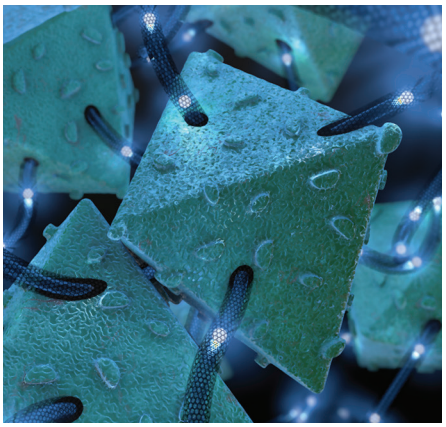
SUCCESS STORY: BIOLOGICALLY-INSPIRED HIGH-POWER BATTERIES



Being a "sponge" for new knowledge means translating out-of-the-box thinking in batteries into marketplace opportunities

THE SITUATION

Breakthroughs in energy storage are critical to achieve the full potential of renewable energy. To support a "smartgrid" and plug-in vehicles, today's batteries simply aren't up to the challenge. Batteries need to be cheaper, safer, and higher in power and capacity. Researchers at UC Santa Barbara are leveraging the unique properties of nanostructured materials to develop new batteries with dramatically increased storage, capacity, and power.

THE CHALLENGE

In today's lithium-ion batteries, metal structures expand and contract with each charge, eventually becoming brittle, turning to dust and losing capacity. Nanostructures have the potential to eliminate this problem by chemically integrating the constituent materials in composites that facilitate the diffusion of ions and electrons in and out, while preventing the troublesome degradation.

THE BIG IDEAS

Daniel E. Morse, Professor of Biomolecular Science and Engineering at UC Santa Barbara and member of the Production & Storage Solutions Group at the Institute for Energy Efficiency, has led the development of a biologically-inspired nanostructured battery with extraordinary properties. Modeling the skeleton-making processes of sea sponges, the team pioneered a low-cost technique for the production of battery anodes. The new material contains nanocrystals of tin inside carbon nanotube structures, allowing the material to expand and contract during charging without losing capacity. The result is an anode with exceptionally high electrical power and longevity.

As Morse explains, "We've developed a generic method which is a low-temperature, low-cost, aqueous method to synthesize nanostructured semiconductor thin-films and nanoparticles."

The improved nanocomposite results in an estimated 10 times more power and 40 percent higher energy density than conventional Li-ion batteries. This technique has also been applied to producing innovative cathodes exhibiting high power and capacity retention similar to the anodes.
Finally, Morse and his colleagues have tackled the thorny problem of battery safety, creating a barium strontium titanate ($BaSrTiO_3$) nanocrystalline ceramic with the ability to switch from a conductor to an insulator with increasing temperature. This advancement makes the batteries essentially fire-proof and explosion-proof.

WHAT'S NEXT?

Together, these advancements could result in batteries readily applicable to next-generation electric vehicles, smart grid, and military applications. And because these technologies – anode, cathode, and safety coating – are produced using chemical processes, they can be readily scaled for mass production.

To take this breakthrough from the lab to the marketplace, Morse founded a start-up company called LifeCel Technology in Goleta, CA. And Morse continues to lead an active team of UC Santa Barbara researchers and students from a variety of departments in his ongoing work. They are focused on new projects relating to energy storage and energy transduction, which could be used in microwave communications and systems. There's plenty more to harvest from Morse's area of concentration. For example, there's opportunity in pursuing what's possible with biologically-inspired photonics. Results already include polymers that use electrical signals to regulate the transmission of information with light-waves without being burdened by moving parts.

Dr. Morse points to the collaborative culture that has kept him at UC Santa Barbara; "I came here years ago on sabbatical from Harvard and immediately noticed that this is a very different environment. People came over and asked me to collaborate on their projects, share research, and participate in their lab work."

In recent years, interdisciplinary work has become more common, but this type of collaboration started very early at UC Santa Barbara and it is deeply ingrained in our campus culture.