Scientists create DNA tubes with programmable sizes for nanoscale manufacturing

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Scientists at the California Institute of Technology (Caltech) have developed a simple process for mass producing molecular tubes of identical--and precisely programmable--circumferences. The technological feat may allow the use of the molecular tubes in a number of nanotechnology applications.

The molecular tubes are composed of wound-up strands of DNA. DNA has been considered an ideal construction material for self-assembling molecular structures and devices because two complementary DNA strands can automatically recognize and bind with each other. DNA has been used to form rigid building blocks, known as tiles, and these tiles can further assemble into extended lattice structures, including tubes. However, it has been difficult to control the diameters of such tubes.

Peng Yin, a senior postdoctoral scholar in bioengineering and computer science at Caltech's Center for Biological Circuit Design, along with his colleagues has designed a series of flexible, single-stranded DNA molecules, called single-stranded DNA tiles. Each single-stranded tile is exactly 42 bases long and contains four modular binding sites. By pairing up the complementary binding sites, these single-stranded tiles bind with each other in a particular orientation like Lego pieces snapped together, forming a tube composed of parallel DNA helices.

The circumference of the resulting tube is determined by the number of different 42-base pieces used in its construction. For example, four pieces create a tube with a circumference of 12 billionths of a meter (or 12 nanometers); five pieces, a 15-nanometer-circumference tube; and six pieces, an 18-nanometer tube.

"We are not the first to make DNA tubes with controlled circumferences. However, compared with previous approaches, our method is distinctively simple and modular," says Yin. The simplicity and modularity of their approach permits the description of the tube design using a simple graphical abstraction system developed earlier this year in the laboratory of Niles Pierce, associate professor_of applied and computational mathematics and bioengineering at Caltech.

Just as a variety of wood sizes are used in construction projects--two by four inches for framing walls, two by eight inches for roof rafters, or four by four inches for fence posts--having nanotubes of various, precisely controlled sizes provides their user with more options. In addition, nanotubes of different sizes have varying mechanical properties; for example, tubes with a smaller diameter are more flexible and tubes with a larger diameter are more rigid. The nanotubes might eventually serve as templates for manufacturing nanowires with controlled diameters; the diameters of electron-conducting nanowires would help determine the electronic properties of the devices they are used to construct.

"The simplicity of the single-stranded tile approach promises to enable us to design ever more complex self-assembling molecular systems. The work is simultaneously elegant and useful," says Erik Winfree, associate professor of computer science, computation and neural systems, and bioengineering at Caltech. Winfree's laboratory was the primary host of Yin's research at Caltech.

The paper, "Programming DNA Tube Circumferences," was published

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Source: California Institute of Technology