A breakthrough in chiral polymer thin films research could enable a new generation of devices

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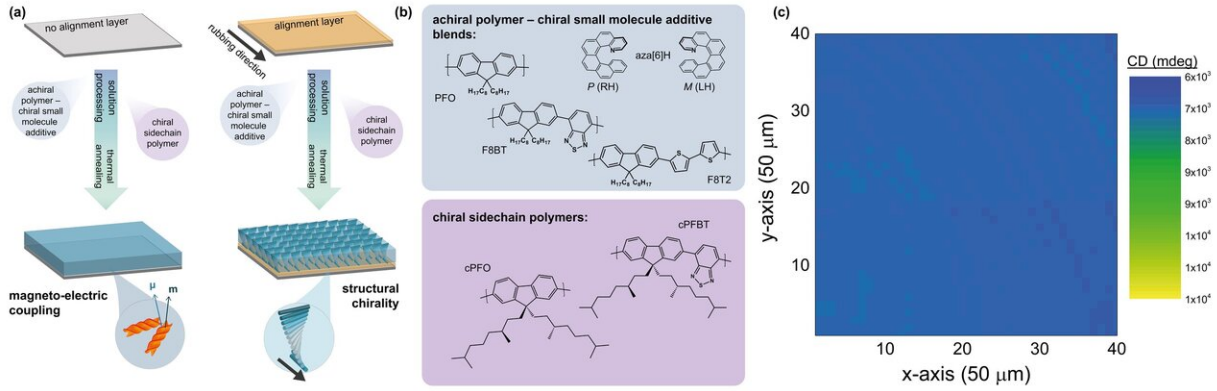


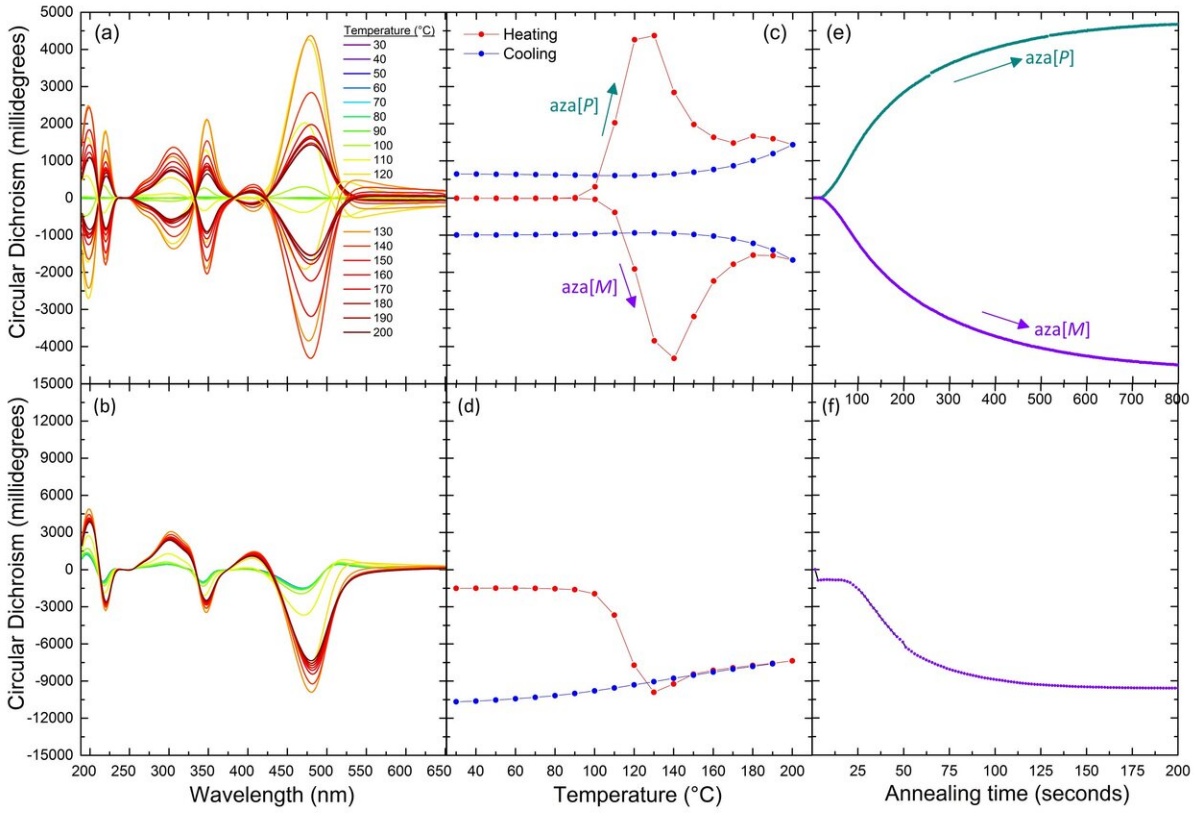
Origins of the chiroptical effects explored in this work. (a) a cartoon depicting the mechanisms that underpin the chiroptical response in nonaligned and aligned thin films and (b) the polymer systems evaluated here, and (c) Spatially resolved circular dichroism (50□micron resolution) of annealed achiral polymer blended with a chiral additive (ACPCA) thin films using B23 beamline. Credit: Nature Communications

