Making light work of artificial muscles

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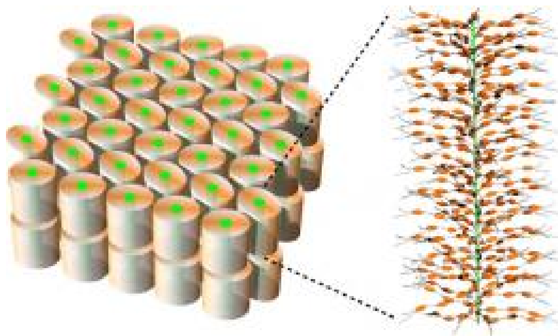

The light-responsive film is made up of polymer brushes (right) that have self-assembled into a two-layer, three-dimensional array (left). Credit: Reproduced, with permission, from Ref. 1 2011 American Association for the Advancement of Science

A new form of self-assembling polymer film that bends and stretches when hit by light is pointing the way to a new family of functional materials. This flexing film is the first material to have been made by coaxing complex molecules to form large-scale, highly ordered three dimensional arrays -- a discovery that could change the way that many active material are made, from artificial muscles to solar cells.

Nobuhiko Hosono, Takuzo Aida and colleagues at RIKEN Advanced Science Institute in Wako and The University of Tokyo developed the self-assembly protocol. The researchers found that brush-shaped polymers would form an orderly film when hot-pressed between two sheets of Teflon.

They made their discovery while studying a polymer in which each side chain, or bristle, of the brush structure incorporates light-responsive azobenzenes—two benzene rings separated by a pair of nitrogen atoms. When hit by UV light, the bond between the nitrogens rearranges, contracting the side chain.

The researchers used this photoisomerization behavior to confirm the remarkable long-range order of the polymer structure. Because the side chains were all aligned, when those at the surface were hit by light they curled up in concert, bending the film. A second beam of light at a different wavelength reversed the isomerization process, and the film relaxed back to its original shape.

The trick to making the material is to heat it between two sheets of Teflon that have been drawn tight in one direction, says Hosono. This tension orients the Teflon sheets' internal structure along a single axis, which acts as a template for the molten polymer brushes sandwiched in between. The side chains of the polymer brush align with the Teflon, pulling each brush upright. As each polymer brush aligns in the same way, it forms a repeating three-dimensional array.

Hosono, Aida and colleagues expect the technique to work for other polymer brushes with similar side chains. To improve the artificial muscle-like behavior of their polymer film, Hosono says the team will try cross-linking the polymer side chains. This will prevent the molecular structure from becoming disordered as the polymer repeatedly curls and relaxes over many cycles, giving the muscle a longer lifetime.

The team is already assessing other potential applications. The wide-area three-dimensional molecular ordering of the polymer brush has great potential for building electronic devices, says Hosono. "We now have designed a new type of polymer brush for development of highly efficient thin-layer organic solar cells."

More information: Hosono, N., et al. Large-area three-dimensional molecular ordering of a polymer brush by one-step processing. *Science* 330, 808-811 (2010).
Read the article here: www.sciencemag.org/content/330/6005/808.short

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