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Nanoscale parts get binding aid

By R. Colin Johnson
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PORTLAND, Ore. — Nanoscale particles that are easy to manufacture piecemeal — but hard to assemble — may benefit from a new "sticky patch" technology that researchers at the University of Michigan say enables nanoscale self-assembly.

"By mimicking biological assembly, we are exploring ways to nanoengineer materials that are self-assembling, self-sensing, self-healing and self-regulating," said Sharon Glotzer, an associate professor of chemical engineering on the Ann Arbor campus.

The researchers' method — using sticky patches that enable parts to put themselves together in programmable ways — could help fabricate new nanoscale materials and devices.

In computer simulation, Glotzer and research fellow Zhenli Zhang showed how to self-assemble nanoparticles into wires, sheets, shells and other even more-complex structures.

With just the parts meant to marry coated with protein-like patches, the computer simulation predicted not only that the correct parts would self-assemble but also that their bonds would be in the correct orientations to make such self-assembled devices functional.

The approach that the University of Michigan researchers took works for both polymers and colloids. It leverages the fact that motion becomes highly cooperative at the nanoscale, near the point at which the polymer becomes hard and brittle, like glass.

That point, which is called the "glass-transition" temperature, results in dramatic changes to the transport and to the deformation and flow characteristics of the material.

Hard plastics such as polystyrene are used below their glass-transition temperatures — in their glassy state — while rubber elastomers like polyisoprene are used above their glass-transition temperature, where they are rubbery, soft and flexible.

By controlling the subtle structural features responsible for the glassy transition, the researchers could control physical aging, shear banding and other complex material behaviors.

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The researchers called their findings significant, saying they have discovered how to make nanoscale parts both attract and repel, as well as snap together in the correct orientations.

Self-assembly is essential at the nanoscale, where devices are so small — the size of the tiniest viruses — that humans cannot build the structures. In any case, the parts are smaller than any of our ordinary tools and involve operations that are too numerous to perform manually.

In the simulation, the nanoscale parts had their surfaces encoded so they would automatically self-assemble into chains, rings and twisted staircase assemblies — the basic building blocks of complex structures, such as tubes, helices and 3-D networks.

These basic building blocks, the researchers said, could serve as scaffolds for assemblies of electronic and optical components.

For instance, sheets of self-assembled spheres, with tunable lattice structures, could act as novel optical filters, as well as microfluidic channels for transporting liquids.