


Tiny perfection

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Nanotechnology is poised to revolutionize energy transfer, mechanics, optics, and data storage, but it started its revolution in medical devices. Ruari McCallion takes a very close look



In 2002, a study by the UK government indicated that the nanotechnology market will be worth over \$1.35 trillion a year by 2010. That's only three years away, and we haven't heard much about the invasion of everyday life by billions of tiny particles. However, the related microsystems market was already worth approaching \$60 billion in 2004 and is growing at something around 20 percent annually. Those tiny pieces of matter clearly have a huge future.

First, let's define what is meant by "nanotechnology," as opposed to microtechnology. The definition from the National Science Foundation (and generally accepted around the world) is particles in the 1–100 nanometer scale—from one-billionth to one-ten-millionth of a meter, which puts them on the molecular level. They're larger than atoms, which puts them outside the strange world of quantum physics, but they exhibit properties that are very useful in a range of applications—particularly medical devices.

"As you make particles smaller and smaller, their relative surface area gets bigger. A golf ball has the surface area of a playing card; take that same mass down to particles of 10 nanometers and you have a combined surface area equivalent to several football fields," says Dennis Schneider, director of sales and marketing with NanoHorizons, which is based at the Penn State campus and is a spin-off of the university. The relative surface area becomes important in exploiting the antibacterial properties of metals such as silver, copper, and zinc. Silver has been known to have antiseptic properties since the Middle Ages, as it doesn't react with human tissue and is not toxic. But don't ingest or inhale large amounts—it will turn your skin blue. What the medieval scientists and physicians didn't know was why silver was so helpful in treating wounds and infections.

"Silver is effective because the ions released by it, when they come in contact with water, disrupt bacterial function at the cellular level," says Schneider. Because silver ions aren't using biological functionality against bacteria, there is much, much less chance of infective agents developing resistance; there are no silver-resistant bacteria.

But making them into effective antiseptic weapons is challenging. The particles want to bind together, and they don't like binding on anything else—like latex, which is used in catheters; surgical plastics; or bandages and wound treatments. NanoHorizon has developed the means of building nanoparticles up from the atomic level, with a proprietary additional compound, in a manner that overcomes that resistance. It began with direct-injection catheters, which medical circles know as notorious seats of infection. Coat the catheter with nanoparticles of silver and infections simply don't start. Essentially the same technology delivers bactericidal bandages, which means antibiotics don't have to be applied. That's a huge advantage in situations as diverse as treating the wounded on battlefields and applying a bandage to a cut while fishing or hunting. It's also cost-effective.

"Using bulk silver to impregnate wound treatments becomes enormously expensive—around \$18 a bandage," says Schneider. Conversely, including nanoparticles in the bandage fabric costs a few cents. The same technology offers hope to those who find gym changing rooms a less-than-pleasant experience. The smell we're familiar with comes from bacteria that thrive in damp conditions—on sweaty clothes or socks, for example. "Putting the material on socks would make them permanently antibacterial, for a cost of around 25 cents a pair—maybe a dollar at the retail point."

The problem, however, is producing useful nanoparticles, without massive expense and without screwing

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up existing processes.

“We work with a number of medical device manufacturers and license the technology to them,” says David Rardin, vice president of marketing and business development for AcryMed, developer of SilvaGard, which coats devices in silver solution. AcryMed controls the amount of nanoparticle silver actually deposited by adjusting the silver concentration and the temperature of the solution as well as the dwell time in the solution. “It’s a relatively easy process; it’s more about the chemistry than instruments and machinery. It’s about how we tailor the technology to the application. It’s also cost-effective, compared with ionic deposition, for example.”

Other medical applications include bandages around prosthetic devices such as artificial limbs, and programmed-release drug delivery systems.

In other uses, nanotechnology typically imparts some property to a material that it lacks, for example:

- anti-reflective properties in optics
- higher density in storage media
- enhanced heat transfer from solar collectors to storage tanks
- improved efficiency of coolants in transformers
- improved catalysts for combustion engines

Whatever the industry or application, the proving ground for nanotechnology was in clinics and hospitals.

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