Inverted liquid crystals

Discotic liquid crystals can be used for a variety of electronic and optical applications including solar cells and display technology. The common structure of discotic liquid crystals consist of a rigid core in the shape of disks or macrocycles with peripheral flexible side groups that point outwards. Sigurd Höger and colleagues have now reported nanometre-sized shape-persistent macrocycles with flexible alkyl chains, attached to the rigid backbone, that actually point to the inside *(Angewandte Chemie International Edition* http:/ dx.doi.org/10.1002/anie.200462319). Thermal behaviour and X-ray single-crystal structure analysis demonstrate that these unusual compounds melt at a certain temperature to form a mesophase, suggesting that the interior space is filled with its own alkyl chains. These investigations indicate that the presence of adaptable substituents is not a structural prerequisite for designing these inverted structures, thereby suggesting the possibility of forming a wide variety of liquid-crystalline macrocycles with different aspect ratios and properties.

SHEDDING LIGHT ON NANOSCALE HEAT TRANSFER

Heat transfer in nanoscale structures such as quantum wells and constrictions is well known to occur through phonon transport. But how is heat transferred between two nanoscale objects that are not in contact (and thus cannot support phonon transport), such as the tip of a near-field scanning optical microscope and a surface? Although radiative heat transfer through photons will be negligible in this situation, near-field radiation may be important. Gilberto Domingues and colleagues have now analysed this situation theoretically (*Physical Review Letters* 94, 085901; 2005) and found that at separation distances (d) greater than four diameters, the thermal conductance varies as d^{-6} due to dipole-dipole coupling of the nanoparticles. But there is a strong enhancement of thermal conductance when the nanoparticles are separated by less than four diameters, followed by a decay as the nanoparticles are brought into contact. This unusual effect at small separation distances is due to the contribution of multipolar Coulomb interactions, and is similar to the coupling of surface plasmons responsible for the waveguiding in strings of metal nanoparticles (S. Maier *et al. Nature Materials* 2, 229–232; 2003). The results lead to the surprising conclusion that the thermal conductance of a chain of closely spaced nanoscale particles could be larger than that of a continuous rod.

Electronic paper sees the light

Researchers have developed a method of improving the surface of paper for use as a substrate for electronic devices. Electronic paper, embedded with flexible electronic circuitry that allows it to change its print dynamically in response to a reader's commands, is the archetypal dream made possible by the advent of organic electronics. But although the properties of paper are ideal for books, newsprint and the myriad of things for which paper is used, as a substrate on which to grow electronic circuits of any kind, it is awful. The main reason for this is the extreme roughness of paper in comparison with the micrometre-to-nanometre-thin layers from which both organic and inorganic electronic components are made. In spite of this, Bernhard Lamprecht and colleagues keep the dream of electronic paper alive by growing an array of organic light sensors on the most challenging paper substrate of all, newspaper *(Physica Status Solidi* **202**, R50–R52; 2005). Taking a cutting from the German weekly, *Die Zeit*, the authors coat their newspaper with two conditioning layers to protect it from moisture and to smooth out its surface, which allows successive electronic layers to be patterning into working devices.

An all-round investigation

Generating ions from a material and then feeding them into a high-resolution mass spectrometer is the general basis for chemical analysis. Although many techniques exist for ionization, current ion sources suffer limitations in terms of practical usability and versatility owing to requirements for reduced pressure, high electrical potentials, elevated temperatures or procedures for sample preparation. A new ion source, based on the reactions of metastable helium and nitrogen molecules produced in an electrical discharge at atmospheric pressure, allows rapid, easy and non-destructive analysis of all materials (*Analytical Chemistry* http://dx.doi.org/10.1021/ac050162j). The excited gas molecules react with analytes in the gas, liquid or solid state. Moreover they can detect compounds directly from the surfaces they lay on. In this way, the presence of a drug can be detected from the cocktail glass in which it was poured, clothes can reveal vicinity to explosive compounds hours after the occurrence, bodily fluids can be found on concrete or asphalt and might even tell whether the person had drunk coffee, had been taking medicines or was poisoned. Other surfaces that can be directly analysed with this method are human skin, metals, paper, leaves, fruit and vegetables. This certainly promises to develop into an excellent tool for forensic investigation, security or health screenings and quick food analysis.

Unique multiferroic

Materials in which both ferroelectricity and ferromagnetism exist hold promise for electronic devices of the future, for example, for storage media that could use both types of polarization. This coexistence is rare, but Peter Lunkenheimer and colleagues have now discovered (*Nature* 434, 364–367; 2005) that the simple cubic spinel structure of $CdCr_2S_4$ has both ferromagnetic ordering and relaxor ferroelectricity (a ferroelectric cluster having a diffuse phase transition). Close to its ferromagnetic ordering temperature, it was found that the magnetocapacitive coupling — variation of the dielectric constant in an external magnetic field — is colossal, approaching 500%, and offers great potential for future applications. Unlike other materials, in $CdCr_2S_4$ the ferroelectricity and ferromagnetism develop independently. Both phenomena are compatible with global cubic symmetry, and are independent of the direction of the magnetic field with respect to the electric field. These combined factors make this spinel system unique, and indicates that $CdCr_2S_4$ belongs to a new class of multiferroics.