Making liquid crystals stand tall

November 21 2011

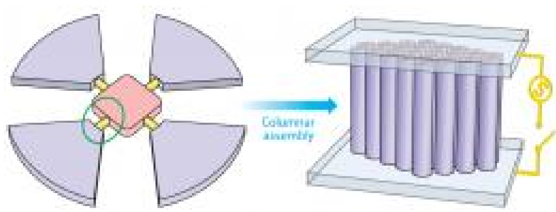

Figure 1: A new electric-field-responsive ‘handle’ (yellow bar, right) allows assembly of disc-shaped liquid crystals into thick columnar films suitable for practical devices. Credit: Wiley-VHC Verlag GmbH & Co.

Most liquid-crystalline displays contain rod-like molecules that quickly switch from one orientation to another when subjected to electric fields. This movement creates a shutter effect that turns light on and off at high rates. But the conductivity of rod-like molecules pales in comparison to disc-shaped, or discotic, liquid crystals. Composed primarily of aromatic molecules surrounded by flexible side chains, discotic molecules can stack into extended columns that enable one-dimensional charge transport and semiconducting capabilities. However, these columns have such tight packing that no one has found a way to orient them reliably using electricity.

Now, researchers led by Takuzo Aida from the University of Tokyo, Hideo Takezoe from the Tokyo Institute of Technology and Masaki Takata from the RIKEN SPring-8 Center in Harima have discovered that aromatic amides with branched, paraffin-like side chains can act as molecular 'handles' for electric field alignment1. Furthermore, they succeeded in growing discotic films hundreds of times thicker than before, putting devices that incorporate this technology one step closer to production.

Aida and colleagues were investigating discotic liquid crystals consisting of molecules called corannulene derivatives when they made their finding. Corannulene has a core of five fused hydrocarbon rings surrounded by ten aromatic amides, giving it a bowl-like shape. Despite this compound's large size, the researchers found that electric fields could uniformly align the columns with hexagonal geometries over a range of temperatures (Fig. 1).

The researchers first postulated that the inner dipole of the curved corannulene core accounted for the field-induced orientations. But when they synthesized a similar discotic liquid crystal containing a flat, non-polar triphenylene core, they observed the same striking field alignment—key evidence that the amide side chains acted as responsive handles that interact with the applied electric field and guide the discotic molecules into place.

Armed with this knowledge, the researchers synthesized several discotic columnar liquid crystals with slightly tweaked handles to optimize this behavior. Nearly all of these entities showed columnar alignment that persisted even after extinguishing the electric field. The team could also break apart the columns and restore the molecules' random orientations using a simple heating procedure.

Because the column heights depended on applied field strength, the researchers produced millimeter-thick films in any desired orientation by sandwiching their compounds between two large-area electrodes. "Unless conducting discotic columns can be aligned to macroscopic length scales, they will remain impractical," says Aida. "Therefore, our achievement is quite important for organic electronic device applications."

More information: Miyajima, D., et al. Electric-field-responsive handle for large-area orientation of discotic liquid-crystalline molecules in millimeter-thick films. *Angewandte Chemie International Edition* 50, 7865–7869 (2011).

Provided by RIKEN