THE SILVERINSTITUTE

Silver News

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Could a Composite of Minerals Including Silver Replace Lithium in Batteries?

Engineers seek safer alternatives

CNN

Spontaneous combustion of lithium batteries in an E-Bike caused this fire in New York City in March that destroyed a building.

Although lithium batteries are the current choice for many applications – including electric automobiles – because of their ease of recharging and longer life than traditional batteries, they suffer from several drawbacks including incidents of combustion and explosion.

Silver may provide some relief, according to researchers at Duke University in Durham, North Carolina. They have been experimenting with replacing lithium with argyrodite, a mineral that contains silver as well as other elements. In fact, the group is using 'machine learning,' a branch of artificial intelligence (AI), to quickly simulate other, new compounds in their quest to find the best mix of chemicals.

The main advantage to using argyrodite is that it allows a battery to be 'solid state' meaning there are no electrolyte liquids in the battery as there is with lithium cells. The liquids make batteries sensitive to high temperatures which not only cause gradual degradation but can also produce what engineers classify as 'thermal catastrophes' – fire and explosions.

Olivier Delaire, associate professor of mechanical engineering and materials science at Duke, quoted in phys.org, said: "Every electric vehicle manufacturer is trying to move to new solid-state battery designs, but none of them are disclosing which compositions they're betting on. Winning that race would be a game changer because cars could charge faster, last longer and be safer all at once." Delaire and his group are publicly disclosing their compositions.

He noted that a material made of silver, selenium and tin, a type of argyrodite, provides a stable structure to which silver atoms move around, which, in turn helps to produce electric current. They also found, unexpectedly, that the structure bends its shape to let the silver atoms move even more freely. Delaire said, "It's sort of like the silver atoms are marbles rattling around about the bottom of a very shallow well, moving about like the crystalline scaffold isn't solid."

Now that AI has become more commonplace in research, researchers like Delaire expect his group's experiments using computer simulations to move forward faster than were previously thought possible.

Silver Plays Vital Role in Wireless "Smart Bandage"

No Batteries Needed

The ability of ultraviolet (UV) light to kill germs has been known since the 1930's, and it's used extensively to keep bacteria at bay on foods, medical equipment and even ventilation systems. Recently, UV light has been used to treat chronic, non-healing wounds – but with a twist.

Medical researchers from the U.K. and France have developed what they call a 'smart bandage' that produces UV light from light emitting diodes (LED) without the need for batteries. This light helps to hasten healing.

"Traditional batteries are bulky, inflexible, and need to be changed regularly. That makes them difficult to use in bandages, which need to conform closely to the contours of patients' bodies to deliver reliable treatment over several hours," said Mahmoud Wagih, Ph.D., of the University of Glasgow's James Watt School of Engineering, co-author of the research report published in *IEEE Xplore*, and developer of the smart bandage's wireless power delivery system. "The system we've developed is flexible and can be seamlessly integrated into the fabric of a bandage to power the LEDs, which deliver UV-C light across any surface." (UV-C is the part of ultraviolet light that has the most germicidal properties.)

The wireless power comes from an inductive coil that receives through-the-air power from a magnetic coil connected to main power. This is similar to how mobile phones are charged by placing them on a charging mat. The bandage's power is supplied by a flexible resistor made from silver and carbon that was printed onto a textile surface. Although carbon generally is brittle and non-conducive, silver provides both flexibility and electrical conductivity.

Lab tests showed that the bandage stopped the growth of several microbes including those that do not respond to antibiotics. Said Professor Steve Beeby, chair in emerging technologies at the University of Southampton, and another co-author of the paper: "The use of ultraviolet light to kill viruses and bacteria is well known, and this is the first work to integrate UV-C emitting LEDs within a bandage and explore its efficacy. This approach could provide a significant benefit to the treatment of persistent wounds and is a major advance over typical smart bandages that attempt to monitor wound condition."

Concluded Wagih: "We believe that smart bandages will be key to future healthcare, but we need to be mindful of their environmental footprint. In the UK alone, over 40,000 tons of batteries are sold annually and less than half of them are recycled. Our wireless power technology will allow healthcare wearables to grow, sustainably, as an alternative to drug-based treatments. We'll be continuing to collaborate on developing the bandage further to integrate sensors capable of monitoring the progress of wounds, as well as setting out to test the technology in clinical settings in the years to come."

