Jumpy electrons make chromophores semiconductors suitable for nanoscale electronics

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The future of high-speed electronics might very well be defined by linking together small, "electrically jumpy" molecules called chromophores. According to researchers at the University of Pennsylvania and St. Joseph's University, electrical charges can zip along chains of linked chromophores faster than any electrical charge yet observed in organic semiconductors, beating the previous benchmark in this regard by a factor of three.

Their findings suggest the use of chromophore-based circuitry that could create nano-sized electronic components for numerous applications. Their findings are presented in the current issue of the *Journal of the American Chemical Society*.
In chemistry, a chromophore is any molecule or part of a molecule responsible for its color. Light hitting a chromophore excites an electron, which then emits light of a particular color.

"Here we have created chains of chromophores that are primed to move charge," said Michael J. Therien, a professor in Penn's Department of Chemistry and lead researcher in the project. "When a charge is introduced to an array of chromophores linked closely together, it enables electrons to quickly hop from one chromophore to the next.

A charge can travel down a chain of chromophores at a rate of about 10 million times a second, which means that these chromophore arrays can do anything that organic semiconductors currently do, only much faster.

Penn researchers Kimihiro Susumu and Paul Frail built chromophore circuits that could, for example, serve as the functional elements in disposable plastic electronics, radio frequency identification tags, electronic drivers for active-matrix liquid crystal displays and organic light-emitting diodes as well as for lightweight solar cells.

Therien and his colleagues have found that the key to creating materials that allow electrons to move so quickly and freely is to build structures that feature long chromophores and short linkers between these units.

"This arrangement of linked chromophores leads to small structural changes when holes (positive charges) and electrons (negative charges) are introduced into these structures and these physical changes help propagate the charge," said Paul Angiolillo of St. Joseph's University, co-author of the study. "The introduction of these structural changes is actually a new idea in the design of conducting and semi-conducting organic materials."

The semiconductor industry is well aware of potential barriers to creating faster and faster electronics. In terms of circuitry, size directly relates to speed. Currently, circuits based on semiconductors have shrunk to dimensions just below 100 nanometers, or one hundred billionths of a meter, across. Chromophores may represent the first relatively easy-to-use materials that function on the nanoscale.

"In order to move significantly past the 100-nano barrier in electronics, we need to develop nano structures that let electrons move, as they do through wires and semiconductors," Therien said. "Our work also shows for the first time that molecular conductive elements can be produced on a 10-nanometer length scale, providing an important functional element for nanoscale circuitry."

Source: University of Pennsylvania