Tiny Particles Solve Big Problems

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Cutting edge nanotechnology research at North Carolina State University is leading to advances in everything from revitalizing HIV drugs to creating harder, stronger nanocrystalline iron that can really take the heat.

Chemists at North Carolina State University have discovered that adding tiny bits of gold to a failed HIV drug rekindle the drug's ability to stop the virus from invading the body's immune system, while NC State materials engineers have created a substance far stronger and harder than conventional iron, and which retains these properties under extremely high temperatures – opening the door to a wide variety of potential applications, such as engine components that are exposed to high stress and high temperatures.

Gold Gives Old Drug New Life

The addition of gold nanoparticles to a modified version of a drug designed in the 1990s to combat HIV - but discarded due to its harmful side effects - creates a compound that prevents the virus from gaining a cellular foothold, say Dr. Christian Melander, assistant professor of chemistry at NC State, and doctoral student T. Eric Ballard.

Their findings appear online in the *Journal of the American Chemical Society*.

The drug, a compound known as TAK-779, was originally found to bind to a specific location on human T-cells, which blocks the HIV virus' entry to the body's immune system. Unfortunately, the portion of the drug's molecule that made binding possible had unpleasant side effects. When that portion of the molecule - an ammonium salt - was removed, the drug lost its binding ability.

That's when Melander and colleagues from the University of North Carolina at Chapel Hill and the University of Colorado at Boulder turned to gold as the answer. The element is non-reactive in the human body, and would be the perfect "scaffold" to attach molecules of the drug to in the absence of the ammonium salt, holding the drug molecules together and concentrating their effect.

"The idea is that by attaching these individual molecules of the drug with a weak binding ability to the gold nanoparticle, you can magnify their ability to bind," Melander says.

The researchers' theory proved correct. They started with a modified version of TAK-779, which didn't include the harmful ammonium salt. After testing, they found that attaching 12 molecules of the modified drug (SDC-1721) to one nanoparticle of gold restored the drug's ability to prevent HIV infection in primary cultured patient cells. When only one molecule of the drug was attached to the gold nanoparticle, the compound was unable to prevent HIV infection, indicating that the multivalency of the drug was important for its activity.

"We've discovered a non-harmful way to improve the strength and efficacy of an important drug," Melander says. "There's no reason to think that this same process can't be used with similar effect on other existing drugs."

Tiny Crystals Make a Stronger, More Durable Iron

Iron that is made up of nanoscale crystals is far stronger and harder than its traditional counterpart, but the benefits of this "nano-iron" have been limited by the fact that its nanocrystalline structure breaks down at relatively modest temperatures. But the NC State researchers have developed an iron-zirconium alloy that retains its nanocrystalline structures at temperatures above 1,300 degrees Celsius – approaching the melting point of iron.

Kris Darling, a Ph.D. student at NC State who led the project to develop the material, explains that the alloy's ability to retain its nanocrystalline structure under high temperatures will allow for the material to be developed in bulk, because conventional methods of materials manufacture rely on heat and pressure.

In addition, Darling says the ability to work with the material at high temperatures will make it easier to form the alloy into useful shapes – for use as tools or in structural applications, such as engine parts.

The new alloy is also economically viable, since "it costs virtually the same amount to produce the alloy" as it does to create nano-iron, Darling says.

Dr. Carl C. Koch, an NC State professor of materials science engineering who worked on the project, explains that the alloy essentially consists of 1 percent zirconium and 99 percent iron. The zirconium allows the alloy to retain its nanocrystalline structure under high temperatures.

The research will appear in the journal *Scripta Materialia*. Kris Darling is the lead author on the paper, "Grain-size Stabilization in Nanocrystalline FeZr Alloys," but co-authors include Koch, fellow NC State materials science professor Dr. Ronald O. Scattergood, NC State doctoral student Jonathan E. Semones, and NC State undergraduates Ryan N. Chan and Patrick Z. Wong.

Source: North Carolina State University