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Xerox's Emulsion Aggregation Toner – An Environmentally Friendly Technology

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Introduction:

Xerox's Emulsion Aggregation (EA) Toner Technology represents a breakthrough in the chemistry and chemical processing of preparing toner materials. It is a unique, environmentally friendly technology that allows customers to print in color more accurately and affordably. There are over 400 patents protecting this Xerox innovation.

The conventional method of making toners is based on a mechanical process that uses a top-down approach of physically grinding composite polymeric materials to micron-sized particles. The EA technology utilizes sophisticated chemical design and control based nanotechnology methodology to generate micron-sized particles in a bottoms-up approach from nanoscale components. Key advantages of EA technology are the ability to control the size, shape, and structure of the particles, leading to improved print quality, less toner usage, less toner waste and lower energy usage for manufacturing toner and using it in printing. This new technology enables production of toner using 25-35 percent less energy/lb of toner. Combined with 40-50 percent less toner needed during printing, EA technology offers an estimated 60-70 percent energy saving per printed page. EA technology produces less waste and enables longer life machine parts. EA is a water based process which is an environmentally friendly process.

The Challenge:

On a computer screen, smaller pixels produce sharper pictures. It's the same with the toner used to form the images printed on a laser printer or copier: smaller particles mean sharper images – plus less toner usage.

But as toner particles become smaller, the cost of making them by conventional technology rises exponentially. Several years ago, Xerox Corporation researchers realized that toner made by their current technology had just about reached the lower limit in size to be cost effective, and they started looking for a new way to make it.

Toner is the "dry ink" for laser printers and copiers. It's a mixture of plastic resin, colorant and other toner ingredients. Today, most toner is made by "melt mixing" the ingredients into strands that are pulverized into small particles - a process that is both inexact and energy intensive. Because the particles are smashed at random, their size cannot be precisely controlled. Some are too big and others

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too fine, so they are mechanically sorted to achieve required toner size and size distribution. It's like sifting dust. This method produces toner with average size greater than 7 microns in diameter; making it smaller is not economically practical.

Technology Development:

The Emulsion Aggregation Toner Technology (EA) developed by the Xerox Research Centre of Canada and its Xerox partners (in Webster, NY and Japan) represents the needed breakthrough in the chemistry and chemical processing of preparing toner materials to solve this challenge. The EA technology utilizes sophisticated chemical design and control based on nanotechnology methodology to generate micron-sized particles in a bottoms-up approach from nanoscale components.

In the development of this technology, the team was faced with significant chemistry and chemical engineering challenges. The process begins with emulsion polymerization to generate nanometer scale polymer particles in water. Although emulsion polymerization is a method that has been known for many years, the particular application to toner required research far outside the ranges normally explored and used in most applications. Much lower molecular weights were required as well as the incorporation of critical components to enable the controlled aggregation of these latex particles with pigment particles in the second step of the process. A novel approach using semi-continuous emulsion polymerization was developed to specifically design lower molecular weight polymers. In addition, the polymer resin properties and functionality had to be carefully designed to enable functional performance in the xerographic steps of development and fusing.

The second step of the process is the aggregation and coalescence of the latex particles with pigment and wax particles to generate the micron size toner particles in water. Understanding the kinetics of particle aggregation was critical to control of the particle size/size distribution. Breakthroughs have been made in identifying the reagents and conditions that yield the best control of particle aggregation and precision structure design.

From an engineering perspective, the invention and development of the complex aggregation/coalescence process entailed the simultaneous control of diffusion, electrostatic and mechanical shear characteristics of a highly heterogeneous system comprised of nano-sized polymeric and pigment particles. The presence of a third low molecular weight component with drastically different visco-elastic properties required a very rigorous control of the heat transfer characteristics of the system. The scale-up of the process involved the severe challenge of maintaining kinematic, dynamic and chemical similarities across all process steps

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in this highly complex system.

The key advantages of the EA technology are the ability to control the size, shape, and structure of the particles (Figure 1). The process can make round or potato-shaped toner particles anywhere from 3-10 microns in diameter (it would take 100 of them to make the period at the end of this sentence). The process is water-based and avoids the use of organic solvents commonly used to make particles in this size range. There are over 400 patents protecting this Xerox innovation.

