Advancing Green Coating Technologies

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Driven by a combination of regulatory, market-based, and economic incentives, the adoption of "greener" technologies—here considered to be those that have reduced environmental, health, and safety impacts—has become a critical aspect of day-to-day operations for many companies in the coatings industry. In addition, green technologies today encompass much more than reducing volatile organic compound (VOC) content. Now, processes are designed to reduce water and energy consumption, emissions and waste generation, while products in general are more durable, effective, and efficient and often have multiple functionalities, reducing material consumption. Industry professionals must also contend with the need to produce greener products that do not sacrifice performance or raise costs prohibitively, and that maintain their environmentally friendly status over the course of their life cycles.

To learn about the most recent developments in green process and product technologies for paints and coatings, *CoatingsTech* surveyed several members of the coatings industry value chain.

CT: What are the overall industry trends with regard to advances in greener technologies?

Pourabnedy, Lubrizol: To begin with, we need to define "green technologies." Every corporation has its own view of green technologies; however, common themes are environmental friendliness, consumer safety, sustainable use of resources, and use of renewable raw materials. At Lubrizol, we follow EPA's 12 principles of green chemistry for the development of green technologies. The adoption of green technologies has been accelerating during recent decades throughout the industry. The drivers for this acceleration are threefold: demand for greener products by customers, environmental regulations, and sustainable business models.

Watson, Dow: Overall, the industry is continuing to progress toward more sustainable technologies, especially where economically viable solutions exist. This movement is driven by three factors. First, consumers are becoming more aware and more demanding. We believe that when all other factors are equal, consumers will gravitate toward the most sustainable product offered. Second, regulatory and certification agencies continue to work closely with the industry to define and advance more solutions with sustainable chemistries. Finally, significant R&D investments across the value chain have led to technology breakthroughs that have enabled more sustainable coatings technologies.

Poelner, Reebok: Research and development in the coatings industry is continuously driven by an increasing ecological awareness of the end user as well as legislative requirements, which has led to a growing demand for eco-friendly and sustainable product solutions. High performance properties and efficiency enhancements are also still major driving factors in the coatings industry. However, sustainability factors such as energy savings,

preservation of resources, and the use of environmentally friendly raw materials are becoming increasingly important to the industry.

Kirby, Sherwin-Williams: Coatings manufacturers such as Sherwin-Williams can help OEMs and finishers meet sustainability, regulatory, and environmental goals with products designed to meet the requirements of changing regulations worldwide. One trend that we see is the increased need for customers to meet existing green requirements, such as Leadership in Energy & Environmental Design (LEED) certification for schools, public buildings, and even homes. Delivering a coating that meets such specifications allows our customer to sell their product to those who are constructing more environmentally friendly buildings. Another trend we see is that some customers want to integrate green coatings and materials in their manufacturing processes to create a sustainable offering that is more appealing to the end user.

Moncla, Celanese: Coatings provide substantial added value by protecting and beautifying an incredible array of products and surfaces. The coatings industry continues to embrace technologies that maximize the benefits while minimizing potential negative impacts and are often referred to as greener technologies. The greatest strides in the past two decades have come through the large reduction in the VOC content of architectural coatings. This trend in lower VOC content will continue through expansion into additional applications. Interior wall and trim paints were the start for VOC reduction. The expansion of low-VOC products is continuing into wood coatings and industrial coatings.

Vaughn, Emerald: The coatings industry remains focused on continued VOC reduction, reformulating to meet that goal and optimizing performance. This trend will continue as VOC standards continue to become more stringent. For example, both the U.S. Green Building Council, using LEED v4, and the AgBB in Germany are adapting the chamber method for determining the VOCs that evolve from an article over the period of one month. The South Coast Air Quality Management District (SCAQMD) in California is also looking to modify the GC method by utilizing a higher boiling point benchmark. In addition to VOC reduction, companies seek to replace ingredients that have been linked to human health hazards, such as bisphenol A, certain phthalates, and formaldehyde.

