# Cleaning Up The Environment Faster And More Cost Effectively

Lehigh University

## Tiny, ultrafine particles of pure iron are making a big difference in aiding environmental cleanup and helping make the world a better place.

This critical progress in environmental restoration is due to technology that was pioneered and invented at Lehigh University, Bethlehem, Pa. Huge rewards sometimes come in tiny shapes and sizes, and Lehigh Nanotech LLC, which produces the nanoscale particles, is making that happen. It only takes six ounces of the tiny nanomaterials, versus a ton of larger compounds, to make sweeping changes in cleaning up contaminated environments.

This revolutionary breakthrough in nanotechnology is helping clean up hazardous waste sites and toxic industrial sites faster and more economically than ever before.

Throughout the United States numerous industrial sites have toxic contaminants in the soil and groundwater. And while environmental remediation is a logical solution to improving the environment, cleanup is often extremely costly and exceedingly time consuming. It can take many years to transform the environment from a previously unusable site to one that is free of contaminants.

Technology invented at Lehigh University is successfully cleaning up a wide range of soil and groundwater sites with toxic materials, heavy metals, fertilizers and pesticides in about a tenth of the time of typical environmental remediation.

This is how the technology, using nanoparticles comprised of pure iron, works to clean up contaminated sites. The particles are so small they remain suspended in water. When they are injected into contaminated groundwater, the iron reacts with contaminants. Paul Osimo, who has more than 25 years of experience in the environmental field as both a consultant and a client, and serves as vice president of the new company, explains, "The complex molecules of chlorinated hydrocarbons, such as industrial degreasers and chemical solvents are broken apart into simple, non-toxic compounds and the iron combines with oxygen and turns to rust. The quantity of iron injected is relatively small compared to the amount of iron which occurs naturally in soils."

Since environmental remediation has a history of arduous, expensive cleanup, many cities are not receptive to bringing in new industry. Yatin Karpe, senior manager of technology transfer at Lehigh University says, "Some cities are simply unwilling to welcome new industry into the area due to a history of pollution and the long, expensive road to cleanup when industry leaves. But now Lehigh Nanotech's products, using technology developed at the university, is changing that direction."

Environmental remediation is a worldwide issue that will continue to be needed as the world's population continues to grow and industry expands. World population is expected to increase to approximately 7.2 billion people by 2015, and about 95 percent of that increase is expected to be in developing areas of the world. Additionally, about 70 percent of the world's industrial wastes in developing countries are discharged into water supplies without treatment, often resulting in pollution.

**A Better Way to Clean Up the Environment**

Twelve years ago, Wei-xian Zhang, Ph.D., associate professor of civil and environmental engineering at Lehigh, began his research on the use of iron particles for removing hazardous waste contaminants like explosives and highly toxic material from the soil and groundwater. About four years later, he began working with nanoparticles. Ultimately, Zhang successfully developed nanotechnology that uses less energy more efficiently and at a fraction of the cost of expensive pump and treatment procedures to clean up polluted sites.

> *The Lehigh Nanotech nanoiron, which is composed almost totally of ultrafine iron particles, is injected into the contaminated groundwater area by gravity or through pressure. It remains in the groundwater for long periods of time attacking contaminants like chlorinated hydrocarbons and pesticides.*

Zhang's research regarding contaminated groundwater has been seen as unique in more ways than one and has received support and recognition from the U.S. Environmental Protection Agency (EPA), the National Science Foundation and other agencies. Karpe explains that Zhang's work in the field of nanoparticles is an extraordinary accomplishment. His work has been featured in a wide range of media including academic publications such as *Technology Review, Environmental Science and Technology, Chemical and Engineering News,* and major newspapers, TV and radio outlets.

"Recently, published reports from the University of Pennsylvania show there are about 120 scientific publications in the field of nanotechnology for every three patents issued, and for about every one product developed," says Osimo.

**Collaboration Leads to a Startup**

Lehigh Nanotech hit the ground running, selling products just four months after it was founded in 2006. But the path to success did not occur overnight. A crescendo of collaboration between the university, the private sector and the state preceded its marketplace debut.

Lehigh University's School of Engineering and Environmental Science had long attracted industry due to its history of innovation. It didn't take long for industry to react to Zhang's work with nanoparticles for environmental remediation.

