

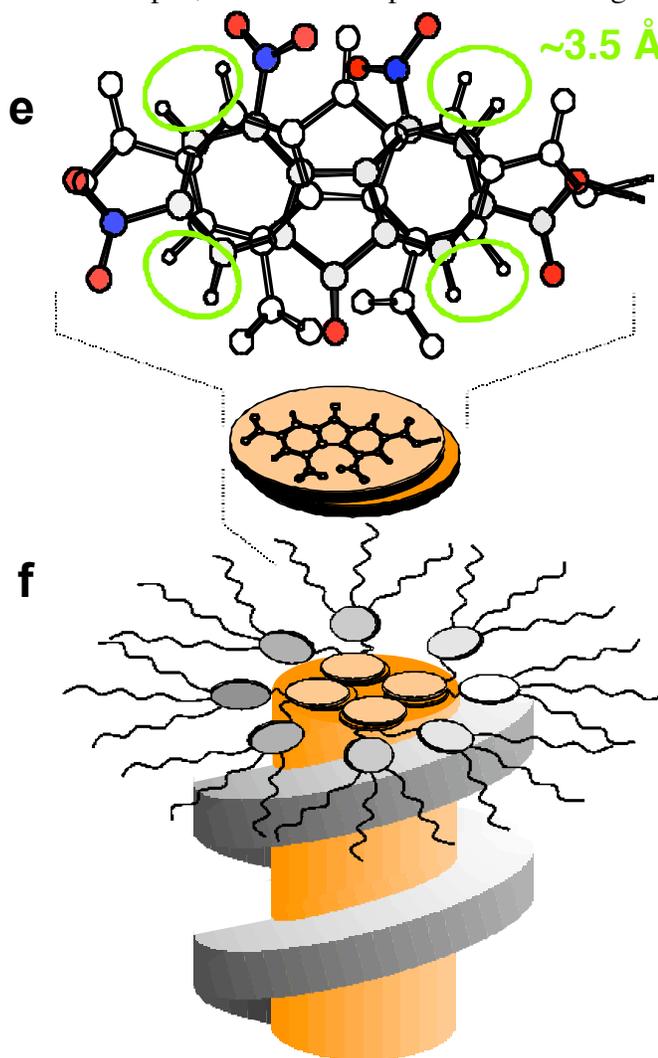
## Single-Molecule Functional Nanostructures

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The ability to transition nanoscience and engineering (NSE) research to nanotechnology will depend on the development of efficient new synthetic methods to produce monodisperse nanoscale objects. To this end, the primary goal of this Nanoscale Interdisciplinary research team (NIRT) is to enable a rational approach to the design and synthesis of libraries of complex, functional, monodisperse objects of well-defined shapes, dimensions up to the wavelength of light, surface, and internal compartmentalized architecture. To accomplish this goal, the NIRT combines synthetic methodologies from Materials and the Life Sciences. The NIRT has assembled expertise in organic, macromolecular, supramolecular, and peptide synthesis, along with theory and modeling, and structural analysis by x-rays, TEM, and SFM. The team effort is amplified by exploiting established links with partners in industry and in Europe. Success will reveal the principles required for the construction of libraries of monodisperse self-assembling dendritic building blocks, to enable the hierarchical design of monodisperse single-molecule functional nanostructures (SMN) with shape, chirality, internal and external structure, and function controlled at the level of precision currently available only in biological systems. The NIRT will investigate the structure and properties of these nanoscale objects at the level of the single molecule and in 2-D and 3-D assemblies. Novel applications of SMNs are elaborated that have potential to yield nanoscale devices for electronic, optical, chemical and medical technologies [1].

