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Reconfigurable DNA Nano-Tweezer

Nanotechnology has grown by leaps and bounds in the past few decades. One of the main goals of nanotechnology is to build machines, switches or devices at the subatomic level that operate in a stimulus-responsive manner. Because DNA, via Watson-Crick pairing, is so precisely programmable, it is an ideal building block for creating such systems. In fact, DNA has been successfully used to create an entire suite of nanoscale mechanical devices including hinges/calipers, pistons, latchable boxes and other actuatable nanostructures. Actuation of these constructs typically occurs by the addition of single-stranded nucleotides that reconfigure the structure through toehold-mediated strand displacement. This approach, however, requires that the strand be added externally, which limits it to ex vivo applications.

Researchers at the Biodesign Institute of Arizona State University have developed a novel reconfigurable DNA nano-tweezer that can be switched between a closed and open state with a brief pulse of UV light. The tweezer is initially held shut using a hairpin with a single-stranded polyA loop. A polyT trigger strand with photocaged residues is also incorporated into the structure. Upon application of the UV light, the caging groups are rapidly cleaved allowing the trigger strand to irreversibly hyb ridize with the loop and open the tweezer. When the tweezer opens, the distance between the arms increases from 4 to 18 nm. This intermolecular process is roughly 60 times faster than adding an external trigger strand, and provides a mechanism for the rapid interconversion of DNA nanostructures with light.

Because the trigger strand is incorporated into the structure, these constructs have great potential utility in studying receptor-ligand interactions, cargo release, constructing dynamic materials such as artificial muscles and in any spring-loaded nanomechanical assemblies.

Potential Applications

- Research – studying receptor-ligand interactions
- Drug delivery – on-demand cargo release
- Constructing dynamic materials such as artificial muscles
- Light-activated nanorobots

- Spring-loaded nanomechanical assemblies
- Micro/nanofluidics
- Quantum devices

Benefits and Advantages

- Detailed and precise control
- Greater than 85% of cages are removed by 3s UV illumination
- Can change state rapidly – roughly 60 times faster than using an external trigger strand
- Reduced exposure time and narrow UV emission spectrum improve cell survival to >85%, enabling biological studies with live cells or in vivo applications
- Up to 46PN of force
- Multiple displacement strands with orthogonal sequences can be used to reconfigure complex DNA nanostructures for enhanced applications

For more information about this opportunity, please see

Liu et al - Angew Chem Int Ed Engl - 2018

For more information about the inventor(s) and their research, please see

Dr. Stephanopoulos' departmental webpage

Dr. Stephanopoulos' laboratory webpage