



## Nano Focus

## Click coupling conjugated polymers to semiconductor nanorods

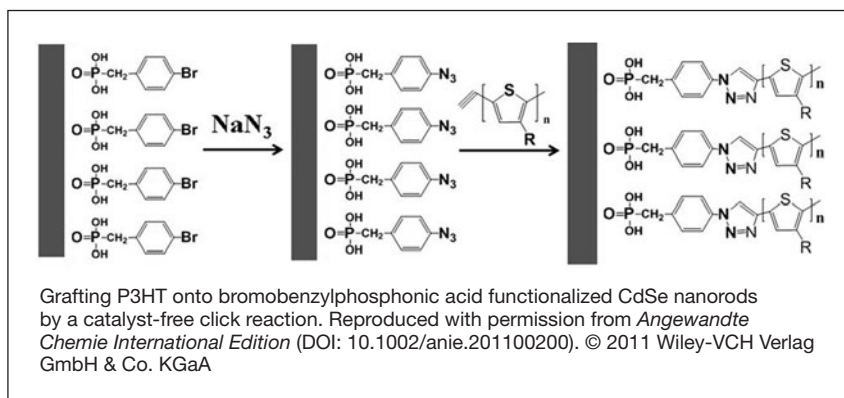
Conjugated polymers combine flexibility and ease of processing with good optoelectronic properties which make them ideal for organic devices such as solar cells. Introducing quantum dots as electron acceptors in such devices can improve electron mobility, but blends with polymers are often hampered by phase separation and slow charge transfer at the inorganic–organic interface. In the April edition of *Angewandte Chemie International Edition* (DOI: 10.1002/anie.201100200; p. 3818), Z. Lin and co-workers at Iowa State University and Georgia Institute of Technology describe a simple “click” reaction for chemically bonding these two materials and facilitating the electronic interaction between them.

Their research employs the widely studied conjugated polymer poly(3-hexylthiophene) (P3HT), and semiconductor nanorods of cadmium selenide. Elongating one dimension of quantum dots to form nanorods has proved to be beneficial in many device applications because of reduced electron conduction pathways and an extended range of absorbed wavelengths. The researchers promote the growth of their CdSe

particles into 40-nm long rods by using bromobenzylphosphonic acid as a surface passivating ligand. The acid group binds to the crystal surface while the terminating bromines are left available for further reaction with  $\text{NaN}_3$  to convert them to azides. These groups can then be coupled to ethynyl-terminated P3HT through a Huisgen cycloaddition reaction which belongs to the direct, catalyst-free, bond-forming reactions

charge transfer between the two materials is evident from almost complete quenching of the polymer fluorescence and much faster fluorescence lifetime for the chemically bound composite.

The use of a cycloaddition to couple conjugated polymers to the surface of a nanocrystal provides an effective alternative to more established ligand-exchange methods, and results in over twice the density of attached polymers. Chemi-



of click chemistry. The success of this step was confirmed by proton nuclear magnetic resonance of the coupled ligand and polymer after detaching them from the crystal surface.

Electron microscopy of the resulting composite reveals that there is no phase separation, and therefore a much larger interface than for an equivalent physically blended material. Efficient

cal bonding appears to considerably enhance charge separation at the material interface, and is therefore promising for hybrid solar cells. This research demonstrates the potential of click chemistry when applied to materials, allowing even further scope for chemical tailoring to device applications.

**Tobias Lockwood**

## Study helps explain superconducting behavior of metallic, insulating pnictides

Researchers Q. Si and R. Yu of Rice University and J.-X. Zhu of Los Alamos National Laboratory have offered one of the first theoretical explanations of how two dissimilar types of high-temperature superconductors behave in similar ways.

Reporting in the May 6th issue of *Physical Review Letters* (DOI: 10.1103/PhysRevLett.106.186401), the research team describes how the magnetic properties of electrons in two dissimilar fami-

lies of iron-based pnictides could give rise to superconductivity. One of the parent families of pnictides is a metal— $(\text{Ca}, \text{Ba}, \text{Sr})\text{Fe}_2\text{As}_2$ —and was discovered in 2008; the other is an insulator— $(\text{K}, \text{Tl})_{1-x}\text{Fe}_{2-x}\text{Se}_2$ —and was discovered in late 2010. Experiments have shown that each material, if prepared in a particular way, can become a superconductor at roughly the same temperature. This has left theoretical physicists scrambling to determine what might account for the similar behavior between such different compounds.

Lead author Q. Si said that the explanation is tied to subtle differences in the way iron atoms are arranged in each

material. The pnictides are laminates that contain layers of iron separated by layers of other compounds. In the newest family of insulating materials, iron atoms are selectively removed, leaving behind an orderly pattern of vacancies in the iron layer.

Si suspected that the explanation for the similar behavior between the new and old compounds could lie in the collective way that electrons behave in each compound as they are cooled to the point of superconductivity. His prior work had shown that the arrangement of the iron atoms in the older materials could give rise to collective behavior of the magnetic moments, or spins, of electrons.