

# Titanium Dioxide for Solar Cells

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Researchers at Oak Ridge National Laboratory working on the problem have come up with a new way of carefully tuning the structure of titanium dioxide, an abundant and cheap material, to do this work.

"It's a totally new concept," says Gyula Eres, a researcher in Oak Ridge's Materials Science and Technology Division. "We substitute atoms of titanium and oxygen in the titanium dioxide lattice, and when you do that, you change its behavior."

The sun issues its energy as photons that radiate in waves of many different lengths. A small amount hits earth as relatively short (and harmful) wavelengths called ultraviolet radiation. A big chunk comes as longer wavelengths called infrared radiation.

The biggest chunk comes as a wavelength we describe as "visible" light. Surely it's no accident we evolved organs that made use of this most abundant part of the spectrum--even if these organs (our eyes!) need corrective lenses to be of much use after the age of 50.

Solar researchers would also like to make use of the most abundant part of the spectrum. The problem is that materials only interact with certain wavelengths. An orange looks orange to our eye because it absorbs all other wavelengths of visible light and reflects orange light back.

Scientists working on solar electricity need to find materials that act as semiconductors when hit with light of the right wavelength and energy. A solar cell works this way: When a photon of the right energy hits the semiconductor, it kicks off an electron that can be run through a circuit as electricity.

Every material requires photons of very specific energies to bounce that electron. The amount of energy needed is determined by what is called a band gap, described in electron volts (eV). "The problem," says Eres, "is that very few semiconductors have band gaps that align with the visible spectrum."

In an effort to capture photons of different energies, researchers have tried all sorts of tricks. They've tried layering materials of different band gaps--the materials on top collect the lower energy photons while the one below collect the more energetic ones. These devices are called multi-junction solar cells.

They have also tried combining a dye material to just catch the rays with a semiconductor like silicon, called dye-sensitized solar cells.

Eres and his Oak Ridge colleague Zhenyu Zhang devised a way to determine in advance what chemical structures would interact with photons of specific energies and how to make those structures.

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They worked with titanium dioxide because it is cheap and abundant. Titanium dioxide's band gap, about 3.2 eV, is great for catching ultraviolet waves, and that's why it's used in sunscreen. But because so little of the sun's rays arrive as ultraviolet rays, it's not very useful for a solar cell.

Eres and Zhang developed a new concept called non-compensated doping, which they predicted would allow them to introduce trace amounts of two elements, chromium and nitrogen, into the titanium dioxide in a way that would reduce the band gap. It worked; they were able to reduce the band gap from 3.2 eV to 1.5 eV. "That puts you in the most interesting area for this kind of conversion," says Eres. With this lower band gap, the duo hopes to create solar cells that can harness light from the visible spectrum.

Eres says the original idea was to use this solar power collector in what would amount to a solar battery. The electricity produced would be used to split water into hydrogen and oxygen that could then be recombined in a fuel cell to make electricity when needed. (See "[Solar Energy All Night Long](#).")

But the material could also be used in a solar cell. Because the titanium oxide is abundant and easy to dope, Eres hopes it could make for a cheap and relatively efficient cell.