UV curing technology has made tremendous strides in the last century -- from the first commercial successes in the 1960s to today where we find applications such as overprint varnishes in the graphic arts industry, medical product assembly, optical fiber coating and CD/DVD production where UV curing is considered the norm. With only 3% to 4% of all coatings being UV cured, we still have far to go, and many opportunities lie before us in the next century. As we enter the new millennium, it is important to take a look at the challenges UV curing technology faces, from an equipment and process perspective, and the likely advances that will be made. This understanding can lead to new insights and greater success for the UV curing industry in the next millennium.

Macro Trends

To better understand future customer needs and project future advances and impediments to overcome, it is helpful to look at the external trends affecting every business today. First and foremost is that we live in a global economy. This means that what happens to Asia's economy affects others, that the workforce is more diverse and that more economies are "opening up." We've already seen consolidations among raw materials suppliers and formulators. Will we see continued consolidation of the equipment manufacturers or among equipment manufacturers and raw materials or formulating companies? Increasingly, companies will have to have a global presence to be players in this global economy. Equipment manufacturers will have to make their equipment easier to use for a more diverse work force. Information must be available in any language, and system graphical user interfaces will have universally understood symbols. As economies such as Russia and China embrace the power and flexibility of UV curing, it will provide tremendous new opportunities for growing UV curing, even in market segments that currently may be mature in Europe, Japan or the United States.

Another trend is a worldwide prioritization of cleaning up the environment. Just as the United States is cleaning up its environment through stricter legislation and with increasing consumer demand for "green" products, this "green" trend will migrate throughout the world. In the next century we are likely to see more strict environmental requirements in Eastern European countries and South America among others. This bodes well for the growth of UV curing technology because it is a clean technology that can often seamlessly replace a "dirty" process as customers are faced with stiffer environmental regulations.

Mass customization is another major trend that will affect our customers and, as a result, affect us. Mass customization means creating individual solutions on a mass scale instead of the mass market/mass production concept of the 20th century. A good example is Dell Computer, which sells millions of personal computers, each one customized to the consumer's specifications. We may need to create flexible UV curing systems that allow customers to quickly and easily change their production lines daily or even hourly, or perhaps systems that are smaller scale for decentralized/small batch runs.

Finally, as we near the end of this century we have transitioned from the industrial age to the early stages of the information age, a trend that will continue to mature far into the next century. Will this result in more Internet publications, less printed materials and thus less UV-cured printed materials? Perhaps, but don't forget all the unforeseen applications that may result because of the information age. Who would have thought about the optical fiber market in the early part of this century, and yet this has become a market dominated by UV curing. Who would have thought of coatings for cell phones when cell phones didn't exist? UV curing likely will enable new products to be brought to market in the information age of the coming millennium.

UV Curing Equipment Trends

Of course, it is always dangerous to forecast the future. In 1981, Bill Gates was quoted as saying, "640K ought to be enough for anybody." At the risk of putting myself in a similar position, I'll discuss some trends and forecast some directions I think equipment improvements will take in the next century.

Much like the software industry, where hardware manufacturers need software that runs on their machines and the software manufacturers need machines that will run their software, UV curing industry suppliers will need to work jointly to create successful customer solutions. Formulators cannot sell their products if there is no lamp that will cure their formulation, and lamp manufacturers cannot sell lamps if there is no formulation to cure. A team approach to process design will serve future...
customer interests and do much to further the growth of UV curing. Lamp manufacturers working closely with original equipment manufacturers will ensure an integrated approach to the process design and more successful applications. In the future we'll see even more collaboration, strategic alliances and formal agreements among suppliers as a way to gain market dominance, especially in the more mature market segments.

