but one factor has remained constant. Powder coatings continue to provide an economical environmentally friendly method of meeting the finishing requirements of a multitude of end users. **PF**

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