The Innovation in Nanotechnology Driving Tomorrow's Technology

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Scientists have broken a speed record in nanoscience, opening the door to possible breakthroughs in fields including biosensing, soft robotics, neuromorphic computing, and speedier battery charging.

Researchers at Lawrence Berkeley National Laboratory and Washington State University have found a way to boost ion flow in hybrid organic ion-electronic conductors by more than ten times. These special materials combine the electron signaling present in contemporary computers with the ion signaling utilized by biological processes, including the human body.

This discovery, which was published on November 19 in Advanced Materials, is based on molecules that direct and concentrate ions into specific nanochannels, so forming a miniature "ion superhighway" that significantly speeds up their motion.

According to Brian Collins, a physicist at WSU and the study's principal author, "it's pretty powerful to be able to control these signals that life uses all the time in a way that we've never been able to do." "Energy storage may also benefit from this acceleration, which could have a significant impact."

Because they permit simultaneous passage of ions and electrons, these conductors have a great deal of potential for energy storage and battery charging. They also drive innovations like neuromorphic computing, which aims to replicate the way the human brain and nervous system think by fusing biological and electrical systems.

It is unclear exactly how these conductors coordinate the flow of electrons and ions, though. Collins and his colleagues noticed that ions traveled within the conductor somewhat slowly as part of their research for this work. The electrical current was additionally slowed by the slow ion mobility due to their coordinated movement.

"We discovered that while the ions were moving freely in the conductor, they had to pass through this matrix, which is similar to a rat's nest of pipelines, in order for electrons to move. The ions were being slowed down by it," Collins stated.

The researchers developed a straight, nanometer-sized conduit specifically for the ions in order to get around this issue. The ions then needed to be drawn to it. They looked to biology for that. Collins' team exploited a similar process found in cells: molecules that love or hate water. Ion channels are used by all live cells, including those in the human body, to transfer substances in and out of cells.

In order to draw in the ions dissolved in water, or electrolyte, Collins' team first lined the channel with hydrophilic molecules that love water. After that, the ions traveled through the channel at a rate that was more than ten times faster than what they would have done through water alone. The ions' motion set a new global record for the fastest ion speed ever recorded in any substance.

On the other hand, ions avoided the channel and were compelled to pass through the slower "rat's nest" when the researchers lined it with hydrophobic, water-repelling molecules.

Collins' group discovered that the molecules' attraction to the electrolyte could be reversed by chemical processes. In a similar manner to how biological systems regulate access via cell walls, this would open and stop the ion superhighway.

The team's research included developing a sensor that could swiftly identify a chemical reaction adjacent to the channel because the reaction would force the ion superhighway to open or close, producing an electrical pulse that a computer could read.

One of the many possible applications of the research, according to Collins, is the ability to detect at the nanoscale, which might aid in the detection of environmental pollutants or the firing of neurons in the body and brain.

"Learning all the basic mechanisms to control this ion movement and bring this new phenomenon to technology in a variety of ways is really the next step," he stated.