UNIVERSITY OF GLASGOW

A silver/carbon component makes this 'smart bandage' possible.

Silver Makes Water Pollution Separating-Membranes Last Longer; Offers Greater Efficiency

Using membranes to separate pollutants such as oil from water is a critical tool in keeping water clean. Unfortunately, this common barrier system often breaks down because the membranes themselves must be replaced often. Most membrane material simply can't stand up over time to harsh environments and chemicals.

One material that does hold promise is being developed by Chinese scientists who have produced a membrane by 'electrospinning,' a process in which drops of a liquid polymer are hit with an electric current and stretched into fibers. The result is a membrane that is 99% effective at separating petroleum from water, they say. To make the membrane's texture rougher – which offers greater surface area and more efficiency – they have added silver nanoparticles. Not only does the addition of silver nanoparticles increase the membrane's ability to separate water from oil better, but the membrane lasts longer as silver helps to physically support the structure. In addition, the silver nanoparticles add antibacterial properties to the membrane which retards the growth of microbial film that can clog the membrane.

Speaking at *WieTec 2023*, at the National Exhibition & Convention Center in Shanghai in June, researcher Jindan Wu, said: "This hydration layer efficiently impedes the passage of oil droplets, reducing membrane pollution and enhancing the composite membrane's permeability and separation efficiency."
He added: "We have discovered that the membrane's surface roughness and hydration layer strength are critical factors that impact its separation performance and anti-fouling ability. This concept of depositing [silver] particles on nanofibrous membranes also has potential for broad applications with other materials."

He concluded: "Water pollution is caused by multiple sources, and oily wastewater is just one of them. It is of vital importance to develop materials that can treat for dyes, heavy metals, and bacteria present in water."

Silver Helps Turn Waste Heat into Green Electricity

Thermoelectric materials – substances that produce electricity when heated – hold promise as a source of clean power from already existing sources of high temperatures that might go wasted such as from power plants or machines used in manufacturing. Unfortunately, it's not that simple to harness this heat and turn it into electricity because it's difficult to find a substance that can connect the hot and cool sides of the material, both electrically and thermally, without it melting or turning unstable.

Now, however, a team led by the University of Houston has discovered that silver nanoparticles used as solder can connect the hot and cold sides of the thermoelectric elements or modules, across a range of temperatures, without destroying silver's excellent electrical conductivity property or melting from the heat.

The researchers tested silver nanoparticles with several widely-used thermoelectric materials, each of which produces electricity at a different temperature. "If you make silver into nanoparticles, the melting point could be as low as 400 degrees or 500 degrees Centigrade, depending on the particle size. That means you can use the device at 600 or 700 Centigrade with no problem, as long as the operating temperature remains below the melting point of bulk silver, or 962 Centigrade," said Zhifeng Ren, director of the Texas Center for Superconductivity at UH, in a prepared statement. This property of silver nanoparticles worked well for one of the tested materials, a lead tellurium-based module, which works at a temperature of about 300 to 550 C and produced a heat-to-electricity conversion efficiency of about 11 percent. It remained stable after 50 thermal cycles, according to the researchers.

Ren concluded that as long as heat does not exceed about 960 degrees Centigrade, silver nanoparticles for the solder will remain stable, and this finding opens a wide range of thermoelectric materials that can be used to produce green electricity.

Silver Spun in Spider-Like Webs

University of California at Los Angeles scientists have taken a tip from nature and developed a process to produce soft, electrically-conductive fibers at room temperature with a method that resembles how spiders spin their webs.

The fibers are made from a synthetic polymer and silver ions, which conduct electricity. The combination is then dissolved in a solvent used to produce synthetic fibers. The resulting fiber is then used to make a sensing glove and smart face mask that are both durable, stretchable, and electrically conductive. The glove can sense hand movements and the mask can monitor the wearer's breathing patterns, among other abilities.

"We wanted to develop a highly efficient and cost-effective manufacturing process for electrically-conductive fibers that can be much easier to implement, mirroring state-of-the-art processes that make conductive 2D sheets and 3D objects," said the study's author Jun Chen, an assistant professor of bioengineering at the UCLA Samueli School of Engineering.

He noted that current methods to make similar fibers required high-temperature environments, large amounts of solvents and specialized spinning equipment. "With this new approach, we can create conductive soft fibers with high efficiency at a low cost."

