Fabiana Ciocchetti, 28 /05/2022

Pumping between phases with a pulsed-fuel molecular ratchet

David A. Leigh, Thomas, D. et al. Nat. Nanotechnol. (2022) https://doi.org/10.1038/s41565-022-01097-1

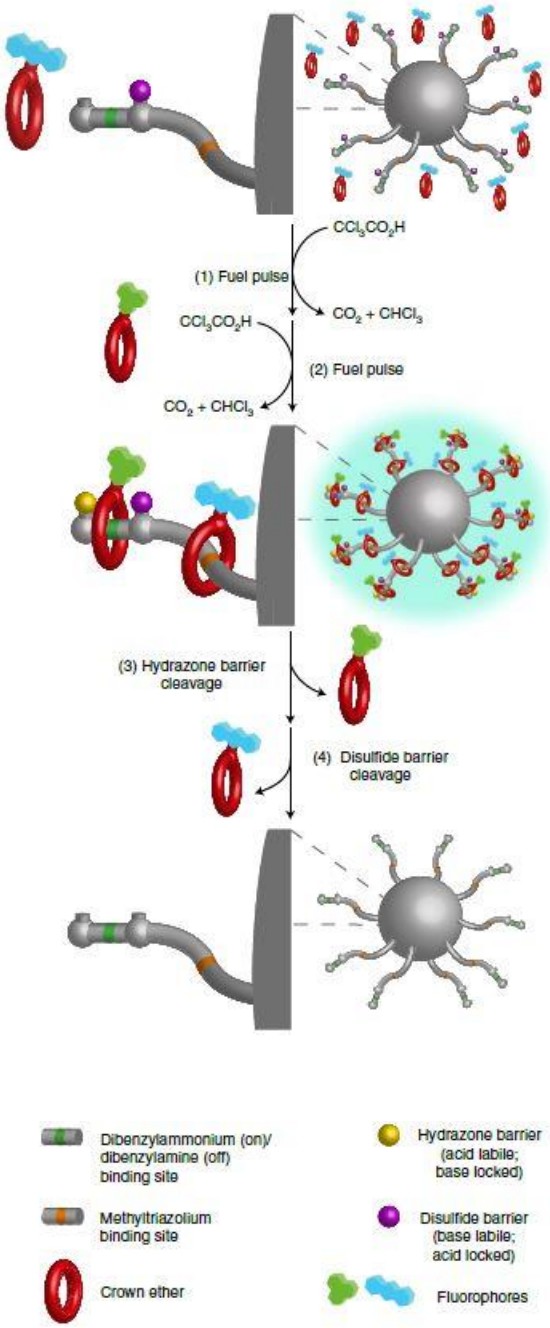

Figure 1: ***Pumping from solution to the solvent-accessible sites of polymer beads with a pulsed chemical fuel****. Progressive pumping away from equilibrium of fluorophore-labelled macrocycles from an acetonitrile solution onto polystyrene beads using a molecular ratchet and pulses of a chemical fuel (CCl_3CO_2H) ((1) and (2)), followed by the sequential release of the bound substrates ((3) and (4)).*

Who are the corresponding authors and what are their research areas?

David Leigh (University of Manchester, GB):

Leigh's group is interested in molecular machinery, molecular ratchet mechanisms, molecular knots, molecular assemblers, and molecular robotics.

What is the main claim of the article?

Here they report molecular pumps immobilized on polymer beads that use an energy ratchet mechanism to directionally transport substrates from solution onto the beads. After fuel consumption, the substrates are mechanically trapped in a higher-energy, out-of-equilibrium state on the beads and cannot be removed by dilution or exhaustive washing.

This differs from dissipative assembled materials, which require a continuous supply of energy to persist, and from conventional host–guest complexes. In addition, the method is extremely general: they used micrometer-sized polymer beads, but the approach should prove applicable to other solids, surfaces, gels and nanoparticles.

How is it demonstrated?

The mechanism of the threading and dethreading of the crown ether onto the axle is demonstrated by NMR analysis and confirmed by electrospray ionization-mass spectrometry.

To analyse the ability of immobilized molecular ratchets to pump substrates from the solution phase to the surface of polymer beads, they employed crown ethers labelled with fluorescent tags and they followed the process with florescence microscopy and spectroscopy.

What are the typical experimental conditions?

MeCN as a solvent, millimolar concentration range of reagent and beads, room temperature.

Which are the key related papers?

- *David A. Leigh, Erbas-Cakmak, S. et al. Science, **358**, 340–343 (2017).*
- *J. Fraser Stoddart, Feng, L. et al. Science, **374**, 1215–1221 (2021).*
  Note: This paper was published during the peer review process of the present work and it reports the out-of-equilibrium adsorption of rings into metal–organic frameworks by redox-driven molecular pumps.

Additional comments, including additional elements of interest

From my perspective, such approach could be really useful for practical aspects like the extraction of chemical compounds from solution or gas phase and also for the storage and release of energy and information in a controlled manner.