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UVic knowlEDGE

Photoswitches—the basis for molecular computing?

By Kristi Skebo

"Essentially, we are molecule-makers in my lab," says Dr. Reg Mitchell of UVic's chemistry department. "We create molecules that nature never thought of." For 30 years, Mitchell has been interested in how electrons move in molecules. In exploring how molecules behave, Mitchell has made a novel discovery that may open the door to creating smart, fast molecular computers.

While conducting basic research on the properties of aromatic compounds that they had synthesized, Mitchell and his graduate students discovered that some of these molecules can be made to conduct electricity. These molecules are called photoswitches.

"A photoswitch is a molecule that switches between stable forms when you shine different wavelengths of light on it," explains Mitchell. "In changing its shape, the molecule switches from one form, that conducts electricity, to another form in which it does not."

Aromatic compounds, like benzene, consist of carbon atoms each joined to at least two other carbon atoms, usually in a flat, hexagonal structure. "In this flat or natural form, electrons can pass through the molecule. Essentially, the molecular switch is 'on' and the molecule conducts electricity," explains Mitchell.

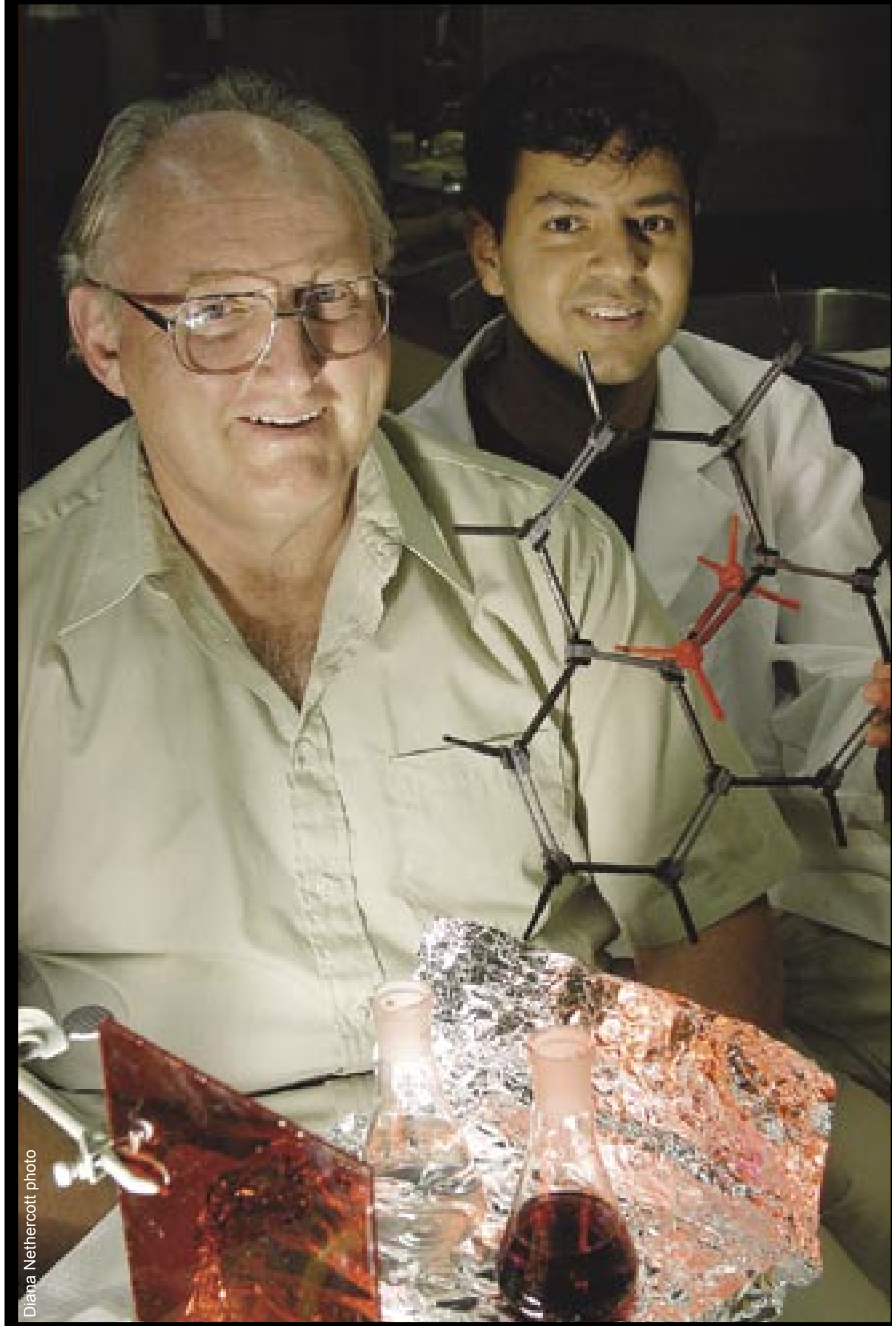
"Shine a particular wavelength of light on the molecule and the molecule changes shape; it's no longer flat. This 'stepped' form of the molecule acts like a broken circuit; electrons are no longer able to pass through it. This is the 'off' form of the molecule." Ultraviolet light returns the molecule back to its original flat form.

While these molecules were originally synthesized to help scientists understand fundamental chemical principles, it now appears that some of these molecules may have significant applications over the next few decades.

A single computer chip, not much larger than a thumbnail, is like a wafer of silicon containing multiple integrated circuits and millions of molecules. But a 'chip' composed of molecular photoswitches could be even smaller; one hundred thousand photoswitches, lined side by side, can fit across the diameter of a single human hair. "If molecular photoswitches could be used as memory and logic components, computers could become smarter, smaller and faster," Mitchell explains.

Even though more photoswitches can fit in a smaller space, there still needs to be a connection between molecules to create a circuit. One of Mitchell's graduate students, Subhajit (Bandy) Bandyopadhyay, is trying to connect photoswitches using a single strand of organic polymer plastic. Linking two switches may enable the molecular circuit to have three states: on/on (both molecules conduct electricity), off/off (neither molecule conducts electricity) and on/off (only one of the two molecules conducts electricity).

"At this point, we're still figuring out how to address each molecule individually, how to turn on one molecule but not its neighbour," explains Mitchell. "But if these can be converted to devices, it may open the door to entirely different computer schemes than the traditional zero and one (on and off) technology,"



Diana Nethercott photo

Mitchell and Bandyopadhyay

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• Several of Mitchell's graduate students are trying to find reliable methods for synthesizing photoswitches. "Typically, it's a 15 or 20 step process to create these molecules. My students try to decrease the number of steps to 10 or 12."

• Originally applied to a small class of pleasant-smelling chemicals derived from vegetables, 'aromatic compounds' now encompass a wide diversity of molecules with no connection to the sense of smell.

• Mitchell's group works closely with other chemists at UVic (Dr. Dave Berg and Dr. Cornelia Bohne of the chemistry department), at Arizona State University (Dr. Devens Gust) and at the University of California, Riverside (Dr. Mike Marsella).

• Mitchell's work is funded by the Natural Sciences and Engineering Research Council. More information about his research is available on his Web site: www.chemistry.uvic.ca/mitchell/mitchell.htm.

This article was written by Kristi Skebo, a student in the Faculty of Graduate Studies, as a participant in the UVic SPARK program (Students Promoting Awareness of Research Knowledge), supported by the Vice-President Academic and Provost and the Vice-President Research.

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