



*Demand for Performance  
and Sustainability Driving*

## FLOOR COATING RESIN DEVELOPMENT

By **Cynthia Challenger**, Coatings/Architecting Writer

Most flooring—whether wood, concrete, tile, or linoleum—requires protection from wear, and for many industrial applications, exposure to harsh environments. Coatings play a critical role in imparting that needed level of protection, and today, building owners (residential, commercial, industrial) and applicators (OEM floor finishers, professional contractors, maintenance personnel, DIY homeowners) are looking for cost-effective, sustainable coatings that are easy to use and provide a durable finish. Resin manufacturers are responding with reasonably priced UV-cure oligomers for both factory and onsite applied coatings, and water based, low odor, one component systems for field-applied applications.

### WOODN'T IT BE LOVELY

The market for floor coatings for wood substrates in the United States totaled \$510 million in 2011, according to Steven Nerlfi, a principal consultant with market research firm Kusunigar, Nerlfi & Growney (KNG). Water-based coatings (13–15 million gallons) account for 80% of that market and are growing at four percent per year, largely at the expense of solvent-based systems, but also due to design trends for finished wood (versus rugs, PVC sheet, tile goods, and other surfaces). Leading suppliers of

polyurethane dispersions (PUDs) for wood floor coatings, according to Nerfi, include Arkema, Bayer, Dow Chemical, DSM, EPS, Lubrizol, and Reichhold.

Bona US, a global hardwood floor product manufacturer, expects to see continued growth in wood as a preferred flooring material due to its warmth, aesthetic properties, and ease of maintenance compared with other surfaces. "Refurbishment of existing homes that are replacing old or worn carpet or vinyl products continues to be a growth factor, even with new construction being suppressed for the last several years," observes Bona's director of operations & innovation Gerald Thompson. "People pull up the old materials to find to their delight that they have wood underneath and decide to just refinish it rather than put another flooring type on top of it."

Polyurethanes are the dominant type of resin system used on wood floors due to their flexibility, toughness, and chemical resistance. "These properties lend themselves to wood because the substrate shrinks and swells with humidity changes (flexibility required), is walked on (toughness for scratch and scuff resistance), and requires protection from household chemicals and spills (chemical resistance)," explains Thompson.

In the past, due to its ease of application and low cost, the major type of resin was solvent-based oil-modified urethane (OMU). This produces tough and durable coatings that are moisture resistant and give the wood an amber color tone, according to Terri Carson, director of technical services and quality control for Alberdingk Boley, Inc. In most markets, however, these systems are losing market share to water-based formulations due to VOC issues. Other solvent-based urethanes include moisture cure systems where curing occurs from moisture vapor in the air producing a hard and durable surface. Asia is one area where these systems still retain a predominant share of the market, but they are difficult to apply and have a strong odor.

Elsewhere, polyurethane dispersions have become widely adopted. "Increasing developments in PU dispersions have been introduced to the marketplace that incorporate crosslinking chemistry, contain higher solids, fast dry-times, have low odor and high durability, and meet the standards for very low emissions while maintaining performance," states Carson. Recent developments in waterborne alkyd technology have, in addition, contributed to the development of new water-based versions of the solvent-based systems that exhibit high performance with an oxidative cure, according to Susan Anderson, a director with consulting firm The ChemQuest Group. "These new modified urethanes can meet VOC requirements and

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have boosted the trend toward waterborne systems for wood flooring," she says.

With respect to the choice of urethane, Carson notes that the aromatic systems are good as a single component (1K) topcoat or they can be used as sealers. While they are economical, hard, chemically resistant, and tough, however, they do pull tannins and cause color marks. As a result, aliphatic urethanes are often preferred due to their versatility in performance depending on the choice of polyester or polycarbonate polyol—good flexibility, toughness, and abrasion resistance can be achieved. Because these materials come at a higher cost, though, water-based acrylic and styrene-acrylic copolymer resins are often blended with polyurethanes, she adds. Depending on the urethane level in the coating, these finishes can provide more wear resistance than an OMU. For Carson, the best performing systems are two-component (2K) coatings that are crosslinked with either isocyanate or aziridine.

The specific type of urethane system is determined by the type of wood and the intended application/expected wear. Regardless of the type of wood, flooring in high traffic areas will require more protection from abrasion and wear. Sports floors, which are typically made of maple, need a highly durable, transparent coating. While traditionally hardwood floors were made of oak, exotic woods such as cork and bamboo are experiencing increasing use, and have different properties that must be considered. In the U.S., there is also a growing interest in virgin pine, which is a softwood used for flooring, and this material has different coating requirements.

