Nanoscale Polarization in Molecular Ferroelectrics

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There has been renewed interest in organic ferroelectrics, stimulated by emerging opportunities in organic electronics. Most of the attention has been focused on linear polymers based on vinylidene fluoride, by virtue of the ease and variety with which they can be fabricated and integrated with organic electronics. One of the limitations of ferroelectric polymers is the unavoidable disorder associated with polymer crystallization. Molecular ferroelectrics are a promising alternative, because they are structurally flexible, can be engineered at the molecular level, and readily form high-quality single crystals of virtually any size. Furthermore they are inexpensive to produce, because they don't require epitaxy for fabrication and can be assembled on nearly any surface, including flexible sheets and fabrics. Until recently, however, molecular ferroelectrics were limited in utility by relatively low polarization, high coercive field, and low Curie temperature, making them of limited practical use.[1] In recent years, several promising *molecular ferroelectrics* have emerged that have robust room-temperature ferroelectric properties. polarization comparable to that of barium titanate, low coercive field, and stable ferroelectricity well above room temperature. I will focus on two promising types of molecular ferroelectric, one involving two-dimensional hydrogen-bond ordering,[2] and the other involving molecular inversion,[3] both of which have stable room-temperature polarization of approximately 20 $\mu C/cm^2$ and coercive field of order 5 kV/cm, comparable to barium titanate. We have had some success probing and manipulating polarization at the nanoscale. For example, both types of molecular ferroeelctric can be grown in textured thin films[4, 5] and exhibit nanoscale domains that are readily manipulated.[5, 6] These developments open the doors to application of molecular ferroelectrics to a wide range of technologies, e.g., energy harvesting, computing, displays, lighting, and sensors, especially when paired with organic electronic materials, or with 2D electronic materials, such as graphene or molybdenum disulfide (MoS_2). The main challenges for high-performance molecular ferroelectrics include the unknown limits of polarization stability at the nanoscale, and in their relatively low tolerance to the high temperatures found in traditional electronics manufacturing.

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