Hardy, Axalta: In the coatings industry, advances in greener technologies relate directly to sustainability. Axalta Coating Systems focuses on products and processes that aid in reducing dependency on fossil fuels. This includes lower-VOC coatings through the use of high solids, waterborne, and powder technologies. Combining these products with consolidated processes for OEMs that eliminate layers or bake steps and time via wet-on-wet process also allows customers to reduce energy consumption. Reducing consumption trends also includes lowering curing temperature and improving coverage and productivity. Greener technology trends are also directly driven by environmental regulations which often involve eliminating the use of identified hazardous substances.

Sayed-Sweet, Alberdingk Boley: Low- and near-zero-VOC dispersions provide latitude for better formulations. In addition, solvent-free and renewable resource-based polyurethane dispersions (PUDs) provide greener solutions. Industry is also looking into the use of recycled raw materials as building blocks for the manufacture of PUDs and low-odor emulsions. Finally, emulsions with lower minimum film forming temperatures (MFFT) that do not contain alkylphenol ethoxylate (APEO) surfactants are promoted in the market.

Tierney, Lonza: Overall, paint manufacturers are looking for renewable and sustainable raw materials.

Green Coating Technologies Roundtable Participants

AkzoNobel—Johan Widheden, sustainability specialist

Alberdingk Boley—Yasmin Sayed Sweet, vice president of sales and marketing

Arkema Coating Resins—Eric J. Kaiser, business director–Americas

Axalta Coating Systems—Joanne Hardy, North America technical director

BASF Corporation, North American Dispersions & Pigments Division—Brad Fogg, market segment manager for industrial/ACE coatings

Celanese—Brad Moncla, marketing manager for the Americas consumer emulsions business

The Dow Chemical Company—Keith Watson, global R&D director for coatings and monomers

Emerald Performance Materials—Julie Vaughn, vice president of business development and marketing

Evonik Corporation, Inorganic Materials Business Unit—Anil Saxena, vice president of functional silanes, North America

Heubach Group—Robert Poerner, business unit leader

Lonza Industrial Solutions—David Tierney, head of global sales

Lubrizol Corporation—Naser Pourahmady, technology manager

Reichhold—Julie Fuell, coatings sales director

The Sherwin-Williams Company, Product Finishes Division—Art Kirby, technical director of the Global Wood Lab

There is great interest in plant-derived ingredients, which have the potential to be both lower in toxicity and more easily recyclable than their petroleum-based equivalents.

Fogg, BASF: We are seeing continual interest from customers in low-VOC systems, including interest in high-solids, direct-to-metal, and water-based technologies. However, in the North American market, customers typically make it clear that they will not pay more for green technology, nor will they sacrifice performance.

Widheden, AkzoNobel: The drivers vary between different markets. In developing markets, the driver is still mainly on lowering the VOC content, while in other markets, programs such as BREEAM (Building Research Establishment Environmental Assessment Methodology), LEED, or national schemes for the environmental performance of building products form the driver for more sustainable coatings products. Of chief importance is improving the entire life cycle of the product and not each phase by itself. The function of the coating is then of greatest importance. That is where the main environmental improvements can be made, be it to reduce drag or energy in its application, to use thinner layers, to improve durability, or making the coating heat reflective or needing less maintenance in its use. The raw materials are also important contributors to the environmental impact of a coating, and the interest in renewable raw materials is growing, as is the availability of such materials.

CT: What are the key trends driving the development of specific greener raw material technologies?

Fuell, Reichhold: Reichhold is focused on various aqueous resin technology platforms utilizing biobased raw materials, such as soybean oil, as opposed to petroleum-based raw materials typically used in acrylics. These raw materials have enabled the company to obtain certification for numerous resins under the USDA's voluntary BioPreferred® program.

Kaiser, Arkema: In general, a key challenge is to deliver the overall performance of conventional coatings at low or zero VOC. In the case of resins, properties associated with film hardness, such as block and print resistance, are relatively simple to achieve with high T_g resins, but these binders tend to require levels of coalescing solvent that are no longer acceptable. To deliver these properties in low- or zero-VOC systems thus requires more complex resin design. In response, Arkema Coating Resins has introduced a line of products that formulators can use to create high gloss coatings with excellent block and print resistance at low or no VOC.