"When we read about professor Zhang's work in publications, abstracts and conference papers, we made our first contact with the university," says Osimo. Karpe notes, "Professor Zhang's research was promoted by two Lehigh University innovation seed grants and a Keystone Innovation Zone (KIZ) grant. The resulting company, Lehigh Nanotech LLC, came about through efforts of the Office of Technology Transfer, was an extensive collaborative venture between the university, the startup company, and the Pennsylvania Department of Community and Economic Development that funds KIZ ."

Lehigh Nanotech also received funds from the Ben Franklin Technology Partners (BFTP), and the Lehigh Valley Economic Development Corporation provided grants to assist production and control procedures.

Osimo says, "A year after professor Zhang and Lehigh University fi led a patent application to protect his technology, we had established a company, licensed the technology from the university and were producing and selling a product."

Osimo credits the expertise of the Technology Transfer Office at Lehigh University in quickly and successfully negotiating the necessary licensing agreements with the startup company, Lehigh Nanotech LLC.

"Lehigh's technology transfer office was technically efficient and helped make the process work smoothly," says Osimo. "Once the company was established, it was a challenging and exciting time. We had several product orders before we even opened our doors. Even as we were getting the electrical system in the production facility completed, orders were coming in!"

**A True Success Story**

The collaboration has proven to be an enormous success. "The technology that originated with professor Zhang's research has been successful not only for the university but also for the state of Pennsylvania," says Thomas Meischeid, director of Research & Sponsored Programs, and interim director for the Office of Technology Transfer at Lehigh University.

No toxic chemicals are used in the production of Lehigh Nanotech's nanoscale iron products, which have been used for environmental remediation projects by the federal, state and local governments, as well as for projects in the private sector.

The following is an example of how Lehigh Nanotech nanoscale iron products are helping make the world a better place. For several years, the owner of a former industrial manufacturing site in Ohio was paying to operate a pump and treat the system. But when the company's engineering consultant learned of Lehigh Nanotech's nanoiron, Lehigh was brought in and was able to achieve complete elimination of the serious contaminant in the groundwater in the treated area in only a few weeks time. Additionally, a full-scale remediation is planned for early 2008.

At another site in New Jersey nanoiron is being used to treat chromium contaminated wastes known as COPR (chrome ore processing residue), which is left over from industrial production in the 1940s, 1950s and 1960s.

Nanoiron is being used to stop the leaching of hexavalent chromium from contaminated soils into the groundwater.

Osimo says, “This is breakthrough technology and it affects every consumer. Currently, the technology is being used to treat groundwater where industrial leaks and discharges have contaminated drinking water supplies. At hazardous waste sites, it can take 10 to 20 years to clean up. These small nanoparticles are solving big problems. They allow us to clean up a toxic site in less than a year. This is a huge breakthrough.”

Behind the scenes, Zhang’s technology led to widespread collaboration among the university, companies and Pennsylvania state agencies in order to make Lehigh Nanotech’s products available. The university and affiliated regional organizations such as the Lehigh Valley Small Business Development Corp. and the Ben Franklin Technology Partners were instrumental in getting Lehigh Nanotech in front of the Secretary of the Pennsylvania Department of Environmental Protection and other state and regional agencies who could utilize the technology at sites throughout the state.

And Lehigh Nanotech’s partnership with the university continues to grow stronger and stronger. Since Zhang was well-known regarding his scientific and technical symposiums, Lehigh Nanotech has arranged meetings for a potential client, who was considering various technological approaches to treat contaminated groundwater at industrial sites, to visit the laboratory and meet the professor.

Osimo says, “This dialogue helped Lehigh Nanotech be more responsive to the client, and allowed the client to have a greater confidence that the product would do the job.”

Osimo says, “Moreover, as we continue to look for ways to produce more materials on the nanoscale, we will create products that allow development of more efficient and less expensive solar panels, heat transfer materials, and many other products that reduce energy consumption and improve the environment.”

Undoubtedly for areas in the world where environmental cleanup is not being done because of the high cost and time it takes to treat contaminated sites, Lehigh University’s technology will become even more beneficial.

Meischeid adds, “Lehigh Nanotech’s products manufactured in Bethlehem, Pennsylvania, will continue to impact the world environment.”

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