"Resin manufacturers must be aware of the properties of the different types of woods in the marketplace when developing new resin chemistries," comments George Ahrens, a senior research and development chemist in applications at Lubrizol. "As a result, field testing has become an important component of the development process at Lubrizol. A combination of laboratory testing and analysis and field testing with professional contractors helps us ensure that we are developing resins that can be formulated into floor coatings that effectively meet the needs of the end user," he explains.

As mentioned previously, there are both 1K and 2K systems for wood floors. Traditionally, professional contractors have tended to use the 2K systems, while homeowners are more comfortable with the easier-to-use one-component products. There is growing interest in simpler 1K formulations in the contractor segment, though. "For contractors, time is money, and they definitely do not want to have to redo a job. As a result, they are slow to adopt new technol-

ogy until it is well proven, but they are very interested in coatings that are easier to use, compliant with regulations, have low odor, and are cost-competitive," Anderson notes.

In many cases, commercial floors are no longer being done by contractors that specialize in floor coatings, but by maintenance personnel, according to Dan Latas, global marketing manager for wood coatings with Lubrizol Advanced Materials. "These applicators generally don't have the experience in floor care that professional contractors do, and thus they are looking for simple, easy-to-use systems," he says.

Contractors, in fact, often choose the coating formulation based on the situation at a given job. "If a building is going to be vacant and the contractor faces cost constraints, then a solvent-based system is often preferred. However, if people will be present in the building, a water-based, low-odor formulation is generally the coating of choice," observes Ahrens. "Odor is definitely a growing issue, and because water-based coatings have significantly reduced odor, it is a key driver for their continued growth," he adds. Being able to work on a floor without having to halt operations in the rest of the building is a real advantage, particularly in the commercial/institutional markets, adds Anderson.

Rapid return to service is also critical for floor coatings of any kind. The quicker the coating cures to the point where it can be put back in service, the better. Some waterborne systems can be ready in just two days, while solvent-based oil-modified urethanes can take up to a week to fully cure. To address the need for faster curing, Lubrizol, for example, continues to develop improved one-component technologies and has also introduced multi-functional technologies with self-crosslinking polymers, according to Latas. "TurboSet™ Ultra Pro self-crosslinking waterborne polyurethane dispersion from Lubrizol, which is designed for use on sports and recreational floors, contains nano-sized polymer particles that crosslink after application and during drying, which reduces the drying time. It is also a one component system with an extended pot life, which makes application easier and safer," he remarks.

Because waterborne systems have positive features when it comes to the main drivers in the wood floor coating market—environmentally compliant, easy-to-use, low odor, and fast curing time—many resin companies have focused their efforts on the development of improved water-based technology. This industry faces two main challenges, according to Latas. "The first is to

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achieve the same level of performance as solvent-based systems with waterborne chemistry—that warm, golden, deep, rich appearance combined with good durability. There has been real progress in that direction, but there is more work to do. Secondly, that performance needs to be obtained with cost-effective, low-VOC, low-odor resins with high renewable content."

"Developing new resin technologies that can be formulated to meet low- to zero-VOC requirements and are made from renewable resources will continue to be a major focus for coatings technology," according to Carson. DSM,

which is also leading the development of waterborne resin systems, is targeting resins with very high renewable content as part of its commitment to sustainable products. The challenge currently is the limited availability of raw materials that do not impact the food supply or local indigenous populations, which drives up the cost, according to Derrick Twene, global industry manager for flooring and construction at DSM Coating Resins.

The company's uralkyds already are based on renewable acids, and the goal is to ultimately offer both the urethane and alkyl portions from bio-based materials, according to application specialist Patricia Bell. "There is high interest in our water-based uralkyds because of their fast drying, high durability, good abrasion resistance, and low VOCs. Our self crosslinking PUDs offer similar properties and are non-yellowing. Understanding the driving demands of the market and focusing on delivering products that meet these requirements has been, and continues to be, our focus," she adds. Lubrizol also has an active development program focused on resins with high levels of renewable content, and also expects to introduce new products for its TurboSet and Sancure<sup>®</sup> families later in 2012. Bona has been utilizing renewable components in its Bona Mega<sup>®</sup> waterborne floor finish for more than 15 years. The finish also has a unique cross linking mechanism that utilizes oxygen in the air as a safe and readily available second component, according to Thompson.