Sayed-Sweet, Alberdingk Boley: Renewable resources (oils such as soya, castor, or linseed oil) are being used for the production of polyols that are key building blocks of biobased PUDs. Consideration is also being given to the use of label-free raw materials according to the Global Harmonization Standard.

Pourahmady, Lubrizol: Regardless of different views on green technologies, there is a general agreement that the use of "greener" raw materials is a major element in the development of green technologies. In many cases, this reference is to biobased materials. Using raw materials from renewable resources not only helps the sustainability profile of the products we offer to customers, but generally helps address the safety concerns of the end user. Lubrizol has developed and commercialized many polymers for coatings applications that contain up to 50% renewable carbon content, and this work continues. On the additives side, some products made of 100% green raw materials have been on the market for many years, and there is an increasing trend to use such additives for the formulation of greener coating systems.

Widheden, AkzoNobel: As the demand to reduce carbon-based raw materials intensifies, companies are not only looking at how they can reduce their consumption, but also how they can find appropriate replacements for fossil-fuel-based raw materials. There are a number of reasons why companies are starting to focus more on biobased alternatives at this time. Some renewable materials are becoming far more viable now and there are significant advantages for companies that are first to market with them. In addition, while recent oil price volatility has made the business case far more compelling for some renewables, we can't yet be sure that prices won't drop in the near future. But perhaps most significantly of all, any company that believes that it is at the forefront of sustainable development and wants to cut carbon across the full value chain needs to take this matter seriously.

At AkzoNobel, 13% of all our organic raw materials come from renewable (biobased) sources, which places the company among the industry leaders. To increase this level, we have created a strategy that focuses on working in partnership with selected companies in our value chain to make biobased products commercially viable. For example, in 2013 AkzoNobel and Solvay struck an innovative deal for the supply of renewable-based epichlorohydrin from 2013–2016. Under the deal, AkzoNobel will work to buy volumes of glycerine-based epichlorohydrin indirectly via the epoxy resins it purchases from Solvay's customers.

Watson, Dow: Formulators want paint to be more sustainable with respect to lower VOCs, less odor, and reduced energy intensity. Of course, these improvements must be delivered without negatively impacting performance or cost. As such, we see a continuing drive toward waterborne technologies in all segments. Additionally, technologies that can facilitate ultra-low VOCs are in particularly high demand as new regulations drive reformulation. Finally, given the cost volatility and energy intensity of TiO_2, technologies that facilitate similar or improved hiding at lower pigment levels are always welcomed by paint manufacturers. Dow has, for example, developed rheology modifiers that help eliminate the need for added solvent or surfactant for high-efficiency, easy-pouring HEUR thickeners that can facilitate ultra-low-VOC formulations.

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Vaughn, Emerald: Guided by market demands and tightening industry standards, Emerald has introduced more than 50 new products that are low- or zero VOC alternatives or 100% solids nonsolvent options, including foam control products, dispersions, coalescents, specialty epoxy resins, reactive liquid polymers, and modifiers. Emerald also incorporates bio-renewable raw materials when they bring performance and value, such as soy- and sugar-derived materials. However, some of the largest ingredients we consume directly or indirectly to synthesize our products—based on C3, C4, and aromatics—are not yet commercially available in bio-derived versions at the scale needed to serve the industry. Emerald continues to monitor ongoing developments to produce these other basic building blocks from renewable resources and evaluate performance of samples as they become available.

Tierney, Lonza: Regarding biocides, manufacturers are interested in lower sensitizing molecules and lower release of the active compounds into the environment. This interest is driven by both governmental regulations and nongovernmental organizations (NGOs) such as Greenshield in the United States. As an example, forthcoming classification and labeling of packaging (CLP) regulations in Europe will drive the need for enhanced activity of existing active compounds at the same or lower concentrations than are currently used. Further changes to the classification of certain actives will impact the choices made by downstream users. Use of formaldehyde and formaldehyde-release technologies will continue to come under increasing regulatory pressure as a result of these trends.