Benefits:

EA is a unique, environmentally friendly technology that allows customers to print in color more accurately and affordably.

Xerox first introduced this new technology in 2002 in its DocuColor 1632/2240 color copier/printers. As of early 2006, other Xerox products using EA include: Xerox CopyCentre C2128/C2636/C3545 copiers and WorkCentre Pro 2128/2636/3545 multifunction systems (Figure 2). Having proven its effectiveness both commercially and environmentally, EA technology will be rolled out in many other products in the future.

In June 2005, Xerox announced plans to build a second EA toner plant on the company's 1,100-acre campus in Webster, N.Y., a suburb of Rochester. The 100,000-square-foot facility represents a $59 million investment for Xerox, including about $20 million for the plant. It is scheduled for completion in the fall of 2007. A key design goal for the plant has been to take energy out of the process everywhere possible. To meet that goal the design for the building and the manufacturing process were integrated from the start. The result is an "intelligent building," packed with sensors and organized into multiple zones that can be separately controlled for most efficient operation.

The key advantages of the EA technology are the ability to control the size, shape, and structure of the particles, which leads to improved print quality, less toner usage, less toner waste and lower energy usage for manufacturing toner and using it in printing. EA technology offers an estimated 60-70 percent energy saving per printed page and less greenhouse gas generation compared to conventional toner. In addition, EA technology produces less waste and is a water based process which is an environmentally friendly process.

- Environmentally Friendly Technology
    - The EA manufacturing process requires approximately 25 percent less energy per pound of toner and generates less waste compared to the conventional method of manufacturing toner.

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- The smaller toner size leads to 40-50 percent less toner per printed page. One hundred grams of conventional toner are needed to produce 1000 prints. With EA Toner, only 50-60 grams per 1000 prints are needed.

- Taken together – the lower energy to manufacture and the lower mass per page -- EA technology requires 60-70 percent less energy/page for printing. EA technology is a key plank in Xerox's pledge to cut greenhouse gas emissions. Xerox has committed to reduce its greenhouse gas emissions by 10 percent from the baseline year 2002 to the end of 2012.

- By eliminating fuser oil, EA technology conserves resources while improving customer satisfaction by eliminating potential service calls for oil streaks.

- EA toner reduces the amount of energy associated with printing in other ways. The greater latitude in resin design enables image fixing capability at lower temperatures, thus further reducing per-page product energy consumption. EA enables the use of lower melt resins since brittle materials are not required in the fabrication process. This translates into less energy to print since the temperature of the fusing subsystem can be reduced.

- The more uniform size and smooth shape of the toner ensures better performance in the print engine, resulting in significantly less toner waste in the machine and its lower mass results in less waste when the image is discarded.

• Performance/Customer Satisfaction

- EA Toner's small particle size, circular shape and narrow size particle distribution improves document quality by providing advanced image resolution and better image homogeny, as well as improved printer reliability, decreased machine downtime and reduction of overall costs.

- The life and reliability of the fusing subsystem is improved by using EA Toner. The EA process has enabled the use of lower melt/non-brittle resins. As a result, the fuser roll temperature can be reduced, thereby increasing the life of the machine. This also leads to longer fuser life meaning fewer replacements and fewer parts for disposal.

- Most laser printers require a unit that delivers oil to heated rollers that

fuse the toner to the paper. The ability to incorporate wax and control its location within the toner particles using the EA technology enables oil-less fusing. The elimination of the oil offers cost advantages and improves the overall quality of the printed image. This simpler system leads to fewer parts and less possibility for part replacement and disposal.

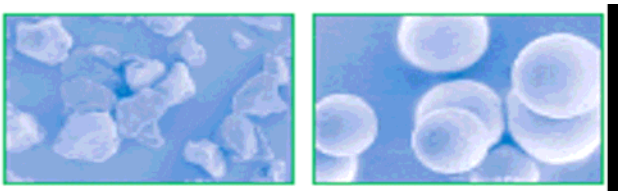

Figure1. Microscopic views show the rough edges of conventional toner (left) and the smooth shape of chemically grown EA toner.

Figure 2. The latest Xerox products to use EA toners include the Xerox CopyCentre C123/C128 copiers, the WorkCentre M123/M128 (above) and the WorkCentre Proc 123/128 multifunction system

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