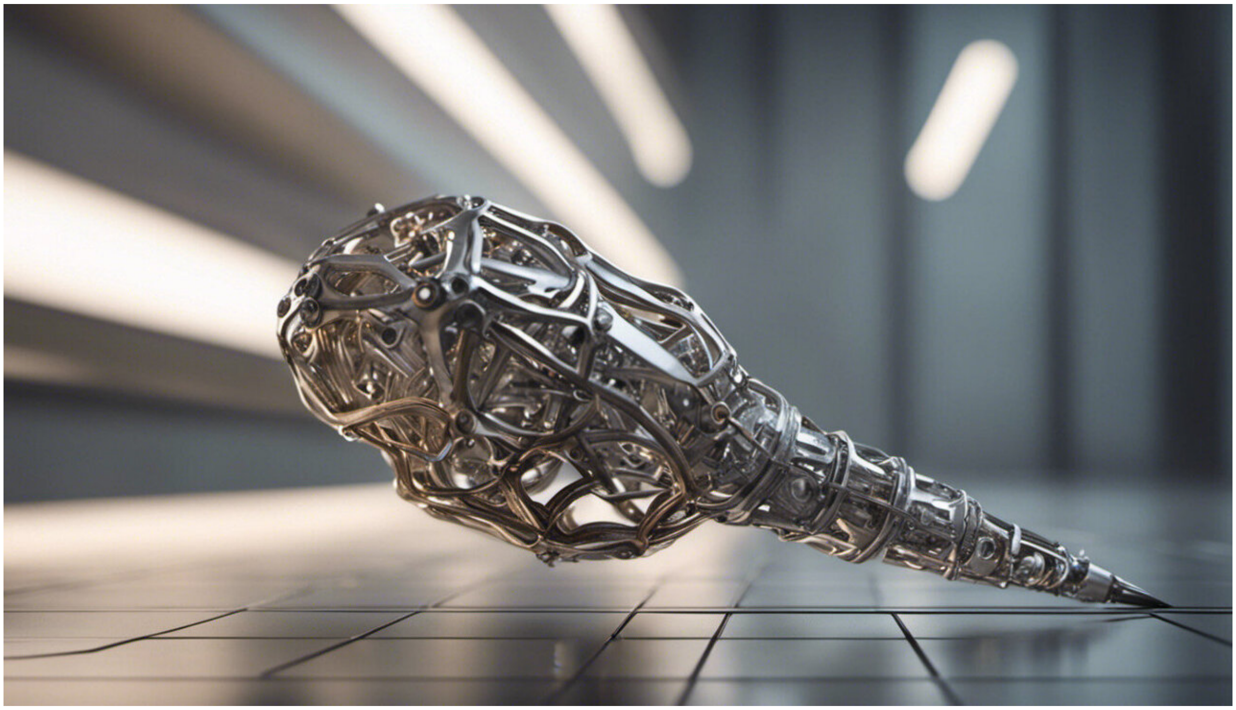
Light-controlled gearbox for nanomachines

March 21 2017



Credit: AI-generated image (disclaimer)

Rewarded with a Nobel Prize in Chemistry in 2016, nanomachines provide mechanical work on the smallest of scales. Yet at such small dimensions, molecular motors can complete this work in only one direction. Researchers from the CNRS's Institut Charles Sadron, led by Nicolas Giuseppone, a professor at the Université de Strasbourg, working in collaboration with the Laboratoire de mathématiques d'Orsay (CNRS/Université Paris-Sud), have succeeded in developing more complex molecular machines that can work in one direction and its opposite. The system can even be controlled precisely, in the same way as a gearbox. The study was published in *Nature Nanotechnology* on March 20, 2017.

Molecular motors can produce cyclical mechanical movement using an external energy source, such as a chemical or light source, combined with Brownian motion (disorganized and random movement of surrounding molecules). However, nanomotors are exposed to molecular collisions on all sides, which complicates the production of directed and hence useful mechanical work. The first molecular motors from the 2000s used the principle of the "Brownian ratchet," which like a notch on a cogwheel that prevents a mechanism from moving backwards, will bias Brownian movement so that the motor functions in only one direction. This makes it possible to provide useable work, but it does not allow for a change in direction.

The research team thus set out to find a solution for reversing this movement, which they did by connecting motors to molecular modulators (clutch subunits) using polymer chains (transmission subunits). A mathematical model has also been established to understand the behavior of this network.

When exposed to ultraviolet irradiation, the motors turn while the modulators remain immobile. The polymer chains thus wind around themselves, and contract like a rubber band that shortens as it is twisted. The phenomenon can be observed on a macroscopic scale, as the molecules form a material that contracts.

When the molecules are exposed to visible light, the motors stop and the modulators are activated. The mechanical energy stored in the polymer chains then rotates the modulators in the opposite direction of the original movement, and the material extends.

More spectacular still, the researchers were able to demonstrate that the rate and speed of the work produced can be carefully regulated through a combination of UV and visible light, like a gearbox functioning through modulations in frequency between the motors and modulators. The team is now attempting to use this study to develop photomechanical devices that can provide mechanical work controlled by light.

Provided by CNRS

Citation: Light-controlled gearbox for nanomachines (2017, March 21) retrieved 27 April 2024 from https://phys.org/news/2017-03-light-controlled-gearbox-nanomachines.html