In essence, the polymer/silver solution is placed on a spinning plate and produces a web as the fibers spread from the center, much in same way as a spider produces threads from liquid protein. The fiber is ready for use in a few minutes. The resulting fibers exhibit a rubber-like stretchiness with the strength of cotton fiber.

Silver and Glass Mixture Speeds Wound Care

Silver has even greater germ-fighting properties when it is infused with so-called 'bioglass,' biomaterials made from silicone that are often used in bone grafts.

Researchers at the University of Birmingham (U.K.) tested these findings on biofilms composed of *Pseudomonas aeruginosa*, a bacterium that is often spread in hospitals through contaminated hands, equipment, and surfaces. The bacteria is resistant to many antibiotics and frequently causes infection in chronic wounds.

The researchers found that the silver-bioglass combination was five times more effective against this particular microbe than silver alone. One possible reason is that the material inhibits the production of silver chloride, which often occurs with silver in wounds. Silver chloride does not have appreciable antibacterial properties compared to pure silver.

An added advantage of bioglass is that it is relatively inexpensive and easy to apply in healthcare settings, the authors of the study suggest. The authors are seeking collaborators to co-develop products for wound care as well as to help fund clinical trials. The global wound management market is estimated at US$30 billion with growth expected to reach US$38.8 billion by 2030, according to research firm GlobalData.

‘Artificial Leaf’ Produces ‘Drop-in’ Fuels

Silver is a crucial component in the production of synthetic gas or ‘syngas,’ helping to take carbon dioxide pollution from manufacturing plants and, with little energy loss, turn it into synthetic natural gas to produce electricity as well as useful chemicals such as ammonia and synthetic petroleum.

Now, silver has become a critical part of an ‘artificial leaf’ produced by scientists from the University of Cambridge (U.K.) that uses sunlight to convert water and carbon dioxide directly into ethanol and propanol. This process produces so-called ‘drop-in’ fuels – that directly power internal combustion engines – in a manner that the scientists suggest mimics plants’ photosynthesis turning carbon dioxide, water, and sunlight into fuel for plant growth.

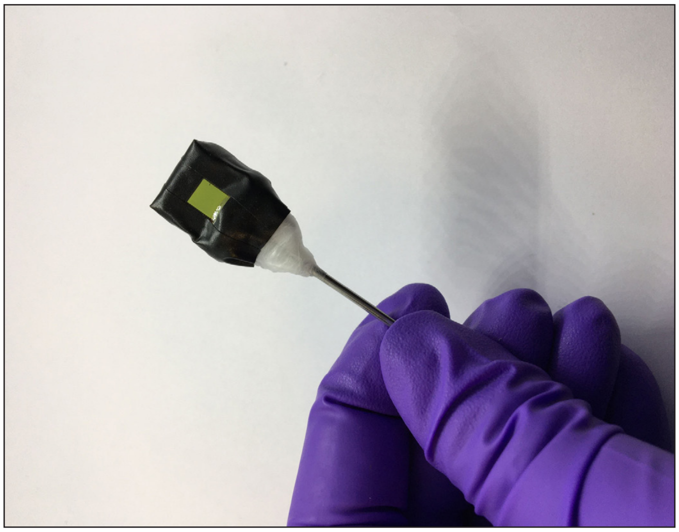
The artificial leaf is composed of layers of silver, glass, copper and graphite. The catalyst, which gets the chemical reaction started, is similar to the job done by light-absorbing chlorophyl in a plant, and is made from copper and palladium.

While the new device shows promise, there are challenges ahead, according to Virgil Andrei, Ph.D., from Cambridge’s Yusuf Hamied Department of Chemistry, the team’s research paper’s co-lead author. “Artificial leaves could substantially lower the cost of sustainable fuel production, but since they’re both heavy and fragile, they’re difficult to produce at scale and transport.”

He claims that while other researchers have produced drop-in fuels using electricity, this is the first time such chemicals have been produced with an artificial leaf using only sunlight.

Research team leader Professor Erwin Reisner said in a prepared statement: “Even though there’s still work to be done, we’ve shown what these artificial leaves are capable of doing. It’s important to show that we can go beyond the simplest molecules and make things that are directly useful as we transition away from fossil fuels.”

Their immediate task is to produce even better light absorbers as well as catalysts that can help convert sunlight into more fuel.



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This artificial leaf doesn’t look like a real leaf, but it acts like one.

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