Customers of DSM are increasingly concerned about the impact that coatings formulated with their resins will have on the indoor air quality of a structure, according to industrial specialist Sandy Wheeler. "We have responded by developing resin systems that are not only very low VOC and low odor, but also are free of other potentially hazardous substances, including N-methylpyrrolidone (NMP)," she says. Bona, meanwhile, recently launched Bona TrafficHD™, which provides excellent scuff, scratch, and chemical resistance at less than 125 g/L

Polyester acrylates are an excellent compromise on cost versus performance. They provide high gloss, high hardness, and fast curing combined with excellent scratch and abrasion resistance, and good pigment wetting.

VOC and with very low odor. The product, according to Thompson, is GREENGUARD Children & Schools<sup>®</sup> Certified. "When specifically designing for lower VOCs, the real challenge is to enhance rather than diminish the performance properties. We have successfully pushed the bar even higher than before by dramatically improving durability while lowering the solvent emissions by 40%," he says. Alberdingk Boley has also made contributions in this area with the development of a new solvent-free PUD, Alberdingk<sup>®</sup> U7800. This product can be formulated at less than 50 g/L and offers high hardness, outstanding abrasion resistance, excellent wood warming, and good chemical resistance.

While most wood floor coatings are often based on urethanes, there are other alternatives. Acrylic emulsions, for example, can be used in some applications,

such as sealers, and can even be preferred where ease-of-use and concerns about handling are a primary issue. For such instances, Lubrizol offers Carboset<sup>®</sup> 2968, an APEO-free, self-cross-linking acrylic polymer emulsion that provides increased chemical, moisture (especially moist heat), and scratch/abrasion resistance. It is a one-component, low-VOC resin with fast dry times that can be used in DIY and factory-applied finishes.

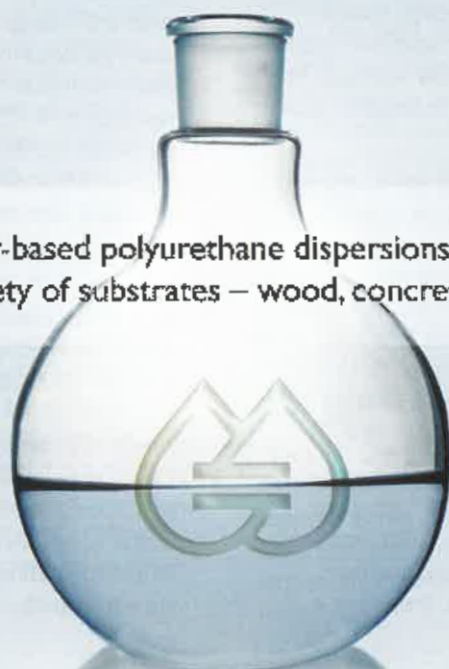
Another trend that is driving resin development at DSM relates to the increased demand for added functionality in floor coatings—a trend that is becoming more common in many coatings markets. Not surprisingly, the desired functionality varies with the end-use application. "Hospitals, for example, want floor coatings that are easy-to-clean and potentially resistant to infectious organisms, while the electronics industry requires antistatic coatings, and yet other sectors are looking for some level of flame retardancy," explains Twene.



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Incorporation of nanotechnology is a trend throughout the coatings industry that is also reaching the floor coatings segment, according to Carson. "Technologies have been introduced that reportedly improve the performance of coatings, including corrosion protection, abrasion and scratch resistance, UV protection, and antimicrobial properties," she observes. She adds, though, that "the success of this technology will primarily be driven by lowering the costs of these products while achieving differentiated performance."

## TIME IS OF THE ESSENCE

For new wood flooring applications, the desire for as little disruption as possible is also driving the growth of prefinished wood flooring. In fact, as much as 80% of new hardwood flooring today is prefinished, according to Anderson. Pre-coated flooring does not have to be pre-conditioned prior to installation and is immediately ready for use. These coatings are generally UV-cured polyester acrylates, most of which are 100% solids, although waterborne systems are seeing increased use. They often contain special additives—microcrystalline silica or other nanoparticles—to make them very scratch resistant, which enables flooring companies to offer 20-year lifetime warranties.

