PMT Packaging Machinery Technology

NOVACENTRIX

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NANOTECHNOLOGY: SMALL BUT MIGHTY

ALTHOUGH CONCEPTUALIZED DECADES AGO, NANOTECHNOLOGY AS A PHYSICAL SCIENCE IS ONLY NOW GAINING A FOOTHOLD IN THE PACKAGING MATERIALS MARKET, USING EXISTING PACKAGING MACHINERY.

BY MARY ANN FALKMAN

Nanotechnology is the science of miniaturizing materials almost to the atomic scale. When reduced to the nano scale, the characteristics and performance of materials may radically alter often providing benefits heretofore impossible to achieve.

Several commercial applications using nanomaterials with existing packaging machinery are currently in use. In terms of packaging applications, nanoparticles can offer a lighter-than-air barrier layer to films and plastic bottles. Nano-sized filaments of silver can provide conductivity for radio frequency identification (RFID) and track-and-trace.

Unfortunately, however, nanotechnology has not lived up to its much-hyped potential . . . yet. Additionally, before nanotechnology can be adapted to food-contact packaging applications, the science faces a long uphill struggle through the regulatory pipeline.

So what is this emerging science? A nanometer is one billionth of a meter, which means that nano scale is larger than atomic scale, by a factor of ten times, but still the smallest level at which something can be created, or recreated, like the science fiction Star Trek Replicator. Nanoparticles could be added to medicines, which could then be aimed with pinpoint accuracy at a target, such as a tumor or the heart. Nano-sized nutrients could become ingredients in functional foods, again aiming the nutrients at a specific area of the body where they would do the most good.

Some nanocomposites have the ability to destroy pathogens in film-packaged foods, or the sensory ability to detect when a food product has passed the point of safety for human consumption. In packaging materials, nanocomposite additives can increase the barrier to gases, improve clarity, add strength and improve resistance to temperature extremes.

Nanocomposite technology is a young material science, and plastic nanocomposites are among its first commercial applications. Nanocomposite products improve barrier permeability, flame resistance, thermal and structural properties of many plastics. They are not only used to improve existing plastics, but also are extending their reach into areas formerly dominated by metal, glass and wood.

While much of this sounds hard to believe, the reality is that some nanotechnology has been commercially viable for several years now. Consumers probably don't know, for example, that their PET (polyethylene terephthalate) beer bottle or carbonated soft drink bottle has a barrier layer of clay nanoparticles to increase shelf life. This is because, to a surprising extent, the identity of commercial applications of nanotechnology remains veiled in anonymity.

The applications are very real, indeed, as the following examples will attest.

INKS' SILVER STANDARD

One manufacturer that is producing commercial nanomaterials is NovaCentrix, Austin, Texas. At the present time, NovaCentrix is focusing on two key product families related to packaging.

According to Stan Farnsworth, vice president marketing, NovaCentrix is leveraging its nanoparticle synthesizing and formulation expertise in the Metalon™ electrically conductive inks products, which can be printed on paper and plastic materials using traditional printing technologies. The first Metalon product from NovaCentrix is a silver-based ink for ink-jet printing which is capable of attaining resistivities of less than 10x bulk silver. (The resistivity of a material is a measurement of its opposition to an electric current.) This ink is optimized for application on paper materials. Applications for the packaging industry include providing the materials for printing functional patterns such as unique RFID tags, sensors or security devices on each item as part of the normal printing for the item's graphics and labeling. The ink is formulated to be interchangeable with traditional graphical inks on traditional graphical ink-jet printers. In this way, the existing equipment can be used to provide new functionality, thereby gaining new value and competitive advantage for the printers and packagers.

The second product family from NovaCentrix is the PulseForge™ line of advanced conductive ink curing tools, explains Farnsworth. These tools are designed to sinter metal-based inks in milliseconds on low-temperature substrates such as paper and plastic film. The tools are not ovens or traditional UV lamp curing systems. Instead, they are based on proprietary lamp technologies designed by NovaCentrix to near instantaneously heat the inks to their sintering temperature without damaging the fragile materials on which the inks are printed. PulseForge tools are capable of processing Metalon inks from NovaCentrix, or any metal-based conductive ink from other ink suppliers, which have metal fillers from nanoparticle-sized all the way up to traditional flake sizes. "Because the process is designed to be effective specifically with paper and plastic films, it is a natural fit for the packaging industry, which is seeking new technologies and tools for increasing packaging performance and value," says Farnsworth.

Users can apply the PulseForge tools to develop and manufacture new on-package sensors, tracing tags or security measures. The functional features can be printed using traditional techniques and conductive inks, then cured with the PulseForge tools to attain the needed conductive performance. "By utilizing PulseForge tools as part of the printing process, users can significantly improve the conductive performance of metal inks without using ovens, either allowing new applications or by removing cost from existing applications," explains Farnsworth.

NovaCentrix has two PulseForge models on the market currently. The PulseForge 1100 is a process development tool for testing new inks and substrate combinations, for applications development in on-package or on-label tags, sensors and security measures. The 1100 has a broad processing window for delivering configurable energy pulses to determine the correct pulse configuration for any specific ink/substrate combination. Factors that can affect the required pulse configuration are ink thickness, ink formulation, substrate material and substrate thickness. The PulseForge 3100 is a new model, designed for applying the pulse technology to manufacturing systems. The 3100 sinters the pre-printed inks in roll-to-roll processing environments, at line speeds of greater than 150 feet per minute. The 3100 can be integrated directly into the client's existing print line or web handling system and enables that existing equipment to be used for printing functional components.