There will be an overall trend to produce UV curing equipment that is easy to use, maintain and operate to meet customer needs—for example, tool-free changeouts, quick disconnects and reduced preventive maintenance requirements. UV curing equipment will get smaller and larger—smaller so that it can fit into smaller spaces in machines and presses, a need of original equipment manufacturers. We may even see portable or hand-held UV curing equipment that is small and lightweight so it can be used safely "free hand" on a shop floor or on job sites. Larger UV curing systems will be needed for wider web presses, for curing large 3-D parts and for accommodating banks of lamps to increase production speeds. More equipment will incorporate smart controls that free the operator from having to worry about the UV curing system and instead focus on the product. For example, remote diagnostics will be tied into automatic replacement parts ordering systems and alert users or even fix problems before they stop production. Eventually, improvements in analytical instrumentation and radiometry will lead to continuous monitoring of cure capabilities and enable better diagnostics resulting in higher product quality.

We will continue to see higher-intensity UV light sources with improvements in maintaining constant output over the life of the lamp. There will be an increased use of excimer (narrow band wavelength) that will be synergistic with new families of photoinitiators. This is being driven by the need to efficiently deliver maximum intensity for faster, deeper curing of pigmented and white coatings. Lamps will be introduced that are precisely tuned to match the spectral requirements of photoinitiators. All of this leads to the design of UV curing systems that are more efficient, using an optimized amount of lamps and cure materials to reduce product costs without compromising product quality.

Better heat management methods will be introduced, perhaps through reduced lamp IR output, better lamp cooling techniques or other new, innovative methods. More sophisticated reflector systems will be developed for better cooling, more efficiently delivering light intensity without the associated infrared.

Impediments to Overcome

A lack of technical and commercial knowledge of UV curing, especially among end users, is a major impediment to the future growth during the next century. In many market segments, UV curing is still viewed as an experimental technology, not a proven technology. Through RadTech International North America, the UV-curing industry has really pulled together as a team, putting competitive interests aside, to increase
Awareness of the benefits of UV curing. The successful introduction of commercial UV powder curing applications in just the last year is an excellent example. Many customers are not always willing to share their successful UV curing stories. After all, they have proprietary processes that incorporate UV curing giving them a significant competitive advantage in their markets. When appropriate, we all must find ways to spread the word about successful applications, especially in new markets, if we are to grow UV curing in the next century.

Closely tied to this lack of knowledge are misunderstandings or preconceived notions about UV curing that must be overcome. For example, customers have reported in Ken Lawson's (president, DSM Desotech and past secretary of RadTech International North America) surveys that UV coatings have poor adhesion to a wide range of substrates. While we would all agree that some substrates are more challenging than others, I think most of us would also agree that UV curing is being successfully applied on a wider variety of substrates. Again, this gets back to the need for industry suppliers to work closely together to find process solutions for customers. With today's higher molecular weight chemistries and cationic curing, a joint effort by industry suppliers usually can meet most customers' needs, no matter what challenges the substrate presents. With the right combination of chemistry, UV light intensity and spectrum, many substrates will accept a UV-cured coating with excellent adhesion.

Certain customers occasionally comment that both equipment and curable products cost too much. Most customers compare the cost of chemicals per gallon or the initial purchase price of the integrated UV equipment. Again, industry suppliers must work jointly to share information and create cost models that focus customers on the bigger picture that affects their bottom lines: the production cost per unit of product. UV curing typically increases product throughput rates, reduces labor, floor space, work in process inventory and energy use. All of these and other factors that affect production costs must be included in accurate cost evaluation for UV curing. RadTech's UV Powder Coating Focus Group has created such a cost model that debuted at the RadTech 2000 conference in April. Additional cost models will be needed for other applications and markets. It is up to each of us to guide customers we talk to and assist them in their analysis.

Conclusion

VOCs often remain the driver, with value-added processes the frequent result. Improved understanding of cure parameters, through better radiometry and tests for "cure," and stronger alliances with process solution providers will ensure continued growth for UV-curing technology well into the next century. We must be less enchanted with the technology itself and instead put more focus on fulfilling customer needs.

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