This scratch resistance poses problems when it is time to recoat these floors, however. "Because sanding is a form of abrasion, the increased scratch resistance makes it very difficult to strip off the coating when it needs to be replaced. Recoatability is a real issue, and will become increasingly important as the amount of installed prefinished flooring that needs to be recoated grows," Ahrens says.

While Lubrizol does not offer resins for UV-cured, field-applied wood coatings, it has recently introduced Carbocure™ 7000, a solvent-free, crosslinkable liquid surface modifier for UV-cured wood coatings that provides a smooth, uniformly matte appearance with a soft touch and low haze without increasing the viscosity. This technology won the Ringier Technology Innovation Award in China in 2012.

Most coating formulations are 100% solids and OEM-applied, according to Bill Schaeffer, industrial applications manager for Sartomer. These systems generally consist of a primer, sealer, and topcoat (sanded between coats) with a total thickness of 4.0–5.0. The industry has settled on polyester acrylates as the resin of choice, after starting with epoxy acrylates, which were found to yellow too much, and then switching to aromatic urethane acrylates, which eventually became too costly.

"Polyester acrylates are an excellent compromise on cost versus performance. They provide high gloss, high hardness, and fast curing combined with excellent scratch and abrasion resistance, and good pigment wetting. Compared with epoxy acrylates, they have a



significantly lower viscosity, enhanced wear properties, improved yellowing resistance, and better flexibility. With respect to the urethane acrylates, they have better flexibility and equal or somewhat improved wear properties but at a lower cost," he explains.

For applications where UV curable urethanes are still desired, such as field-applied floor coatings, Sartomer offers alkoxyated functional monomers that can be used to incorporate UV curable properties into polyurethane coatings. "The addition of these acrylate monomers allows for accelerated film property enhancement through UV curing. There is no waiting period required when the coating is UV cured immediately after flash-off to remove water," Schaeffer says.

## COATING CONCRETE FLOORS

While urethanes are also used on concrete floors, epoxy-based systems are by far the most widely used resin technology. The global market for concrete floor coatings including thick film floors and trench lining is estimated by Michael D. Brown, a director with market research firm T.Z. Chemicals, to have been approximately \$1 billion in 2011. About \$525 million of that is attributed to U.S. sales, according to George Pilcher, a vice president with the consulting firm The ChemQuest Group.

In the U.S., epoxies account for about 55% of dollar sales (67% 2K 100% solids, 13% 2K epoxy novolac, 11% solventborne, and 9% water based), polyurethanes about 23% (35% moisture cure, 31% 2K solventborne, 17% 2K 100% solids, and 17% water-based), acrylics about 8% (USDA verified meatlockers and other areas where application can be achieved at freezing temperatures), polyureas about 5%, and polyaspartics about 8%. A minor amount of vinyl ester coatings are used for containment areas in chemical plants, and field-applied, UV-cured coatings are about 1% of total sales, but growing very rapidly.

Overall, 60–65% of the coatings are 100% solids formulations, and that percentage is growing, according to Pilcher. Solvent-based systems still account for 20–25% of the market, but—not surprisingly—their use is decreasing. For concrete floors, water-based systems have only penetrated the market to a level of 10% of dollar sales, but demand is growing for these products, generally for applications that do not require real heavy duty performance.

“Epoxies are the dominant resin system because they are high performance. They are used in various industrial applications from chemical plants to food and beverage production facilities and virtually everywhere concrete flooring can be found,” Pilcher says. Most are three-coat systems with a primer, intermediate coat, and topcoat, although some two-coat systems have been introduced. Furthermore, 75% of concrete floor coatings are applied purely for functional purposes (note that these numbers do not include stains or sealers or any other non film forming systems). By end-use segment, 45% of concrete floor coatings end up in industrial applications, 35% for commercial locations, 17% are found on residential flooring, and an additional 8% are destined for use by DIYers.

Perhaps reflecting the wide variety of resin types used for concrete flooring, the supplier base is a highly fragmented one. Stonehard (RPM) and Sherwin-Williams/General Polymers combined account for about 40% of the market with \$100 million and \$90 million in sales, respectively, according to Pilcher. The next largest manufacturers include Sika and BASF, each at \$35 million in sales. The rest of the over 100 suppliers have sales below \$20 million, and many are regional players with just \$1–2 million in turnover.