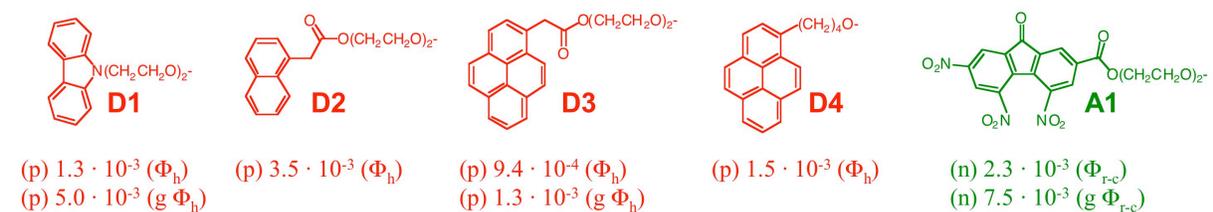


**Figure 1**

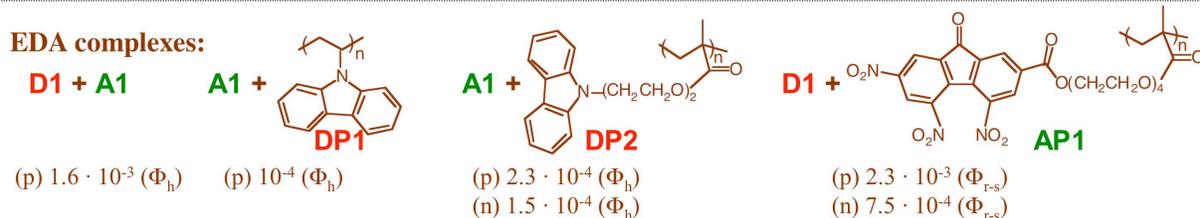
We have successfully functionalized dendrimers with electron donors and acceptors which self-assemble into columns of  $\pi$ -stacks with carrier mobilities enhanced by two to three orders of

magnitude over the amorphous state (see Figure 2) [2]. In Figure 1, we show an example (e) of two stacked nitro-flourenone moieties with proton-proton separations of 3.5Å. These are stacked in the center of a helical dendron coat (f), responsible for the self-assembly of the sandwiches. Each of these nanocolumns further self-assemble into a “self-processed” material with roughly  $10^{12}$  columns per square centimeter. More importantly, the electron and hole mobilities are between  $10^{-4}$  and  $10^{-3}$  cm<sup>2</sup>/V/s, in a range useful for molecular devices. Because these materials self-assemble they should provide an alternative, simpler route to nanoscale electronics – single columns can be assembled *in situ* to connect electrodes and components. It will be possible to replace molecular components, such as carbon nanotubes, with supramolecular components [3].

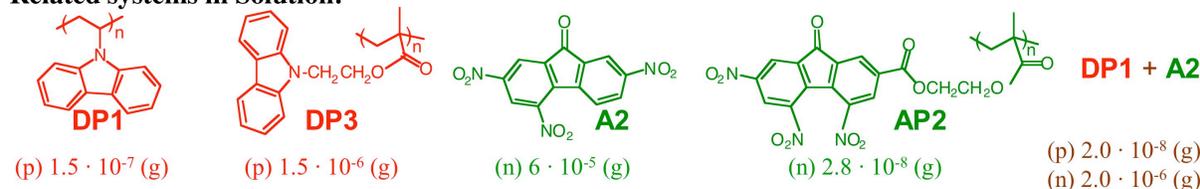
**Self-processed Structures:**



**EDA complexes:**



**Related systems in Solution:**



**Figure 2:** Donor, acceptors and donor-acceptor complexes in self-processed structures have significantly higher mobilities (in cm<sup>2</sup>/V/s) in the amorphous state. For comparison, typical mobilities in conducting polymers are roughly 1 cm<sup>2</sup>/V/s.

**References**

- [1] For further information about this project email [percec@sas.upenn.edu](mailto:percec@sas.upenn.edu) or [kamien@physics.upenn.edu](mailto:kamien@physics.upenn.edu)  
 [2] V. Percec, *et al.*, “Self-organization of helical dendrimers into complex electronic materials”, *Nature* **419** (2002) 384–387.  
 [3] E.W. Meijer and A.P.H.J. Schenning, “Material marriage in electronics”, *Nature* **419** (2002) 353--354.