On the path toward molecular robots

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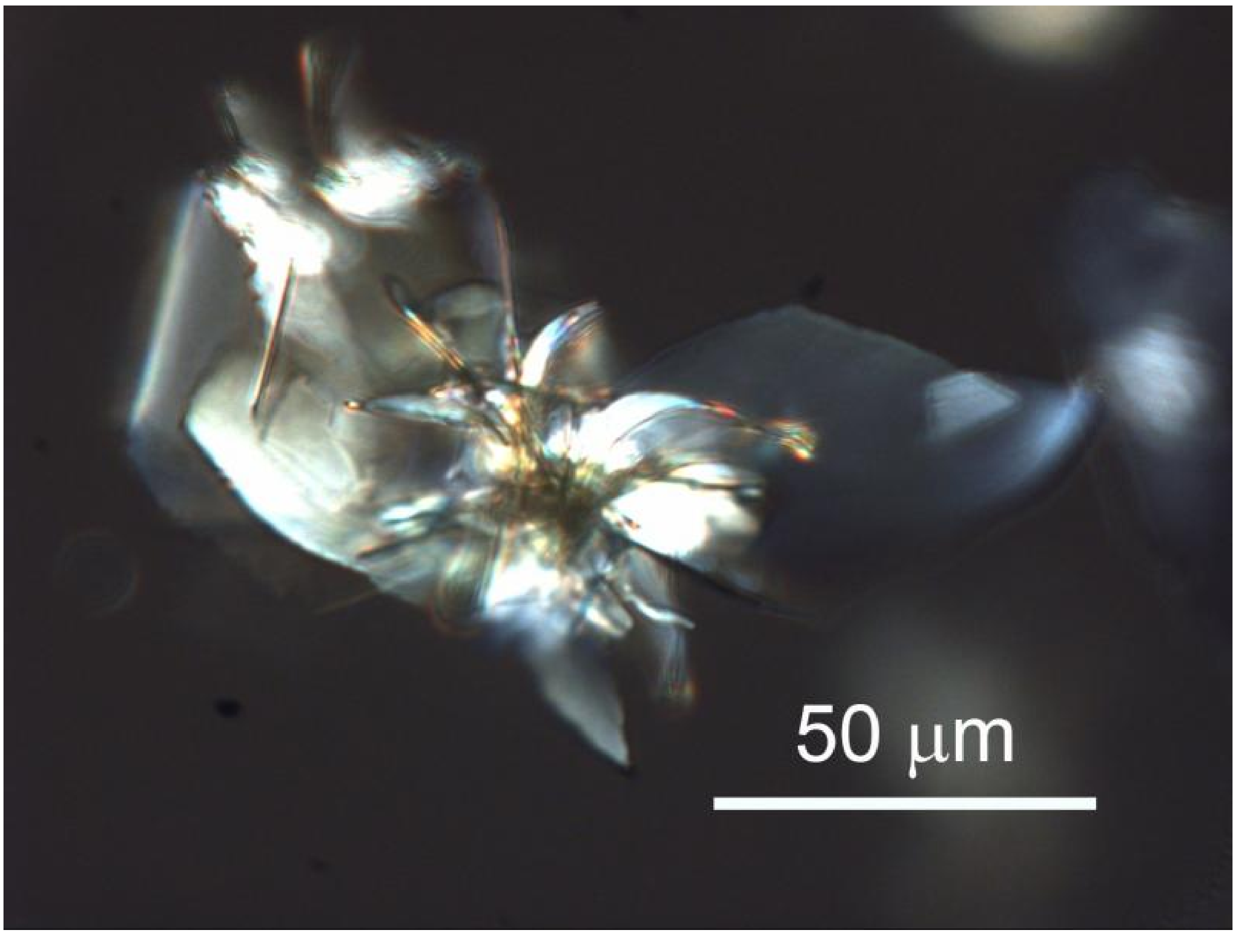

The crystals repeatedly flip under a blue light. Credit: Hokkaido University

Scientists in Japan have developed light-powered molecular motors that repetitively bend and unbend, bringing us closer to molecular robots.

Researchers around the world are trying to mimic cellular systems to develop molecular motors that can drive materials, including delivering drugs to target tissues. To this end, researchers must find ways to convert motion at the molecular level to motion at the macroscopic level. They also must find ways to cause chemical reactions to repeat autonomously and continuously.

Yoshiyuki Kageyama, Sadamu Takeda and colleagues at Hokkaido University's department of chemistry have successfully created a chemical compound, called a crystalline assembly, which repeatedly flips under a blue light.

The team made crystals composed of an organic compound called azobenzene, commonly used in dye manufacturing, and oleic acid, commonly found in cooking oil. Azobenzene molecules take two structurally different forms: cis and trans. They repetitively convert from one form to the other under blue light. The scientists tested if this would influence the structure of the azobenzene-oleic acid crystal, which contained unequal amounts of cis- and trans-azobenzene.

By applying blue light to the crystals in solution, the team observed, under a microscope, a repetitive bending-unbending motion of the thin crystals, which suggests the existence of two stable structures, bent or unbent, depending on the cis/trans ratio. The frequency of the motion increased when the light intensity was increased. Some crystal complexes even exhibited 'swimming-like' motions in the water. Previously reported light-responsive materials have been limited in their ability to deform. The properties of the new compounds, however, allowed for a two-step switching mechanism, resulting in regular repetitive oscillations.

"The ability to self-organize rhythmic motions, such as the repetitive flipping motion we observed, is one of the fundamental characteristics of living organisms," says Kageyama. "This can be observed, for example, in the repetitive contractions of the heart," he explains.

This mechanism can be used in the future to develop bio-inspired molecular motors and robots that will find applications in wide areas, including medicine. To this end, the team is investigating ways to create autonomously working chemical systems by means of hierarchically assembling molecular machines.

Provided by Hokkaido University