Saxena, Evonik: We are seeing continued growth in interest in low-VOC or waterborne chemistries, biobased resins, and organic pigments at the expense of older technologies. Heavy metals such as hexavalent chromium Cr (VI) and tin (IV) are either being phased out or the permissible amounts in formulations are being reduced.

Poerner, Heubach: Paint companies are more than ever interested in the sustainability of pigment products, from the standpoint of carbon footprint, efficient use of resources and energy, and other environmental issues. There is a growing demand for environmentally friendly, value-added products and solutions. For pigments, the highest performance possible includes chemical, temperature, and weather resistance and lightfastness, along with an extended color space and effects while maintaining or improving cost effectiveness. Recent examples from the Heubach Group include zinc-free anticorrosive pigment, VOC (EPA Method 24)-, APE-, and formaldehyde-free colorants for volumetric dispensing at point-of-sale, and pigment preparations that are alternatives to lead chromate.

Moncla, Celanese: To achieve VOC targets, many companies have already switched to vinyl acetate/ethylene (VAE) emulsions, which do not require a coalescent or co-solvent for film formation. In addition to being a pioneer in VAE chemistry, Celanese has introduced vinyl acrylic resins designed for low- to near-zero-VOC coatings. Furthermore, customers are looking at removing other chemicals such as APEO from their final products, and Celanese has responded by offering a line of emulsions that meet this market expectation.

CT: What are the key trends driving the development of specific greener formulated coating technologies?

Tierney, Lonza: Overall, it is generally one of a paint manufacturer's objectives to produce paints with lower emissions as well as longer-lasting performance to improve sustainability.

Watson, Dow: An important trend with more sustainably formulated coating technologies is making all the new "pieces of the puzzle" fit together. Inventing more sustainable raw materials is only the first step. Ultimately, a fully formulated final product that actually works must be produced. Collaboration between paint manufacturers and their suppliers is critical to achieve this goal.

At Dow, we have made substantial investments in high throughput technology in order to demonstrate that robust formulations can be developed with more sustainable raw materials. This investment has allowed Dow to reduce the product development cycle by at least a factor of five.

Functionality represents another trend in formulated coatings technologies. Consider our new acrylic binder that actively improves indoor air quality by abating formaldehyde from the air of homes and commercial buildings. We expect to see several technology breakthroughs in the functionality space in the coming decade.

Saxena, Evonik: Faster curing times at low temperature and without heavy toxic metals are now in favor. Reduction of waste, especially water, is also desired. Customers are willing to look at technologies that are greener as long as the performance is not compromised.

Fogg, BASF: We are seeing strong interest in biobased materials for formulated coatings.

Fuell, Reichhold: Contractors have historically preferred traditional solvent-based systems for ease of application and excellent performance properties, so developing an economical water-based coating without sacrificing performance is desirable. With our new alkyd latex platform, Reichhold has met and exceeded the needs of both contractors and consumers with high-performance waterborne systems that provide an environmentally friendly alternative to traditional solventborne and acrylic systems.

Kaiser, Arkema: There are, of course, trends around continued reduction of VOCs by product category, but there is also specific focus on the reduction or elimination of individual formulation components, such as APEO surfactants and formaldehyde contributors. Arkema Coating Resins offers a special self-certification program to formulators that clearly identifies products in our portfolio that are suitable for green formulating in a way that is consistent with the latest industry requirements, based on a clear set of specific factors outlined in the program.

Hardy, Axalta: Formulated coatings reflect a balance of properties that provide performance attributes along with workability latitude for customers. Greener formulated technologies add another variable to the coating manufacturer to help design systems that can deliver improved performance with fewer layers or with less energy needed during the application and curing of those layers. Waterborne coatings, powder coatings, and high solids/low-VOC coatings are among technologies that Axalta provides that help support sustainability goals. For OEMs, Axalta's solventborne and waterborne wet-on-wet systems along with the Eco Concept technology, where layers are consolidated by combining primer with basecoat, have demonstrated significant energy reduction, based on estimates. These coatings continue to evolve with improved appearance, color capability, and processing latitude. For the refinish markets, waterborne productivity systems such as Cromax® provide less material consumption through improved coverage. For industrial markets, lower-temperature curing systems can reduce energy consumption for commercial vehicles. Powder coatings provide virtually no VOC and targeted HAPs alternatives for customers that rely on powder brands.