NovaCentrix is working with a number of progressive companies in the packaging space, says Farnsworth, supporting clients in developing advanced packaging technologies on paper and plastic media and taking those to market. Often these new packaging approaches, such as those based on nanotechnology, can appeal to premium packaging consumers, or add new value to mid-tier consumers and maintain or grow market share. By providing the Metalon inks and the PulseForge processing tools, NovaCentrix can work with these companies to strengthen their competitive advantage and their market position.

HP Specialty Printing Systems, San Diego, Calif., is currently using conductive inks for a variety of purposes, "anywhere conductive or metallic ink can make a difference—RFID antennae; passive metallic tags, interrogable via radar, terahertz or other readers; decorative metallic; conductive traces on lotto tickets and smart labels; membrane switches and scratch-off cards," explains Steve Simske, principal scientist for security printing and imaging in the Print Production Automation Lab in HP Labs, Palo Alto, Calif. All of the applications he cites are currently in commercial use.

"With thermal ink-jet inks, variable data printing (VDP) is enabled," he says. "This is essential for customized and security printing applications, in which each printed material is different—e.g., has a different bar code, number or identifier. Regular ink-jet equipment can be used. Some alterations may be necessary to reduce drooling, since excess ink, being conductive, could short-circuit the printer." The printer can be changed back to normal mode simply by swapping cartridges.

Are there any precautions for the operators in the plant? According to Simske, "Toxicology and environmental issues around many nanoinks—silver and carbon nanotubule, for example—have not been fully worked out. In general, the inks should be treated with the same care as other potentially non-salubrious inks, like UV-curable inks."

NovaCentrix-PCS1100's can use PulseForge tools to develop new security measures.

CLAY COMPOSITES

In a much different application, nanocomposites are currently in use as barriers within plastic containers. Nanocor, Arlington Heights, Ill., is a relatively new operating subsidiary of AMCOL International Corporation. The company is the largest global supplier of nanoclays specifically designed for plastic nanocomposites. Over the past decade, Nanocor has developed patented technologies for producing nanoscale clays suitable for incorporation into plastics and technologies for making nanocomposites themselves. Commercial nanoclay production began in 1998; today, the company offers a variety of products under the Nanomer® trademark.

According to the company, their customers' applications are as varied as plastics themselves, and they potentially intersect a multitude of products used by consumers and the industry every day. Nanocor sells its clay products to resin producers, compounders and product fabricators. One of Nanocor's main focuses is food packaging.

Tie Lan, technical director, explains that the nanoclay additives increase the barrier of the base resin in the range of 50 percent to 500 percent, depending upon the resin and the processing. The Imperm product line, designed for multilayer rigid containers and flexible packaging films, is a modified nylon MXD6, co-developed in collaboration with Mitsubishi Gas Chemical, New York, N.Y. Nanocor also worked with Honeywell Specialty Polymers, Morris Township, N.J., to develop a nanocomposite barrier resin based on nylon-6. Lan says that multilayer bottles and films are currently in the commercial marketplace. The nanocomposite packages reportedly run on existing packaging machinery.

Lan reports that packages now under development for future commercialization include Meals Ready to Eat (MRE), PET food packaging and retort packages.

Both Honeywell and Mitsubishi are using Nanocor's clay composites as barrier layers in nylon for multilayer PET bottles and films for food packaging. MGC's MXD6 nylon is being used for beer and other alcoholic beverages. Other applications include multilayer thermoformed containers for deli meats and cheese. Honeywell's Aegis line of nylon 6 nanocomposites was originally aimed at beer bottles. In late 2003, the Aegis barrier packaging debuted with a 1.6-liter Hite Pitcher bottle from the Hite Brewery Co., Seoul, South Korea.

The U.S. military and NASA, working under a grant with Triton Systems Inc., Chelmsford, Mass., have experimented with nanoclay as a barrier enhancer for EVOH (ethylene vinyl alcohol) in long-shelf-life MRE packaging. The material supposedly provides a three- to five-year shelf life without refrigeration.

According to Steve Zagarola, founder of The ZDM Group, Portland, Ore., and a former consultant to the blow molding market, the nanoclay particles boost the barrier properties in the resin but do not alter the blow molding or multilayer injection molding process. "Every situation probably demands its own individual configuration to optimize the blow molding operation," he says. The nanoclay allows the amount of barrier plastic to be reduced, which in addition to increasing barrier, also reduces material costs. Zagarola says his group worked with Nanocor to examine the feasibility of adding nanoclays to plastic resins other than PET, but no commercial uses were realized yet.

A LONG ROAD TO TRAVEL

According to the Helmut Kaiser Consultancy, Tübingen, Germany, in the next decade, nanotechnology will impact 25 percent of the food-packaging market, which is currently estimated at $100 billion. Whether that happens, and how quickly it might transpire, will depend to a large extent on nanotechnology passing muster through the regulatory regime (see page 80). Because nanotechnology is such a new science, there is no track record on long-term safety to humans. While the greatest concerns will focus on nanoparticles ingested in medicines and foods, packaging will surely not slip through unnoticed.

Mary Ann Falkman has been covering the packaging industry for nearly 15 years. She currently resides outside Chicago, Ill.

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