11th International Conference on Advanced Materials

Rio de Janeiro Brazil
September 20 - 25

ICAM2009

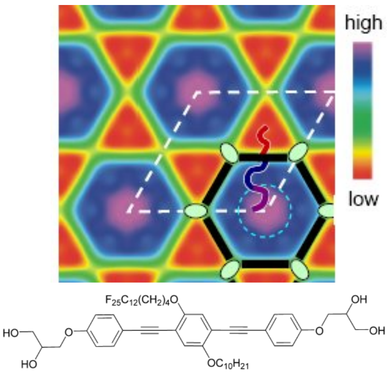
Liquid crystal columnar phases with multicolour tiled superlattices

M. A. Bates(1)*, B. Glettner(2), R. Kieffer(2), F. Liu(3), C. Tschierske(2), G. Ungar(3),
M. Walker(1) and X.B. Zeng(3)

(1) Department of Chemistry, University of York, UK.
(2) Institute of Chemistry, University of Halle, Germany.
(3) Department of Engineering Materials, University of Sheffield, UK.
* Corresponding author. E-mail: mb530@york.ac.uk
Web: http://www.york.ac.uk/chemistry/staff/academic/a-c/mbates

Abstract – New columnar liquid crystalline phases have been discovered with large, multicolour tiled superlattices. The relatively small molecules forming these phases are based on X-shaped bolaamphiphiles, with a rigid central aromatic core, H-bonding terminal groups, and two incompatible side chains. The phase behaviour observed depends on the relative lengths of the lateral chains. Small modifications of these lengths can lead to a multitude of different phases with different two dimensional cross-sections.

A range of new liquid crystal structures have been found recently in T-shaped bolaamphiphiles, which typically contain an aromatic rod-like core, two terminal H-bonding groups and an aliphatic lateral chain. Many of these have the form of columnar "honeycomb" phases with aromatic walls and aliphatic channels. The cross-sections of the honeycomb cells can take many forms, from triangle to hexagon and beyond [1,2]. These studies have been extended to X-shaped amphiphiles, with two similar chains attached to the opposite sides of the aromatic core [3,4]. The honeycombs thus created have walls only one molecule in thickness. Here we report a new development where the two side-chains are different and incompatible with each other. The structures were studied by SAXS and GISAXS, with electron density map reconstruction and model refinement, combined with computer simulations which help in the interpretation of the experimental X-ray data and the design of new compounds with targeted tiling patterns. The inclusion of incompatible lateral chains (R1 and R2) has led to the creation of honeycombs having channels with different contents, or "colours". The channels, or in 2D, polygonal tiles, can contain pure R1 and R2. An example is the well-known kagome lattice, consisting of hexagons and triangles, and achieved here for the first time in liquid crystals [5] (Fig. 1). However, due to conflicting geometrical requirements for some lattices, complete nano-phase separation cannot always be achieved, and channels may have mixed content. This miscibility-geometry balancing act leads to a wealth of frustrated tiling patterns and a number of very large 2D unit cells, containing up to 16 tiles (channels) of various shapes. These results illustrate the potential of liquid crystal engineering in creating highly complex but regular self-assembled nano-scale patterns. Even with relatively small molecules, large periodicities can thus be obtained, approaching the photonic scale.



1: Cr 75 °C [6.3] M 86 °C [0.9] Col_{hex}/*p6mm* 116 °C [4.2] Iso

Figure 1: The liquid crystalline kagome lattice [5], formed by bolaamphiphiles with two incompatible side chains.

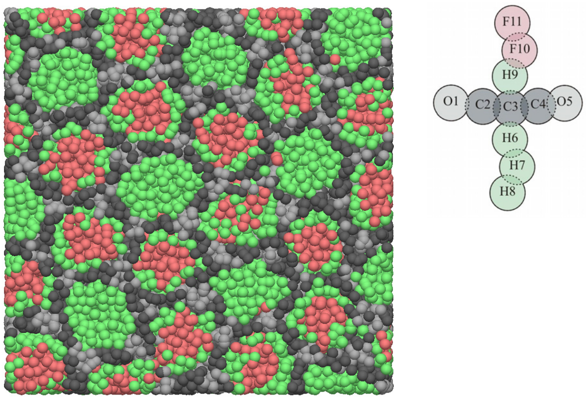


Figure 2: Computer simulation of a frustrated 2-colour hexagonal columnar phase [4].

This work is the result of a collaboration within the SCALES network (http://scales.nano-sons.eu) under the European Science Foundation Eurocores SONS-2 scheme, supported by funds from EPSRC (UK) and DFG (Germany).

[1] M. Prehm, F. Liu, U. Baumeister, X. Zeng, G. Ungar and C. Tschierske, Angew. Chem. Int. Ed. 2007, **46**, 7972.
[2] M. A. Bates and M. Walker, Soft Matter 2009, **5**, 346.
[3] R. Kieffer, M. Prehm, B. Glettner, K. Pelz, U. Baumeister, F. Liu, X. Zeng, G. Ungar and C. Tschierske, Chem. Comm. 2008, 3861.
[4] M. A. Bates and M. Walker, Phys. Chem. Chem. Phys. 2009, **11**, 1893.
[5] B. Glettner, F. Liu, X. Zeng, M. Prehm, U. Baumeister, M. Walker, M. A. Bates, P. Boesecke, G. Ungar and C. Tschierske, Angew. Chem. Int. Ed. 2008, **47**, 9063.