Vaughn, Emerald: From a marketing perspective, we have seen that companies are really promoting their "greener" coatings products to the consumer—creating new brands and driving awareness of the more environmentally friendly alternatives on the market. We have also seen an increase in the use of waterborne alkyds. Alkyds can be entirely natural; there has been a lot of progress made in that area.

Kirby, Sherwin-Williams: Coating systems are developed to address existing requirements for emissions and regulations. The LEED certification and government contract business are examples of industries that drive this type of development. Coatings manufacturers can help their customers by balancing product look and performance with the specific environmental technology needs of OEMs worldwide. Programs such as ISO14001 also produce a "greener" overall manufacturing process.

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Widheden, AkzoNobel: The major sustainability trends include renewable raw materials, lower VOC, and waterborne systems, but also moving to systems that require less energy for curing in many applications, because this step is where much of the environmental impact occurs. These trends are driving coatings companies like AkzoNobel to produce sustainable innovations such as: coatings that can reduce surface heat gain from sunlight to help lower cooling costs, light-reflective coatings for brighter rooms and energy savings from lower-wattage lighting, more durable coatings for reduced maintenance and repaint cycles, laminated beam adhesive and appli-

cation equipment technology for optimized material use and bonding, and liquid paints that contain less solvents and powder coatings that contain no solvents at all.

CT: What are the major challenges to developing and implementing greener technologies for the coatings industry?

Poemer, Heubach: As previously mentioned, legislative requirements will continue to have a major impact on the "green" movement. SCAQMD in southern California, which currently has the toughest regulations in the United States regarding coatings emissions, will begin reviewing them, starting June 2014, to potentially enact even tougher ones. In the United States, TSCA reform is currently being considered in the House and the Senate. REACH legislation in Europe also continues to have a global impact and will strongly encourage raw material suppliers and paint companies (particularly global ones) to switch to safer alternatives

Tierney, Lonza: Specifically relating to biocide development, a key obstacle is the limited number of active molecules available to scientists due to the extremely high entry costs for new molecules. An additional consideration is that the overall paint formulation may become more susceptible to microbial contamination as some raw materials are substituted with natural-based ingredients.

Vaughn, Emerald: Coatings formulators have taken a number of different approaches to reformulating to lower VOCs, such as replacing harder polymers with lower MFFT alternatives and reducing or removing high-VOC ingredients, such as glycols and traditional high-VOC coalescents and solvents. In doing so, formulators have faced a number of performance challenges, such as microfoam, blocking, and poor freeze-thaw resistance, open time/dry time, tack, dirt pick-up, and scrub resistance properties. These properties thus must be optimized while still meeting goals for VOC content, which has been the focus of Emerald's product development efforts.

Widhaden, AkzoNobel: There are a number of challenges when developing greener technologies. For example, when looking at renewable/biobased raw materials, it is important to recognize that many renewable alternatives are often immature in their development and so struggle to compete commercially. Although often a temporary situation, this commercial bottleneck can stop many excellent projects from getting off the ground.

The availability of viable renewable alternatives is also a challenge. Despite significant media attention, biobased materials still only account for a very small proportion of the chemical industry's feedstocks. Thus the challenge is to find among the few that are available those materials that can offer the "win-win" of sustainability and economic competitiveness. Furthermore, they can be subject to some security of supply issues and price volatility.

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We have also faced challenges in implementing our VOC reduction projects in some parts of the world. Although we have increased growth in waterborne wall paint products in all regions globally, we are experiencing a slower transition to a low-VOC content portfolio in China, where consumer demand for low-VOC content products has historically been lower, with the market more favorable towards a product portfolio that is on average higher in VOC content.

Hardy, Axalta: Regulations that prohibit the use of various compounds will continue to challenge and drive innovation in the coatings industry. Finding replacements for these materials while still providing the balance of properties in a paint film have advanced fundamental understanding, particularly in the area of structure property relationships. Lower energy consuming products maintain a fine balance between application, high-glamour color capability, sag resistance, and appearance. Viscosity, atomization, and rheology control are fundamental to furthering the development of greener technologies.