The 10,000th paper published by Diamond Light Source could fundamentally change the technology landscape by enabling a new generation of devices. This study presents a new way of looking at chirality in thin polymer films that are important for electronics. It presents disruptive insights into chiral polymer films, which emit and

absorb circularly polarized light, and offers the promise of achieving important technological advances, including high-performance displays, 3-D imaging and quantum computing. These findings were published recently in *Nature Communications*.

Chirality is a fundamental symmetry property of the universe. We see left-handed (LH) and right-handed (RH) mirror image pairs in everything from snails and small molecules to giant spiral galaxies. Light can also have chirality. As light is traveling, its internal electric field can rotate left or right creating LH or RH circular polarization. The ability to control and manipulate this chiral, circularly polarized light presents opportunities in next-generation optoelectronics (Figures 1a and 1b). However, the origin of the large chiroptical effects in polymer thin films (Figures 1c and 2) has remained elusive for almost three decades. In this study, a group of researchers from Imperial College London, the University of Nottingham, the University of Barcelona, Diamond Light Source and the J.A. Woollam Company made use of Diamond's Synchrotron Radiation Circular Dichroism beamline (B23) and the Advanced Light Source in California.

"This breakthrough study shows how Diamond's capabilities can be used to study processes that normally occur far out of our reach. The team's findings present a roadmap for introducing chiroptical properties into more electronic devices in the future," says Professor Laurent Chapon, director of physical science at Diamond.



In situ chiroptical response of ACPCA and cholesteric chiral sidechain polymers (CSCP) thin films. In situ CD spectra recorded during heating and cooling of ACPCA (F8BT: aza[6]H) and CSCP (cPFBT) thin films (note blue represents low temperatures and red represents high temperatures), (c) and (d) the CD intensity recorded at 480nm as a function of temperature during heating (red) and cooling (blue), and (e) and (f) CD intensity of thin films held at 140°C as a function of time for [P] (turquoise) and [M] (purple) systems (note the different time on-axis). Credit: *Nature Communications*

Circular dichroism (CD) has a surprisingly long history. In the 19th century, French scientists observed that chiral molecules that do not superimpose to their mirror image absorb left and right circularly polarized light differently depending on their configuration (like for L or D amino acids) and also the handedness of their structure. By the 1960s,

scientists had realized that CD could be extremely helpful for the study of intricate material structures. Diamond's B23 beamline is dedicated to CD and generates a unique highly collimated monochromatic micro beam from vacuum ultraviolet (UV) to visible light.

For this study, the research team combined ultraviolet CD studies at Diamond with resonant carbon K-edge soft X-ray scattering measurements at the Advanced Light Source.

"Using a combination of spectroscopic methods and structural probes, the researchers questioned the validity of hitherto data interpretation of these polymer films," explains Professor Giuliano Siligardi, principal beamline scientist on Diamond's B23 beamline.

It was previously thought that the large chiroptical effects seen in these polymer films were caused by structural chirality like that seen in cholesteric liquid crystalline phase. However, this study shows that—under conditions relevant for device fabrication—they are caused instead by magneto-electric coupling that generates the natural optical activity of these polymers.

Dr. Jessica Wade, lead author of the paper, says, "This study presents a new way of looking at chirality in thin polymer films, which is important for electronics. The discovery that magneto-electric coupling—and not the longer-range structural chirality—is responsible for the large chiroptical effects will allow the rational design of polymers for a broad range of device applications."

All of the experiments were carried out under conditions relevant for real-world applications, with active layer thicknesses (

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