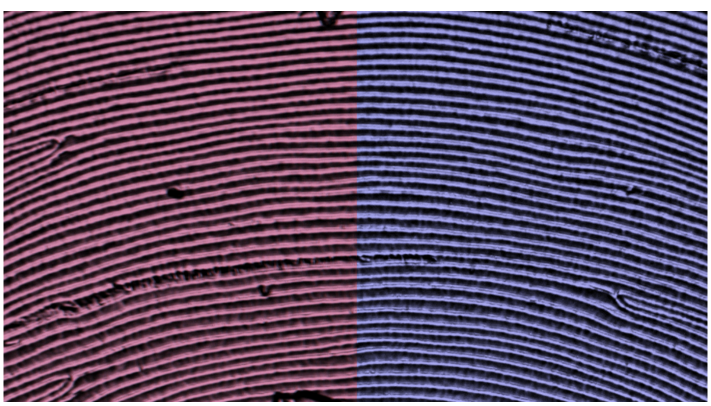
Nonchiral Clusters Self-Assemble into Chiral Films

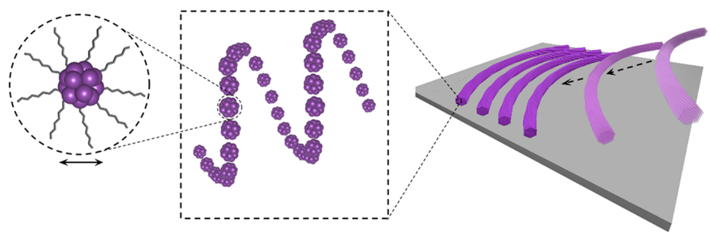
Researchers have demonstrated a method to create circular polarizing films from nonchiral nanoclusters that form spiral chains during drying.

By **Katherine Wright**

Biology is awash with chiral molecules, ones that selectively absorb left- or right-handed circularly polarized light. Examples of chiral organic molecules include left-handed amino acids and right-handed sugars, as well as synthetic chiral supramolecules assembled from nonchiral (achiral) organic components. Researchers have also fabricated chiral structures from achiral inorganic ingredients, but examples remain few and far between. Now Richard Robinson of Cornell University and his colleagues have demonstrated a way to make large-scale chiral films from three different achiral semiconductor materials [**1**]. The findings could pave the way for new antireflective coatings, noninvasive blood-sugar monitors, and technologies for quantum computers.



This micrograph shows a chiral film formed by drying a solution of nanoclusters. The nanoclusters assemble into twisted chains that absorb left-handed light on one side of the film and right-handed light on the other side.
Credit: T. J. Ugras *et al.* [**1**]



Inorganic nanoclusters assemble into helical chains that stack in a rainbow-like pattern.
Credit: T. J. Ugras *et al.* [**1**]

For their demonstration, Robinson and his colleagues turned to a popular method for making thin polymer films: meniscus-controlled drying of a particle-laden solution. For their starter material, they chose 1.5-nm "magic-sized" nanoclusters made from an achiral semiconductor (either cadmium sulfide, cadmium selenide, or cadmium telluride). The researchers placed these nanoclusters in a solvent and loaded the resulting solution between two glass plates separated by 100 μm and sealed on three sides.

The researchers found that as the liquid evaporated, it drew the particles together in long horizontal chains. The middle of each chain was pinned along the central axis of the glass sandwich, while the two ends of each chain were free to twist around in spiral structures. "It's like a towel being twisted while one person is holding the end of it," Robinson says. Because of the central pinning, the twisting increased with distance from the center. These chains stacked side by side along the length of a glass slide, forming a rainbow-like pattern that was up to a few centimeters long.

Testing the light response of the films, Robinson and his colleagues found that all three materials exhibited excitonic chirality. An exciton is an excited state of an electron and a hole. When light hits the material, the electron and the hole separate but can travel together through the material. In the case of the films, an exciton is restricted to move along a twisting chain, meaning that it can only absorb light with a similar twist—or circular polarization. This excitonic chirality was left-handed on one side of the films and right-handed on the other, with the center remaining achiral.

"For a single nanocluster the exciton was not chiral," Robinson says. "But with a bunch of these clusters lined up close together, we created a helical pathway that the exciton could travel through and could absorb circularly polarized light." He adds that the magic size of the clusters was key in creating this pathway. "Magic-sized clusters are atomically precise replicates of each other," Robinson says. That uniformity means that each cluster has degenerate energy levels and an identical, repeated shape asymmetry that drives self-alignment. "Both are critical pieces for making excitonic chirality work," Robinson says.

"I am amazed at how effectively such a simple process produces high-quality chiral films across a considerably large area," says Yadong Yin of the University of California, Riverside. Yin notes that methods for creating chiral films from achiral nanoparticles often require the building blocks to have specific structural configurations or to be connected by chiral linkers. Here, instead, the technique only requires precise control of the drying meniscus front. That simplicity, he says, could allow the technique to be used to make chiral films from a wide variety of materials.

This ease of production is also a key feature for Jessica Wade of Imperial College London, who has developed organic chiral materials. "I love the techniques they use," she says. "Showing that you can imprint chirality on achiral [inorganic] building blocks and get such a strong response is really cool, and it complements lots of research activity going on in the organic world." Now that they have a proof-of-principle demonstration that inorganic chiral materials can be made this way, Robinson and his colleagues are looking at creating more complex patterns in their chiral-responsive films. "People know how to do this patterning in the organic world. Now we have access to it with the inorganic world," Robinson says.

Katherine Wright is the Deputy Editor of ***Physics Magazine***.

REFERENCES

1. T. J. Ugras *et al.*, "Transforming achiral semiconductors into chiral domains with exceptional circular dichroism," **Science 387 (2025).**