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“China is the leading user of radiation-curing technology, and the industry is being affected by the government’s determination to clean up smog and reduce VOC emissions from manufacturers.”

Along with concerns about tin compounds and BPA, Rayle notes that there are regulations affecting the use of perchloroethylene in airplane manufacturing, and California’s new Safer Consumer Products law (also known as the California Green Chemistry Initiative) will impact the use of numerous chemicals in that state. In addition to the ingredients used in coating formulations, another major concern for users of UV-cured coatings is the upcoming European legislation on mercury, including the mercury in the UV lamps used for curing. The revised Restriction of Hazardous Substances (RoHS) directive does not apply to fixed installations through 2016, so a large part of coating operations will be exempt at least then, according to Harbourne. He notes that small lamps for nail varnishing (e.g., nail polish curing), will be subject to the requirements of the directive. After 2016, the automatic exemption for fixed equipment will no longer be in effect, and companies will need to apply for exemptions.

In Asia, China is the leading user of radiation-curing technology, and the industry is being affected by the government’s determination to clean up smog and reduce VOC emissions from manufacturing. In September 2013, the State Council released the Air Pollution Prevention and Treatment Action Plan to guide air pollution control in the coming years. One of the 10 measures in this policy deals specifically with VOC regulations. “Local governments have already started to pursue local implementation, including the closure of coating factories that do not meet standards. In response to these closures, the research and development teams of many companies are proactively researching UV and waterborne technologies with new vigor,” notes Taara Sourik, Asia Pacific marketing manager for coatings & digital media with Grace.

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markets served or global in reach, and thus it has become incumbent for Alimes to design products with the broadest regulatory acceptance possible," he notes. ""China is leading the user of radiation-curing technology, and the industry is being affected by the government's determination to clean up smog and reduce VOC emissions from manufacturers.'"

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In Asia, China is leading the user of radiation-curing technology, and the industry is being affected by the government's determination to clean up smog and reduce VOC emissions from manufacturers. In September 2013, the State Council released the Air Pollution Prevention and Treatment Action Plan, and is driven by a desire to cut manufacturing costs, improve overall manufacturing process efficiencies, and lower VOCs in compliance with local air quality regulations, according to De Wulf. He notes that the challenges are adhesion and overall cost of ownership against existing organic solvent and waterborne coating technologies. Sartomer has been working with customers to develop radiation-curable products for metal substrates and anticipates that there will be significant future interest for this application, according to Rayle.

Meanwhile, although the initial euphoria about field-applied radiation-cured coatings has subsided, ...
this market also holds great potential, according to Sweetwood. "Companies seem to have over-simplified this market because it seems straightforward, when in actuality field-applied coatings require precision, extensive process know-how, testing, etc. I do believe that it will eventually live up to its potential, though, most likely first in Europe, where the most progress has been made to date," he explains. De Wulf adds that Alives continues to support efforts to make this technology mainstream through new product introductions, general market education, specific customer support, and co-supplier interactions. Two new products from Alives use technology that indicates exposure to UV via a color change, thereby assisting the contractor in the accurate application and curing of the floor coating.

Another market segment within the packaging industry that is providing potential growth for radiation-cured coatings is flexible plastics, or filmic substrates. These materials are attractive because they allow for packaging in all types of shapes, are lighter in weight than rigid materials, and provide better protection if they are multi-walled, according to De Wulf. "Coatings are often applied to filmic substrates in order to homogenize the surface for better printability and can serve as barrier protection with a decorative function," he notes.

There are hurdles to the use of radiation-cured coatings for plastic packaging, however. De Wulf points out that as the demand for and usage of virgin and recycled plastics in consumer product packaging increases, the demand for low migration profiles remains with robust adhesion to filmic and rigid substrates also increases. "Finding raw material building blocks and resin systems that promote adhesion to nonporous plastics while complying with regulatory requirements for indirect food contact is a constant challenge," he observes. Roelands adds that ensuring proper adhesion to a variety of substrates is also a key and requires technological advancements, some of which have been achieved and are already driving the use of radiation-curable coatings on metals and plastics. Alives recently launched several oligo-metatic systems that promote adhesion to plastic for flexo and litho applications with supporting toxicity and migration test data.

With UV-cured coatings for glass substrates, the use of radiation-cured coatings to color glass beer bottles is increasing in popularity. This approach enables beverage bottlers to produce colored bottles without having to incorporate any pigment in the glass, which makes it much easier to recycle the glass. The wide range of color concentrations of the coatings means that the bottles are easily recyclable. This approach enables beverage bottlers to produce colored bottles without having to incorporate any pigment in the glass, which makes it much easier to recycle the glass.

DEVELOPMENTS IN LED CURING

The area with the most active development efforts appears to be LED curing, however, and there are vigorous efforts to develop UV LED technology to replace Hg lamps, according to Hesen. UV LED lamps are becoming more popular due to their reduced cost of ownership, less operating costs, lower cost of operation, and the ability to use the same type of resin as Hg lamps. LED curing systems are being developed for a wide range of applications, from electronics to woodworking. LED curing systems are also being developed for use in the medical industry, where they are being used for applications such as dental curing and medical imaging.

