NAIST® Research Highlights

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Polymer chemistry

Handedness theory usurped

Right circularly polarized light does not necessarily give left-handed molecules

It had long been accepted that right circularly polarized light is needed to produce right-handed polymer molecules. But to the surprise of researchers at NAIST, right circularly polarized light can also give rise to left-handed polymer molecules, and vice versa: polymer handedness depends on other factors, including the wavelength of the light and the refractive index of the solvent.

Chemists often want to produce either a left- or right-handed version of a chemical. The two forms, which are known as enantiomers, are identical except that they are mirror images of each other — like left-handed and right-handed gloves. However, they react very differently with other enantiomers, which are frequently found in biological systems.

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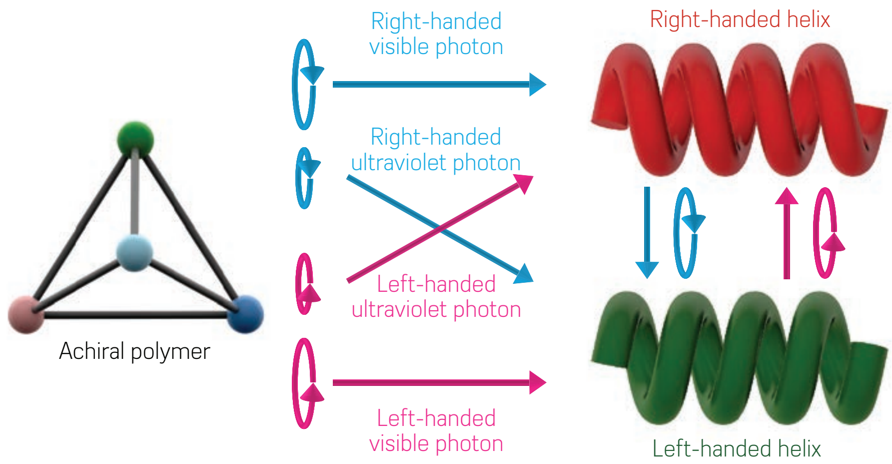
An attractive way to produce enantiomers is to use circularly polarized light, as this method can induce handedness without using expensive chemicals. Up until now, conventional wisdom had dictated that left-handed circularly polarized light preferentially produces left-handed molecules, and vice versa. Furthermore, the handedness of a molecule was thought to be independent of the wavelength of the light used. Now, Michiya Fujiki and co-workers at NAIST have overturned both these assumptions[1].

Using a green-emitting chain-like polymer known as PF8T2, the researchers found that the handedness of PF8T2 depends on both the wavelength and the handedness of the circularly polarized light used. Specifically, they found that when a right-handed circularly polarized light in the visible region is used, right-handed PF8T2 was produced; whereas when right-handed circularly polarized light in the ultraviolet region was used, left-handed PF8T2 was formed (see figure).



NAIST researchers find that left circularly polarized light can give rise to right-handed molecules and vice versa.

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They also found that, by precisely controlling the refractive index of an inexpensive organic solvent, they could increase the yield of PF8T2 up to 10 per cent — the highest yield ever reported for an enantiomer using this light-based synthesis method.

The researchers anticipate that their findings will lead to the production of various photoluminescent substances and polymeric materials that can be used for re-writable optical memory, efficient erasure, and long-term data storage. They also expect that the findings will facilitate efficient switching using a circularly polarized light source once a detector for circularly polarized light has been developed.

"In the future, we will try to induce and control the helix sense of polymers and the chirality hand of small molecules with a 100 per cent yield driven by circularly polarized light, spinning electron beams, anti-neutrinos and magnetic and electric fields," Fujiki states. "This has probably been the ultimate goal of chirality-related scientists in chemistry and physics over the last two centuries."

Reference

1. Fujiki, M., Donguri, Y., Zhao, Y., Nakao, A., Suzuki, N. Yoshida, K. & Zhang, W. Photon magic: Chiroptical polarisation, depolarisation, inversion, retention and switching of non-photochromic light-emitting polymer in optofluidic medium. *Polymer Chemistry* advance online publication, 08 December 2014 (doi: 10.1039/C4PY01337A).

More information about the group's research can be found at Michiya Fujiki's laboratory webpage:
http://mswebs.naist.jp/LABs/fujiki/english/index-e.html