DNA construction kit for nanoengines

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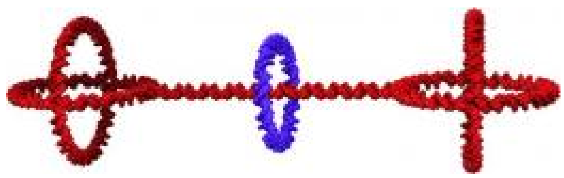

DNA rotaxane. Image: Famulok/Uni Bonn

Chemists have long been tinkering with rotaxanes. The name, derived from the Greek, basically means "wheel axle" - and not without reason.

For a rotaxane molecule consists essentially of an axle and a ring, or hoop, threaded over it. To prevent the hoop from slipping off the axle, bulky "stoppers" are placed at each end. These, in turn, consist of intertwined rings. The whole construction looks rather like a dumbbell with a hoop around its handle (see diagram).

All previous DNA rotaxanes are products of organic chemistry. They are also much smaller in size and therefore exhibit shorter margins of mechanical movement at the nanoscale. Moreover, the new DNA alternative can easily be equipped with additional functions, so that sophisticated mechanical systems can be quickly developed.

To build the new rotaxanes, the research team around Dr. Damian Ackermann and Prof. Michael Famulok from the Life & Medical Sciences (LIMES) Institute at the University of Bonn made use of a material that is normally known for constituting the building blocks of life itself: DNA. But the researchers are not primarily interested in DNA's function as a genetic carrier. Rather, their focus of interest lies in using the principles of base-pairing of DNA double-strands for constructing sophisticated architectures at the nanoscale. The double-helix forms a very stable scaffold. Moreover, a part of one strand can be removed at any chosen position to serve as a connecting point for other components of a nanomachine. " The specificity of individual strands makes DNA highly suitable. It offers us quite a lot of possibilities," explains Damian Ackermann. "DNA is like a Lego brick, It's the ideal material for nano-architecture," adds Professor Famulok.

The Bonn-based biochemists have created a completely new kind of rotaxane. It forms a stable mechanical unit, with a freely moving inner hoop. A great deal can be done with this wheel. "We envisage quite a few things," says Professor Famulok. "Our initial aim is to construct systems in which movement can be controlled at the nano-level. The axle and wheels are now available, and we have some ideas for how to get the wheels turning." These nanoengines might then also be combined with other biological systems, such as proteins.

The researchers now realize that, with their DNA rotaxanes, they have laid the foundations for developing all sorts of different nano-mechanical systems based on mechanically interlocked double-stranded DNA. It remains open what will finally emerge from these efforts, but the important breakthrough has been made. "What matters is that we now have a set of novel components with which we can build things that were previously impossible," says Ackermann: "The boundaries of our imagination have, in a sense, been pushed a little further."

More information: *Nature Nanotechnology* paper: doi:10.1038/NNANO.2010.65

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