Researchers find space between polymer chains affects energy conversion

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A team led by FAMU-FSU College of Engineering researchers has new insight into molecules that change their shape in response to light.

The researchers studying azobenzene-based polymers found that their free volume—a measure of the space between polymer chains—was strongly linked with the polymers' ability to convert visible light radiation into mechanical energy.

The results were published in *Advanced Functional Materials*.

"If you put a bunch of people in an elevator, it's really hard to get out," said senior author Billy Oates, the Cummins Inc. Professor in Mechanical Engineering at the FAMU-FSU College of Engineering. "But if you have enough space in between, you can move around. That's what we found, that the space in between the mass of polymer molecules makes a difference."

Azobenzene is a photoswitchable chemical compound. That means electromagnetic radiation—in particular, ultraviolet and visible light—can alter the geometry and chemical properties of a molecule.

A network of azobenzene polymers looks like a lot of strings of spaghetti clumped together. When light reaches the network, it causes some molecules to get shorter and change from a rod shape to a boomerang shape.

Previous studies have investigated the photomechanical nature of azobenzene, but this work was the first to quantify the bulk energy conversion for a system of azobenzene polymers at the molecular scale. Researchers found that the light-to-mechanical energy conversion ratio grew 10 times larger as the free volume increased from 0.5 percent to 12 percent.

As another part of this work, the researchers also developed a new coarse-grained model to explain how the azobenzene polymers interact. Coarse-grained models are a way to simplify the behavior of large, complex molecular systems with minimal loss of information so scientists can perform simulations that would otherwise be infeasible with finely detailed molecular models.

The research could lead to new smart materials technology. For example, instead of using wires to move electricity, engineers could use light to remotely control machine components. One possible application could be a method to move the many mirrors that are part of an array at a solar-thermal power plant.

"You don't need to worry about messy electrical wiring," Oates said. "You just need a line of sight to get the light in the system. That's the biggest opportunity here, the development of a new way to actuate materials and structures with light."

More information: Chenxi Zhai et al, Conformational Freedom-Enhanced Optomechanical Energy Conversion Efficiency in Bulk Azo-Polyimides, *Advanced Functional Materials* (2021). DOI: 10.1002/adfm.202104414

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