The electrostatic origin of chiral patterns on nanofibers

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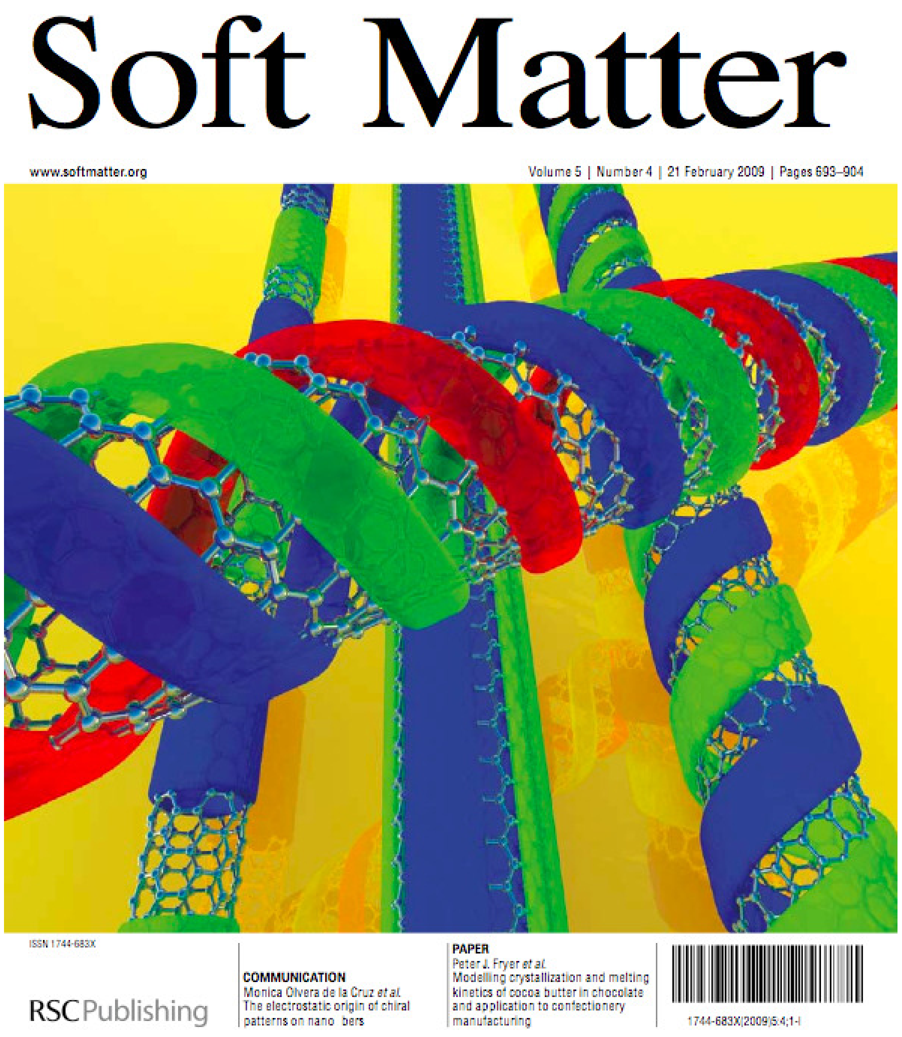
Soft Matter, 2009, **5**, 736.



"An object is chiral if it cannot exactly superimpose its mirror image by translation or rotation". We live in a world that is full of chiral objects: shoes, scissors, corkscrew, and newspapers. At a more microscopic level and in the realm of biological systems, Nature seems to play a symphony with chiral structures: DNA, proteins, amino acids, sugars are all chiral, and opposite chiral version have often completely different properties. Moreover, helical structures (that are a quintessential example of chirality) spontaneously arise in the form of collagen, actin, or viruses. Helices appear also in simpler systems, such as synthetic materials at the nano-meter scale like carbon nanotubes, or fullerenes. Clearly all of the above fits with the general evolutionary strategy of achieving biological functions by breaking the symmetry of the forces that are responsible of their self-assembly, i.e. electrostatic interactions. However, while on one hand it is well known that the at the sub-atomic level weak-forces are fundamentally chiral, on the other hand how electrostatic forces can generate a chiral world is still one of the most enigmatic of all biophysical phenomena to date.

Our group has recently shown how electrostatic interactions alone can give rise to helical shapes. We constructed a model that captures all possible regular shapes an object like DNA or a helical virus could have and computed, the preferred arrangements induced by electrostatic interactions. Chirality can spontaneously arise as a consequence of electrostatic interactions only, without requiring the presence of other more complicated interactions such as dipolar or short-range Van Der Waals types. The model describes several ionic cylindrical helical structures including viral helical surface arrangements. It also describes arrangement of DNA mixed with carbon nanotubes, which have been shown to have the ability to form helices around the nanotubes thereby separating the different types of carbon nanotubes into families.