“Self-assembly of Organic Ferroelectric diodes” Abstract

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During the past few years, many efforts to construct organic non-volatile memory devices have been directed towards ferroelectric diodes that are based on blends of ferroelectric and semiconducting components.¹ The ferroelectric components polarize in response to an external electric field acting as a “memory system” and the semiconducting components are responsible for efficient charge injection. The current designs for organic non-volatile memory devices are based on blends of random copolymer poly(vinylidene fluoride-trifluoroethylene) (P(VDF-TrFE)) and poly(3-hexylthiophene) (P3HT) as organic ferroelectric and semiconductor, respectively.² In the blends of P(VDF-TrFE) and P3HT, phase separation takes place at a scale of a few hundred nanometers (100-200 nm). In our work, a new type of ferroelectric diodes for plastic electronics will be developed, based on the self-assembly of an organic nanophase separated material with columnar structure consisting of a ferroelectric component and a semiconducting component. We try to reduce the length scale of phase separation to approximately 1 nanometer. Thus, a better defined structure and more controllable polymer system which has a high storage density will be obtained.

Benzene-1,3,5-tricarboxamides (BTAs) are ideal candidates as ferroelectric components, based on their columnar liquid crystal properties, self-assembly behavior and the strong macroscopic dipole (Figure 1).³

Figure 1: The microstructure, liquid crystal and macrodipole properties of BTA.

In order to create a bicontinuous, microphase separated material containing both ferroelectric switchable and semiconducting components, a series of BTA derivatives connected with polymerizable pyrrole groups in different alkyl chain lengths from four to twelve carbon atoms have been synthesized. The chemical information of all compounds was analyzed by Nuclear Magnetic Resonance (NMR) and Infrared Spectroscopy (IR spectroscopy) and the phase behavior of all compounds were studied by Differential Scanning Calorimetry (DSC) and Polarized Optical Microscopy (POM). Wide-angle X-ray Scattering (WAXS) was used to determine the crystalline and liquid crystalline structures. The compounds 1 – 4 all show a liquid crystalline phase in temperature range between 25°C and 135°C. XRD shows columnar phases of different complexity. Identification of these phases is in progress. Future work will be aimed at polymerization of the pyrrole units in the LC phase.

References:
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