Seyed-Sweet, Alberdingk Boley: While very often new greener raw materials bring opportunities for better manufacturing, sometimes they also create challenges for the manufacturing processes that often lead to higher raw material costs. Passing these costs on to formulators is not always possible.

Saxena, Evonik: Industry is slow in adapting to changes because of the long product qualification times and higher costs for greener raw materials. Many formulators look at only the cost of the raw materials, not the total cost of producing and applying the final product, which includes not just the raw materials, but also waste generation and disposal, application, and the active life of the product.

Kaiser, Arkema: Key issues include not only the technical challenges associated with obtaining equal or improved performance with new raw materials and formulation approaches, but also balancing this need with the need to maintain competitive economics. To be commercially viable, innovations in green formulating need to deliver performance at a formulated cost that is practical for the market. It can be challenging to gain market acceptance for green innovations that are technically interesting but expensive relative to current formulating approaches. As a supplier to the coatings market, we must always keep both the technical and cost control factors in mind in product design.

Watson, Dow: The key challenge in developing and implementing more sustainable technologies is finding the appropriate cost/benefit trade-off, especially during the early phases of commercialization. Of course, once economy of scale is reached, new technologies can effectively compete. However, the first few years inevitably involve higher costs. In these circumstances, breakthroughs in performance are a must. Otherwise, the market will not move in the absence of strict regulations.

Kirby, Sherwin-Williams: There are two primary challenges: the overall cost and acceptance of green technologies if no specification requires their use. Raw materials for green products typically cost a bit more, and that means that the end user must have a business incentive—such as a specification—to accept the higher cost, along with the environmental incentive.

Fogg, BASF: Although customers are interested in more sustainable solutions, i.e., low-VOC systems, they generally are not willing to pay more for them. The caveat is that if regulatory controls influence product selection to lower-VOC products, customers will adopt the technology, even with added cost.

CT: Where are improvements still needed with respect to advancing green technologies for the coatings industry—both across the supply chain and for products and processes?

Widheden, AkzoNobel: The coatings industry must continue to improve if it is to meet the needs of its customers and society at large. There is still a lot to do to minimize the environmental impact of coatings over their life cycle, but for many markets the incentive and pull is not there yet. On renewable raw materials, collaborations in the supply chain are needed to get supply reliability and to get the volumes up and the costs down. On the user side, providing better functionality through, for example, better durability or protective properties, as well as lowering the energy demand for curing and the spill in application, is where major improvements can still be made.

The challenge is to reduce the environmental footprint of products without compromising quality by moving to lower-VOC formulations, switching solvent-based products to water-based, working with suppliers to make raw materials less carbon intensive, expanding the use of renewable and recycled materials, and working with customers to develop better functionality.

Pourahmady, Lubrizol: Better collaboration throughout the coatings supply chain is needed to bring "greener" products into the market. Although the common goal is to create a greener coatings system for end users, the development activities throughout the supply chain are usually isolated and one-dimensional. Most activity is focused on finding a quick fix, such as solvents that are not regulated as VOCs or additives that are still acceptable for use, even though their safety profiles are under question. A coordinated effort from all actors throughout the supply chain is needed in order to combine material safety and process safety elements for the creation of the best cost-efficient, green solutions for coatings consumers.

Hardy, Axalta: Waterborne will continue to advance as a green technology and will benefit with improvements in engineering processes that will allow for wider workability latitude. Axalta's recent announcements to invest in China, Brazil, and Germany waterborne production capacity speak to our commitment to meeting this need. Engineering improvements such as Intellimist™, which controls moisture in refinish spray booths, expands workability in low-humidity regions for refinish body shops. Further engineering advances will continue to expand waterborne usage, particular in areas where current engineering controls are too costly.

Kirby, Sherwin-Williams: The main issue for the coatings industry is to further define what a greener coating system really is, and to establish a common set of specifications or criteria, such as how to calculate the reduced carbon footprint or sustainability. If we have a hard specification, products can be developed based on the specification data. If we talk in general terms, then it is difficult to know what type of product complies. It may vary for specific customers or global regions.

