



**Figure 1 | Capturing the chiral structure of liquid crystals in a solid film.** **a**, Cellulose nanoparticles with spindle-like shapes arrange themselves into chiral, helical liquid-crystal arrays. Only part of the helical structure is shown here. **b**, Shopsowitz *et al.*<sup>1</sup> report the optimal reaction conditions for preserving the helical arrays when cellulose nanoparticles are embedded in a silica matrix to produce composite materials. **c**, After eliminating the cellulose nanoparticles from the composites using heat, the authors obtained self-supporting films of silica that have a chiral porous structure.

systems, and is responsible for the specificity of many biological processes for particular substrates. Chiral substances also interact with polarized light, an effect that is used in liquid-crystal displays. These displays contain a layer of cigar-shaped molecules that can line up parallel to each other, like fish in a school swimming in the same direction, forming a nematic liquid crystal. But, in another state, they form a twisted, screw-like assembly. This twisting introduces handedness to the ensemble of molecules, so that polarized light travelling through the resulting chiral nematic liquid crystal is rotated.

Numerous applications can benefit from the incorporation of chirality into hard materials, including catalysis, molecular separation, chemical sensing and optics. The interactions of chiral materials with other chiral species are amplified if very large interfaces are used between them. Porous materials can provide the necessary large surface areas, particularly mesoporous materials — those with pore sizes of 2–50 nanometres. Such materials have attracted much interest because their pore morphology can be controlled using templates. Commonly used templates include surfactant-based micelles, which form various phases such as cylindrical or spherical arrays<sup>2,3</sup>. Inorganic structures can be assembled around micelles so that subsequent removal of the template yields porous materials.

Prior to Shopsowitz and colleagues' work<sup>1</sup>, a mesoporous material had been made<sup>4</sup> from silica using chiral surfactant molecules as templates. The product consisted of micrometre-long, twisted, rod-like structures of hexagonal cross-section and contained nanometre-sized channels that spiralled around the rods, reminiscent of fibres in a rope. Cheaper, naturally abundant templates, in particular cellulose nanocrystals<sup>5,6</sup>, have also been explored as alternatives to inducing chirality in mesoporous silica. These are easily obtained by acid treatment of bulk cellulose, which is present in wood pulp, cotton, green algae and other natural sources.

Cellulose nanocrystals have spindle-shaped structures, diameters of a few nanometres and screw symmetry. They are prone to lining up

to form nematic liquid crystals with helical structures. One would therefore expect nanocrystalline cellulose to be a suitable template for the nanocasting of chiral porous systems. Indeed, two early studies<sup>5,6</sup> hinted that chiral mesopores in silica could be formed using these cellulose derivatives as templates, but the authors were careful to note that the chiral domains may have been confined to small, localized regions. Obstacles to achieving long-range helical ordering have included the high sensitivity of the chiral phase of the cellulose templates to pH, concentration and temperature, and the tendency of the silica precursor used in the synthesis to disrupt the order of the nanocrystalline cellulose template<sup>7</sup>.

These obstacles have now been overcome by Shopsowitz and colleagues<sup>1</sup>. They report that careful optimization of the synthesis conditions, especially the pH of the reaction solution, permits the preparation of mesoporous silica films in which chiral ordering of the pores occurs throughout the film (Fig. 1). The films were self-supporting after the removal of the cellulose template, and had high surface areas of several hundred square metres per gram of material. The authors obtained scanning electron micrographs of film surfaces, from which the chiral nature of the material was evident from the arrangement of the twisted rods that make up the film (see Fig. 3d on page 423).

Shopsowitz *et al.* observed that the iridescent colours of the template were reproduced in their solid inorganic material, but varied with the fraction of silica precursor included in the synthesis mixture. The colours of the silica films could therefore be tuned across the visible spectrum to the near-infrared region. The authors carried out circular dichroism experiments on their films — that is, they illuminated the films with circularly polarized light in which the electric-field vector of the light beam traces a helix around the axis of the beam. They thus confirmed that the films' colours originate from the selective reflection of left-handed polarized light by the left-handed chiral nematic structure of the films. The colours disappeared when Shopsowitz *et al.* filled the mesopores with liquids that had a refractive index the same as

that of the silica walls, because this cancelled out the effects of the chiral pore geometry throughout the film.

This study opens up new opportunities for chiral solids because it demonstrates that long-range helical ordering of pores is achievable using inexpensive, renewable, chiral template materials, in a process that should be scalable. As the authors point out<sup>1</sup>, cellulose is already widely used to separate mixtures of chiral compounds. Mesoporous silica that reproduces the helical features of cellulose should therefore also benefit numerous applications that rely on chiral effects — perhaps more so than cellulose itself, because mesoporous silica is easily modified with other chemical groups<sup>8</sup>.

Shopsowitz and colleagues' silica films should be suitable templates for nanocasting replica films made of other materials<sup>9,10</sup>. Nanocrystalline cellulose templates could probably also be used directly to make films of different compositions, although the authors' research<sup>1</sup> shows that it will be necessary to find the optimal reaction conditions for each material used. What's more, they clearly demonstrate the effects of chiral pore structures on the optical properties of their films, which rely on feature sizes at the length scale of several hundred nanometres — the wavelength of visible light. Whether the chiral features in these materials will influence molecular interactions on a much smaller length scale remains to be seen. But now that a robust synthesis of chiral mesoporous materials has been developed, the necessary testing is feasible. ■

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#### CORRECTION

In the News & Views article 'Biological physics: Filaments band together' by Jean-François Joanny and Sriram Ramaswamy (*Nature* **467**, 33–34; 2010), reference 12 (Chaté, H. *et al.* *Phys. Rev. E* **77**, 046113; 2008), not reference 11, should have been cited as the source of the image in Figure 1a.