Reversible assembly leads to tiny encrypted messages

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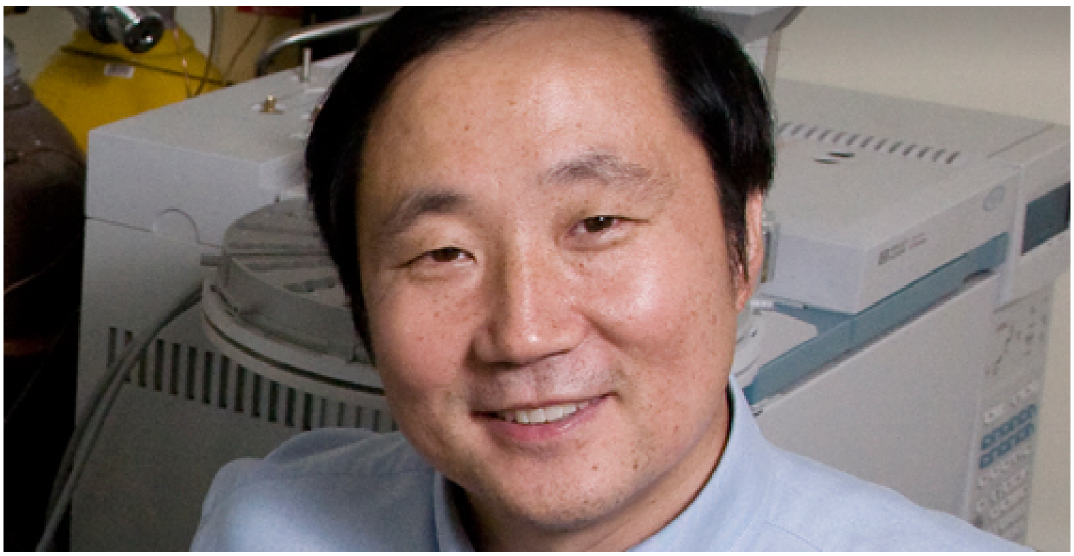

U. of I. chemistry professor Yi Lu and his research group developed a method for reversible and dymanic nano-assembly and used it to encrypt Morse code messages on a DNA origami tile. Credit: L. Brian Stauffer

(Phys.org) —Hidden in a tiny tile of interwoven DNA is a message. The message is simple, but decoding it unlocks the secret of dynamic nanoscale assembly.

Researchers at the University of Illinois at Urbana-Champaign have devised a dynamic and reversible way to assemble nanoscale structures and used it to encrypt a Morse code message. Led by Yi Lu, the Schenck Professor of Chemistry, the team published its development in the

Journal of the American Chemical Society.

Scientists and engineers who work with nanoscale materials use an important technique called programmable assembly to strategically combine simple building blocks into larger functional components or structures. Such assembly is important for applications in electronics, photonics, medicine and much more.

Most standard nano-assembly techniques yield a particular, static product. But looking at biology, Lu saw a lot of dynamic assemblies: reversible building processes, or substitutions that could be made after assembly to add or change function. Such versatility could enable many more applications for nanoscale materials, so Lu's group set out to explore nanoscale systems that could reliably and reversibly assemble.

"I think a critical challenge facing nanoscale science and engineering is reversible assembly," Lu said. "Researchers are now pretty good at putting components in places they desire, but not very good at putting something on and taking it off again. Many applications need dynamic assembly. You don't just want to assemble it once, you want to do it repeatedly, and not only using the same component, but also new components."

The group took advantage of a chemical system common in biology. The protein streptavidin binds very strongly to the small organic molecule biotin – it grabs on and doesn't let go. A small chemical tweak to biotin yields a molecule that also binds to streptavidin, but holds it loosely.

The researchers started with a template of DNA origami – multiple strands of DNA woven into a tile. They "wrote" their message in the DNA template by attaching biotin-bound DNA strands to specific locations on the tiles that would light up as dots or dashes. Meanwhile, DNA bound to the biotin derivative filled the other positions on the

DNA template.

Then they bathed the tiles in a streptavidin solution. The streptavidin bonded to both the biotin and its derivative, making all the spots "light up" under an atomic force microscope and camouflaging the message. To reveal the hidden message, the researchers then put the tiles in a solution of free biotin. Since it binds to streptavidin so much more strongly, the biotin effectively removed the protein from the biotin derivative, so that only the DNA strands attached to the unaltered biotin kept hold of their streptavidin. The Morse code message, "NANO," was clearly readable under the microscope.

The researchers also demonstrated non-Morse characters, creating tiles that could switch back and forth between a capital "I" and a lowercase "i" as streptavidin and biotin were alternately added.

"This is an important step forward for nanoscale assembly," Lu said. "Now we can encode messages in much smaller scale, which is interesting. There's more information per square inch. But the more important advance is that now that we can carry out reversible assembly, we can explore much more versatile, much more dynamic applications."

Next, the researchers plan to use their technique to create other functional systems. Lu envisions assembling systems to perform a task in chemistry, biology, sensing, photonics or other area, then replacing a component to give the system an additional function. Since the key to reversibility is in the different binding strengths, the technique is not limited to the biotin-streptavidin system and could work for a variety of molecules and materials.

"As long as the molecules used in the assembly have two different affinities, we can apply this particular concept into other templates or processes," Lu said.

More information: The paper, "Nano-Encrypted Morse Code: A Versatile Approach to Programmable and Reversible Nanoscale Assembly and Disassembly," is available online.

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