Moncla, Celanese: The establishment of broader industry guidelines and standards for green products is definitely needed. There is now a myriad of state and federal requirements for coatings in addition to a number of "voluntary" third-party certification systems. These systems require additional expense in both product development costs and actual fees for certification.

Vaughn, Emerald: Industry initiatives can also be beneficial for promoting proper handling at the end of the product life cycle, including proper disposal, and for initiating programs that facilitate recycling, which reduces waste. For example, the American Coatings

Association (ACA) created PaintCare®, a nonprofit 501(c)(3) organization, and worked with state and local government stakeholders to pass the first paint stewardship law in the United States in the state of Oregon in 2009. The new law, which provides for an industry-led program for the management of postconsumer (leftover) paint in Oregon, was made permanent in June 2013. To date, seven other states have passed similar laws, and ACA continues to work to increase the rate of adoption of PaintCare across the country.

Sayed-Sweet, Alberdingk Boley: In the United States, we are still conservative in upgrading our manufacturing equipment, but modular manufacturing technologies are very much the road to the future. The adoption of such technologies will help reduce space, time, and labor costs while simultaneously producing consistent, high-quality products.

Watson, Dow: Consistency of labeling and the development of industry standard test methods would be very helpful. At the moment, it can be difficult to determine if a product has truly improved environmental performance due the variations in labeling standards. In addition, claims can be difficult to substantiate or reproduce due to unique testing protocols. This issue applies to products and processes alike.

Saxena, Evonik: Faster qualification and testing for both equipment and methods is needed. The availability of biobased polymers in large quantities and fillers is also required. Nonmetallic corrosion inhibitors are also an area where improvements need to be made.

CT: What do you expect to see in terms of further advances in green technologies in coatings manufacturing (entire supply chain) in the near and longer terms?

Tierney, Lonza: Increased use of encapsulation technologies and creative delivery systems will help to optimize usage levels of critical raw materials.

Moncla, Celanese: Advances will continue in coating technologies that will allow progressively lower VOC content while leading to improved functional and aesthetic performance.

Vaughn, Emerald: Companies can do a lot to improve their own environmental footprints in terms of manufacturing. Emerald Performance Materials has made this goal a major focus, reducing emissions over 50% since the company was formed in 2006. Sustainability initiatives have included use of greener energy sources, such as biobased or cleaner gas versus coal sources, and more efficient methods for capturing and re-using waste streams. These initiatives have had a major impact on reducing air pollutants and providing cleaner effluent water. From a raw material ingredient standpoint, in addition to greater use of biobased raw materials, we expect greater scrutiny of VOCs and semi-VOCs, should the chamber test standard from LEED v4 and AgBB continue to be more widely embraced.

"Looking further into the future, we expect to see the widespread use of renewable/biobased raw materials across the industry and the emergence of a fully functioning new biobased industry."

Fogg, BASF: Customers want to differentiate themselves in the market and want new, innovative technologies/products/services to help them be successful. BASF is focused on creating chemistry for a sustainable future and on sustainable solutions for achieving improved environmental performance while addressing needs for zero- and low-VOC formulations, low-energy curing, replacement of heavy-metal pigments, and latexes with minimal environmental impact.

Widheden, AkzoNobel: In the future, products that offer tangible downstream benefits to customers will become more prevalent across the coatings industry. In due course, these products will actually start to positively impact the sustainable development of many important industries. Looking further into the future, we expect to see the widespread use of renewable/biobased raw materials across the industry and the emergence of a fully functioning new biobased industry. At AkzoNobel, we know that our future depends on our ability to do radically more while using less, and we are determined to turn this challenge into an opportunity and bring more value to our customers and society in general. We call this approach "Planet Possible"—it's our commitment to doing more with less.

Watson, Dow: Technologies will continue to deliver improved sustainable solutions and higher-performing paints. We will see new technologies that enable manufacturers to save energy, water, raw materials, and costs during paint formulation. We will also see an array of new functionalities, including pollution abatement. Overall, it is an incredibly exciting time to be in the paint and coatings industry!