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Scientists demonstrate the first chemically synthesized optical switch

May 19 2020

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Optical switches allow for transmitting information using light, which will be useful for the development of ultrafast optical memory cells in the future. Using a femtosecond laser usually used in chemistry for gas absorption, ITMO University scientists have demonstrated how to create an all-optical switch based on a metal-organic framework that can be synthesized in vitro. The research has been published in the journal

Angewandte Chemie.

Current devices transmit information based on the movement of electrons. It is expected that computing elements operating on photons will work faster, more efficiently, and consume less energy. But in order to realize optical computing, it is necessary to solve a number of theoretical and engineering problems. One of them is achieving reliable, energy-efficient and low-cost light control.

"All of today's digital electronics are built on so-called triggers," explains Nikita Kulachenkov, a junior research associate at ITMO University and one of the paper's authors. "These are devices for switching between two states, zero and one. For optical devices which might in the future take the place of our electronic devices, we also need a special switch."

One of the options for such a switch comes in the form of metal-organic frameworks (MOFs). This is a class of functional materials that combine the properties of crystal lattice substances and organic compounds. But for the purposes of developing optical computing devices, the most important aspect is that some MOFs contain special photochromic compounds capable of changing their optical properties when exposed to light. This process, however, usually takes place over a relatively long period of time, from several minutes to several days, which puts significant limitations on the practical application of such structures as switchers.

A group of scientists from ITMO University's Russian-French laboratory, headed by Valentin Milichko, took a different path—the researchers used standard metal-organic frameworks that don't contain any photochromic compounds and have been used in the chemical industry for a long time. "We decided to use a group of MOFs that demonstrate the property of changing their structure under external stimuli such as pressure, temperature and others," says Nikita

Kulachenkov. "Among these metal-organic frameworks was HKUST-1. It was very well-researched in the field of gas absorption, but no one could ever have thought that its properties, and consequently, its structure, could undergo significant changes when exposed to light."

Experiments with HKUST-1 metal-organic frameworks have shown that when subjected to an ultra-short pulse of an infrared laser, this MOF suddenly starts to transmit less light. "The number of photons passing through the MOF decreased by about 100 times," explains Nikita Kulachenkov. "The switch-over period amounted to several dozen milliseconds. This is two to three orders better than offered by existing MOF-based organic systems."

The researchers found that the femtosecond impact generated by the infrared laser is, in effect, enough to evaporate the water from the metal-organic framework. The MOF becomes less transparent for the laser-emitted light. But once the light is off, the framework reabsorbs water molecules from the air and returns to its initial state.

More information: Valentin A Milichko et al, Photochromic Free MOF-Based Near-Infrared Optical Switch, *Angewandte Chemie International Edition* (2020). DOI: 10.1002/anie.202004293

Provided by ITMO University