Press release
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A molecular whirligig

Enter the world of molecular mechanics! This is the playground of scientists working in a disciplinary field whose goal is to create machines and motors at the molecular scale - an area of research that came under the spotlight in 2016 during the co-attribution of the Nobel Prize in Chemistry to Jean-Pierre Sauvage.
Nicolas Giuseppone, professor at the University of Strasbourg, and his research team at the Charles Sadron Institute of the CNRS, present a brand new synthetic molecular motor that is similar to a spinning whirligig craft. The strength of this new system: its ability to chain cycles to store mechanical energy and restore it reversibly in the form of a chemical transformation. This work was published on May 23, 2022 in the *Journal of the American Chemical Society - JACS*.

Link towards the publication: https://pubs.acs.org/doi/10.1021/jacs.2c02547

Molecular machines

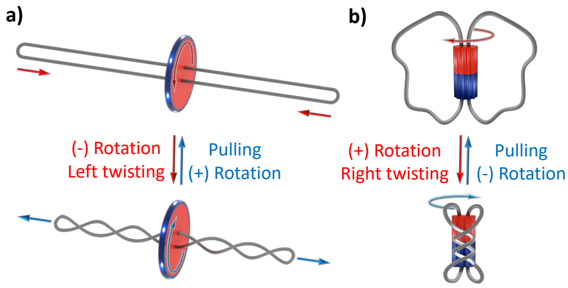
Just like conventional size machines, molecular machines are systems capable of absorbing energy, for example light, to then restore it in a useful way, instantly or later, via mechanical work. The living world is full of such molecular motors that cut, move or synthesize biological elements. One of the most characteristic examples is ATP synthase: a gigantic rotating enzyme (with a mass of 600,000 Da) that very efficiently produces the ATP molecule, the source of energy which all living organisms need to live.

The challenge for scientists lies in the ability to mimic this very complex mechanism using small synthetic molecules.

A new reversible motor inspired by a children's toy

By grafting two oligomer chains on a light activated nanometer scale rotary motor (with a mass of 1,500 Da), the researchers demonstrated that this motor could wind up the polymer chains and that the mechanical energy stored in these twists allowed the motor to then turn in the opposite direction and return to its initial state by carrying out a chemical transformation of high energy, thus creating winding and unwinding cycles.

The operating principle of this motorized molecular device is similar to the macroscopic one of the famous "whirligig" used by children.



The originality of this work

1 / The first observed reversibility of these synthetic rotary motors: By correctly adjusting the size of the polymer chains, the clockwise rotation of the motor under UV light creates twists that strain the whole system; in this strained conformation, the energy stored in the molecular object is sufficient to trigger a chemical transformation that also allows the motor to reverse spin to its fully relaxed state. "Wind-unwind" cycles are thus made possible and the work produced can accumulate continuously as long as the system is exposed to light.

2/ An enigma solved: For a very long time in the field of molecular machines, scientists have sought to measure the key values of the mechanical work provided by a single molecular motor. By precisely measuring the winding and unwinding speeds on this molecular motor, the research team was able to precisely determine the work, torque and force produced by this motor. The values found are comparable to those known for ATP synthase.

3/ Prospects for use: this simple and innovative system shows how it is possible to use these motors to store a large quantity of mechanical energy (for example from a light source), and then restore it in a useful way (e.g. to enable high-energy chemical transformations).

Reference:

Light-driven molecular whirligig | *Chuan Gao, Andreas Vargas Jentzsch, Emilie Moulin and Nicolas Giuseppone, SAMS Research Group, Université de Strasbourg, CNRS, Institut Charles Sadron UPR22, Strasbourg.* DOI : 10.1021/jacs.2c02547

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