Demands for improved coating performance for concrete floor coatings are similar in many ways to those for wood floor coatings. Faster cure for faster return to service is a key expectation, as is the demand for low odor. There is also interest in coatings made from renewable materials. DSM has responded to this need by signing an MOU with Empresa Brasileira de Biotecnologia for the launch of a new line of DSM-branded bio-based, castor oil materials for the concrete floor coatings market.

Specific to concrete, according to Pilcher, is the need for improved adhesion with 100% solids systems, which can have difficulty penetrating the surface. Coatings that are more breathable are also required, as water trapped under concrete flooring can build up hydrostatic pressure, which can cause the coating to lift. Increased breathability with respect to water vapor helps relieve that stress and extend the life of the coating. The creation of different looks for concrete, development of formulations that are suitable for use with airless sprayers, improved chemical resistance, and primer-less coatings are other unmet needs that resins producers are tackling for their concrete coating customers.

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Polyureas and polyaspartics are a good value proposition, according to Brown. “These coatings provide a better appearance than epoxies and, unlike epoxies which can be brittle, have increased flexibility, which allows these systems to bridge small cracks in the concrete,” he notes. “They also breathe better than epoxies—polyurethanes in general do—which helps address the issue of water buildup.” The main disadvantage of polyaspartics, according to Carson, is their cost, which tends to be 3 to 10 times more expensive than 100% solids epoxy resins.

With respect to contractor-applied concrete coatings, Brown notes an interesting trend that is not seen with other flooring coatings. “It appears that perhaps 10–20% of coating applications are being completed by contractors that are buying the coating ingredients directly, rather than purchasing formulated systems. It makes some sense, as 2K coatings require mixing anyway, and the formulations are generally pretty basic, and include the resin, curative, and colorant. Some resins manufacturers are encouraging sales in this manner.”

Line striping is also an interesting—and profitable—niche segment of the concrete floor coatings market, according to Brown. Generally acrylics and alkyds are used, and these coatings are laid down on top of the epoxy. They come in various safety colors and are used to mark aisle ways or to separate walkways from areas where forklifts and other machinery are driven. “For these coatings, cleanliness and quality are key issues,” he observes.

The DIY segment of the concrete floor coating market has its own issues. Because preparation is such a critical issue for these coatings, it can be difficult for homeowners to properly clean an existing concrete floor so that the coatings will adhere properly. “It is difficult to get all of the oil and grease cleaned from a used floor,” Brown notes. Safety is also an issue, as coatings can be very slippery. Some DIY garage floor coating kits include “confetti” or aggregates that can be blended in that create an interesting look while also reducing the slipperiness of the surface.



Floor coatings are also competing to some extent with concrete hardeners, which are much less expensive, and with new liquid type flooring systems. DSM is also participating in this sector. Its new URelle-Crete is the first of a new family of products that the company is developing. The three-component urethane cement system meets current USDA and FDA standards and is designed to withstand extreme thermal shock, physical impact, and chemical exposure. The company is targeting applications in food and beverage and pharmaceutical facilities.

## POLISHING THE ACT

Floor polishes comprised of water-based acrylics and styrene acrylics, with recent developments in the use of styrene butadiene as a resin for floor polish, are yet another category of floor coating. As with the above-mentioned coating systems, the biggest areas of growth for floor polishes tend to focus around environmental sustainability, reduction in maintenance costs by using higher crosslinked coatings, and coatings that help maintain hard floor surfaces such as concrete, according to Jamey Gaston, OMNOVA Solutions floorcare and graphic arts team leader. "For these types of systems, the most notable recent trends have been a move away from zinc as a divalent metal used to crosslink and build durability, and the removability of the floor polish," comments Gaston. "The use of 2K systems has the potential to provide extended durability," he adds. In addition, styrene butadiene resins help reduce the total formulation cost. A key development goal is the identification of a lock and key mechanism that does not require harsh chemicals to remove the coating. "The major challenges for producers of resins for floor polishes include finding a viable replacement for zinc, the rising cost of resins, and the increasingly more stringent demands for low VOC formulations," Gaston remarks.

## UV ON THE GO

The need for a 1K coating with 2K properties, fast return to service, fast development of coating properties, low VOCs and HAPs, and low maintenance requirements is driving the expansion of UV-curable field-applied coatings, according to Jo Ann Arceneaux, technical manager of New Business Development with Cytec Industries. "In addition to meeting the above drivers, the coating perfor-

mance is not diminished, and in most cases is improved versus conventional coatings. Immediately after UV cure, the coating properties are fully developed, allowing the floor to be put back into normal service very quickly," says Arceneaux. "The development of on site waterborne and 100% solids UV products is a growing market that has significant potential in the industrial and sports flooring market," adds Carson.

