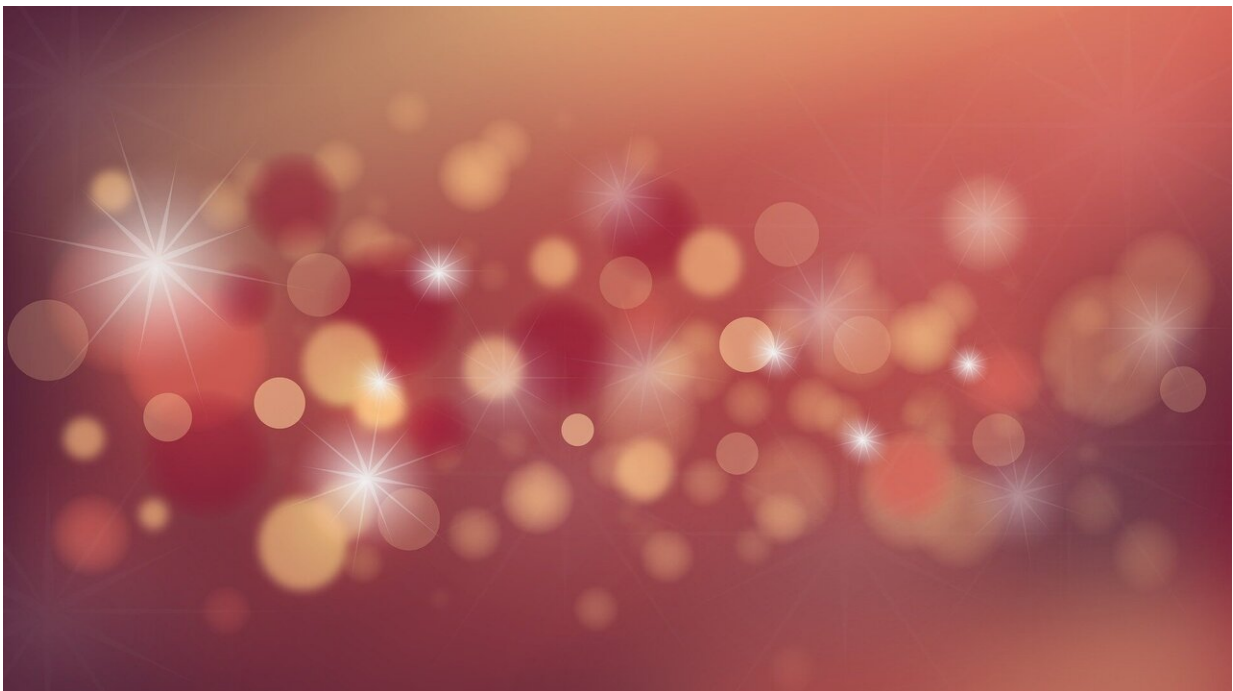


Study shows promising material can store solar energy for months or years

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As we move away from fossil fuels and shift to renewable energy to tackle climate change, the need for new ways to capture and store energy becomes increasingly important.

Lancaster University researchers studying a [crystalline material](#) have discovered it has properties that allow it to capture energy from the sun.

The energy can be stored for several months at room temperature, and it can be released on demand in the form of heat.

With further development, these kinds of materials could offer exciting potential as a way of capturing solar energy during the summer months, and storing it for use in winter—where less solar energy is available.

This would prove invaluable for applications such as heating systems in off-grid systems or remote locations, or as an environmentally-friendly supplement to conventional heating in houses and offices. It could potentially also be produced as a thin coating and applied to the surface of buildings, or used on the windscreens of cars where the stored heat could be used to de-ice the glass in freezing winter mornings.

The material is based on a type of 'metal-organic framework' (MOF). These consist of a network of metal ions linked by carbon-based molecules to form 3-D structures. A key property of MOFs is that they are porous, meaning that they can form [composite materials](#) by hosting other small molecules within their structures.

The Lancaster research team set out to discover if a MOF composite, previously prepared by a separate research team at Kyoto University in Japan and known as 'DMOF1', can be used to store energy—something not previously researched.

The MOF pores were loaded with molecules of azobenzene—a compound that strongly absorbs light. These molecules act as photoswitches, which are a type of 'molecular machine' that can change shape when an external stimulus, such as light or heat, is applied.

In tests, the researchers exposed the material to UV light, which causes the azobenzene molecules to change shape to a strained configuration inside the MOF pores. This process stores the energy in a similar way to

the potential energy of a bent spring. Importantly, the narrow MOF pores trap the azobenzene molecules in their strained shape, meaning that the potential energy can be stored for long periods of time at room temperature.

The energy is released again when external heat is applied as a trigger to 'switch' its state, and this release can be very quick—a bit like a spring snapping back straight. This provides a heat boost which could be used to warm other materials of devices.

Further tests showed the material was able to store the energy for at least four months. This is an exciting aspect of the discovery as many light-responsive materials switch back within hours or a few days. The long duration of the stored energy opens up possibilities for cross-seasonal storage.

The concept of storing solar energy in photoswitches has been studied before, but most previous examples have required the photoswitches to be in a liquid. Because the MOF composite is a solid, and not a liquid fuel, it is chemically stable and easily contained. This makes it much easier to develop into coatings or standalone devices.

Dr. John Griffin, Senior Lecturer in Materials Chemistry at Lancaster University and joint Principal Investigator of the study, said: "The material functions a bit like phase change materials, which are used to supply heat in hand warmers. However, while hand warmers need to be heated in order to recharge them, the nice thing about this material is that it captures "free" energy directly from the sun. It also has no moving or electronic parts and so there are no losses involved in the storage and release of the solar energy. We hope that with further development we will be able to make other materials which store even more energy."

These proof-of-concept findings open up new avenues of research to see

what other porous materials might have good energy storage properties using the concept of confined photoswitches.

Joint investigator Dr. Nathan Halcovitch added: "Our approach means that there are a number of ways to try to optimize these materials either by changing the photoswitch itself, or the porous host framework."

Other potential applications for crystalline materials containing photoswitch molecules include data storage—the well-defined arrangement of photoswitches in the crystal structure means that they could in principle be switched one-by-one using a precise light source and therefore store data like on a CD or DVD, but at a molecular level. They also have potential for drug delivery—drugs could be locked inside a material using photoswitches and then released on demand inside the body using a light or heat trigger.

Although the results were promising for this material's ability to store energy for long periods of time, its energy density was modest. Next steps are to research other MOF structures as well as alternative types of crystalline materials with greater [energy](#) storage potential.

More information: Kieran Griffiths et al, Long-Term Solar Energy Storage under Ambient Conditions in a MOF-Based Solid–Solid Phase-Change Material, *Chemistry of Materials* (2020). [DOI: 10.1021/acs.chemmater.0c02708](#)

Provided by Lancaster University

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