New Carbon Nanomaterials by Covalent Capture of Discotic Liquid Crystals

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The excitement surrounding new carbon nanomaterials is largely due to their *directional* properties, which arise from the inherent directionality in the graphene layers that are their basic building blocks. This new NIRT project focuses on new ways of controlling graphene layer orientation in nanocarbons and its exploitation in the fabrication of tough nanocomposites.

In the first phases of the project, the team has fabricated two wholly new carbon materials: orientationally ordered and patterned thin films [Jian et al., 2004] and a crystallographically "inverted" form of carbon nanotubes [Sousa et al., 2004]. Figure 1 shows a surface with a unique pattern of molecular orientation formed by contacting the liquid crystal material with a lithographically produced template. The patterned template is fabricated from thin films of polyimide, which orients the disk-like liquid crystal molecules face-on, and photoresist, which orients the molecules edge-on. The structure is then locked in place by oxidative stabilization and heating above 700 C to create the first orientationally patterned carbon surfaces.

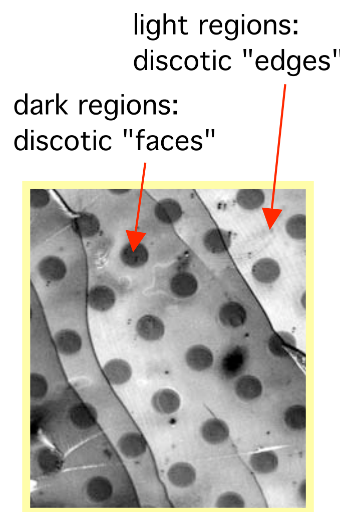

Figure 1. Orientationally patterned discotic surface

The team has also made novel "all-edge" thin films using a new water-soluble precursor material (see Fig. 2). Edge-plane crystal facets in carbon are known to have high activity for many chemical processes. Thus, we anticipate a variety of applications for these edge-rich films, including catalyst substrates and interfacial bonding layers in composites.

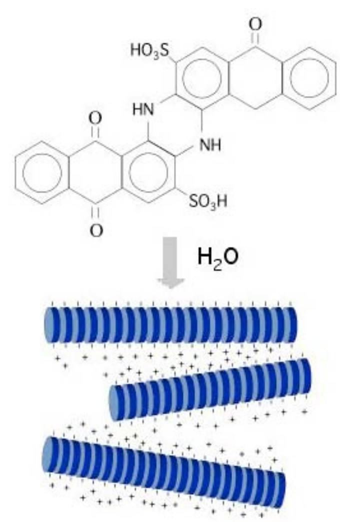

Figure 2. Indanthrone disulfonate, a water soluble polyaromatic compound that forms rod-like aggregates and lyotropic liquid crystalline phases in aqueous solution.

The use of liquid precursors also offers the ability to "write" our nanotubes and nanofiber arrays using liquid injection "pens" driven by computer-controlled translation stages (see Fig. 3). This allows arbitrarily complex micro-patterns of straight, uniform, aligned, and unentangled nanotube arrays to be written on flat substrates [Sousa et al.].

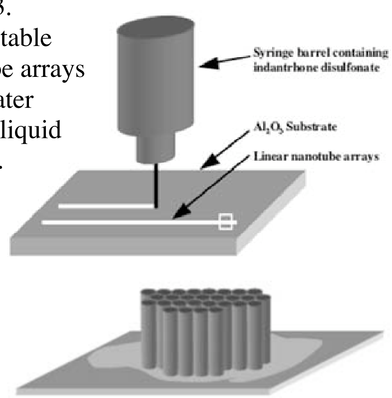

Figure 3. Pen-writable nanotube arrays from water soluble liquid crystals.

Jian K., Xianyu H., Eakin J., Gao Y., Crawford G.P., Hurt R.H., "Orientationally Ordered and Patterned Discotic Films and Carbon Films from Liquid Crystal Precursors," *Carbon*, 2004 in press.

Sousa, M. Chan, C., Jian, K., Gao, Y., Paukshto, M., Yang, N., Crawford, G.P., Hurt, R.H. "Micro-Patterned Carbon Nanotube Arrays using Pen-Writable Lyotropic Liquid Crystals", SID Digest, 2004, in press.