This application, however, depends on the synergistic development of the coatings, application processes, and equipment in one solution, according to John Brandt, head of business development, UV & Wood Coatings NAFTA, Bayer MaterialScience LLC. There is ongoing work on all three components to continue to enhance site-applied UV coating formulations," notes Brandt. Bayer MaterialScience, Cytec, DSM, and others are working closely with equipment manufacturers to ensure that coating formulations are optimized in terms of the speed of cure, thickness of the applied coating, and other factors.

The last six to seven years have seen both increased equipment and coating supplier market entry, as well as improvement of the equipment and floor coatings, according to Arceneaux. These developments have allowed the commercialization of UV-curable field-applied floor coatings for concrete, wood, vinyl composition tile (VCT), resilient vinyl, and tiles.

Two types of UV-curable field applied coatings are available: 100% solids and waterborne. The performance characteristics of the two technologies are basically the same, with a few exceptions. For matte coatings, waterborne technology must be used. For end uses that require low shrinkage, waterborne is preferred and it is easier to eliminate/prevent "zippering" with waterborne coatings. (Zippering is caused by light leakage from the sides of the mobile UV curing units.) The disadvantage of waterborne coatings, however, is the additional drying step, which must occur before UV cure.

UV-curable field-applied wood coatings are currently applied in gymnasiums, restaurants, retail stores, casinos, dance floors, and residences. Most are waterborne, because the conventional coatings are also mostly waterborne, which allows the floor preparation and coating application steps to remain the same, according to Arceneaux. The exception is gymnasiums, which tend to be 100% solids. "UV-curable coatings provide indefinite potlife, and much better hardness, abrasion resistance, and chemical resistance compared to conventional coatings," Arceneaux asserts. Alberdingk Boley, for example, has focused its effort on the development of new water based UV PUDs for wood



Photo courtesy of Cytec Specialty Chemicals

floors. Specifically, LUX 255 has been introduced to the market and produces a coating with excellent scratch resistance, good wood warming, very fast water release, and a quick cure response.

For concrete, clear and pigmented floor coatings are available. The clear coatings may be used alone, or as topcoats for epoxy basecoats. "The UV-curable topcoat provides indefinite potlife, additional weathering, improved chemical resistance, easier cleaning, and much better hot tire pick-up resistance compared to epoxy coatings," states Arceneaux. Most of the pigmented coatings are used for line striping, but entire floors can also be pigmented. While most of these applications are industrial, commercial and institutional markets are also served, along with residential garages and some decorative applications. "Because UV curing is not affected by temperature, the refrigerated warehouse market is especially accessible," adds Arceneaux. Mainly 100% solids coatings are used for concrete.

For VCT in the institutional, education, and retail markets, replacement of the floor polish with a UV coating provides a much more durable finish and allows the maintenance to be reduced to simple cleaning. Some coating manufacturers give multi-year warranties for their coatings. Others continue to use the strippable model, but do so on a much reduced schedule, according to Arceneaux.

"UV-curable field applied floor coatings are already in commercial use today on multiple substrates and in many markets. We believe that the best summary of the value proposition for these UV-curable field-applied coatings is 'fast return to service with fully developed properties,'" Arceneaux concludes.

## FOCUS ON 'FLOORING' THEIR CUSTOMERS

While tremendous advances have been made in resin technology for floor coatings, resin manufacturers recognize that there is still much room for improvement in waterborne systems for all types of flooring applications.

"Owners, architects, and engineers are increasingly looking for environmentally friendly options with ultra-low- to zero-VOCs, eco-friendly raw materials, such as solvent-free and waterborne coatings, and improved



coating performance to reduce required re-applications," comments Kathy Allen, senior scientist, Bayer MaterialScience LLC. The development of a 1K water based product that performs comparably to a 2K system is a top candidate, according to Carson. "New cross-linking chemistries will be key to creating a water-based system

that is quick drying, has better wear resistance, low odor, and easy clean-up, but like a solvent-based system is inexpensive, has better aesthetics, and is easy to apply," she adds. "As importantly," notes Latas, "validation of new systems through both laboratory and extensive field testing is absolutely critical." ■

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