INVESTING IN THE FUTURE OF RADIATION CURING

The complexity of radiation curing in general must continually be addressed, according to Harbourne. "This technology appears to be simple on the surface, but it is in fact complicated, and a greater understanding of the curing process is needed in order to enable the development of this market need," he says. There are still issues to be addressed with LED curing, however. Both the LED lamps and formulations for LED curing are quite expensive, according to De Wulf. "Developing short wave UV range LED systems with enough power is therefore a key goal," Hesen notes. Allied also runs into challenges with 3D applications where it is not possible to get the LED lamp close enough to the part to maintain the proper distance.

In addition to the transition to LED lamps is influencing coatings formulations. First, as long as LED lamps cannot achieve the same wavelengths required for good surface cure (lower energy transferred to the coating), the more reactive monomers (as opposed to mono-functional) will be required, which generally translates to increased cost of the coating formula, according to Strunk. She also notes that the specific UV wavelengths emitted require careful selection of more expensive photoinitiators that are able to absorb at these wavelengths and thus ensure good cure. "For these reasons," adds Raye, "suppliers need to understand and prepare for the trend toward LED curing". In 2014, Alives is launching a unique co-resin for low-intensity UV-curing formulations that enable easy-to-formulate coatings that mitigate oxygen inhibition, according to De Wulf. "When used as a co-resin, this new resin transforms UV-curable formulations into UV LED-curable formulations that provide back-face surfaces with performance similar to coatings cured with higher-intensity UV light. Based on new chemistries that maximize cure response, this UV LED transformer has low viscosity, low color, and good stability," he states.
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forts appears to be LED curing, however, and there
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to replace HG lamps, according to Hasen. UV LED
lamps are becoming more popular due to lower
operating costs, lack of ozone generation, and
longer wavelength emission spectra versus stan-
dard mercury lamps. In addition, UV LED lamps are
considered to be more environmentally friendly and
can be used for curing UV-sensitive materi-
als. They also result in less heat development in the
substrate, so heat-sensitive materials can be
coated using LED lamps. The longer lifetimes of
LED bulbs and the fact that LED lamps do not
contain mercury are further advantages of the
technology, particularly considering the European
RoHS Directive discussed previously. "We continue
to see a growing interest in LED curing, particularly
with customers that are repairing their UV cur-
ing equipment," says Sweetwood. "It's fair to say
that the LED companies are doing a terrific job of
marketing LED curing, and we recently completed
some in-house testing that confirmed that the tech-
nology has continued to improve," he continues.
UV LED technology, according to Harfoxe, has
indeed moved from the introduction phase, through
which it struggled over the last three to four years,
to the adoption phase. "Our customers are looking
to evaluate UV LED systems now, so Hereaus Fusion
UV has introduced a UV LED-curing platform in re-

investing in the future of radiation curing

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There are still issues to be addressed with
LED curing, however. Both the LED lamps and
formulations for LED curing are quite
effective, according to Harboe, but their
prices are coming down with time. There is also
a lack of short wave
length emissions from LED lamps, which can result
in oxygen inhibition that leads to reduced coating
properties or uncured, tacky surfaces, according to
De Wulf. "Developing short wave (UV range) LED
systems with enough power is therefore a key goal,"
Hasen notes. Allied also runs into challenges with 3D
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new solutions," he asserts. Achieving that goal will require collaboration across the value chain, says Roelands. "It is clear that resin and coating manufacturers alone cannot drive the required technology advances. Radiation-curing coating equipment and lamp manufacturers will also play a crucial role in responding to the key trends driving the market," he states. "DSM does believe that through such collaborations, the industry will be able to deliver the technological advances required to continue to widen the use of radiation-cured coatings and ensure strong global growth in the years to come," he continues. Sweetwood agrees: "We have always believed that choosing the right partners is a critical piece of our business, and includes raw material suppliers, equipment integrators, and even (sometimes) customers. We are so much better when we team with companies that allow us to stick to our strengths and at the same time by leveraging a partner’s expertise. I think it’s one of the keys to doing business in this era."

To extend its portfolio range and in response to various market trends, Allnex acquired the nonwaterborne Desmolux® (a Bayer trademark) radiation-curing resins business of Bayer MaterialScience in 2013 and moved its Americas headquarters to state-of-the-art facilities in Alpharetta, GA, with a significantly larger radcure applications lab and enhanced capability for joint customer and co-supplier development projects in 2014.

"DSM also has a clear commitment to strengthen the technology for radiation-curable coatings, because it is one of the key sustainable coating technologies, next to water- and powder-based technologies," according to Roelands. To this end, the company has invested in a new facility for the production of a variety of classes of radiation-curable resins and monomers that is operated under its DSM-AG I joint venture. DSM is also developing new easy-to-matte coatings, formulations that provide steel wool resistancy, those that are suitable for vacuum metallization, waterborne UV systems, and field-applied radiation-curable coatings.

Sartomer believes that the future is bright for radiation-cured coatings. "This technology is still in the early stages of adoption for advanced coatings, and we expect continued growth, especially for sustainable chemistries that provide more environmentally friendly solutions at a cost equal to or near that of traditional solutions," says Rayle.