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Conducting Polymers

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Conductive polymer (organic polymers)

* A conductive polymer is an organic polymer semiconductor, or an organic semiconductor. Roughly, there are two classes the charge transfe complexes and the conductive polyacetylenes. the latter include polyacetylene itself as well a polypyrrole, polyaniline and their derivatives.

Most commercially produced organic polymers are electrical insulators. Conductive organic polymers often have extended delocalize bonds (often composed ~~from~~ of aromatic units). At least locally, these create a band structur similar to silicon, but with localized states. When charge carriers (from the addition or removal of electrons) are introduced into the conduction or valance bonds the electrical conductivity increases dramatically. Technicall almost all known conductive polymers are semiconductors due to the band structure and low electronic mobility.

However, so-called zero band gap conductive polymers may behave like metals. The most notable difference between conductive polymers and inorganic semiconductors is the mobility, which until very recently was dramastically lower in conductive polymers than their inorganic counterparts, though recent advancements in molecular self-assembly are closing that gap.

Delocalization can be accomplished by forming a conjugated backbone of continuous overlapping orbitals. For example, alternating single and double carbon-carbon bonds can form a continuous path of overlapping p orbitals. In polyacetylene, but not in most other conductive polymers, this creates degeneracy in the frontier molecular orbitals (the highest occupied and lowest unoccupied orbitals named HOMO and LUMO respectively). This leads to the filled (electron containing) and unfilled bands (valence and conduction bands respectively) resulting in a semiconductor

However, conductive polymers generally exhibit very low conductivities. In fact as with inorganic amorphous semiconductors conduction in such relatively disordered materials is mostly a function of "mobility gaps" with phonon-assisted hopping, polaron-assisted funnelling etc. between localized states and not band gaps as in crystalline semiconductors.

In more ordered materials, it is not until an electron is removed from the valence band (p-doping) or added to the conduction band (n-doping) which is far less common) does a conducting polymer become highly conductive. Doping (p or n) generates charge carriers which move in an electric field. positive charges (holes) and negative charges (electrons) move to opposite electrodes. This movement of charge is what is actually responsible for electrical conductivi in crystalline materials.

In contrast, typically, "doping" in the polyacetylene-derived conductive polymers involves actually oxidizing the compound. Conductive organic polymers associated wit a protic solvent may also be "self-doped"

Melanin is the classic example of both types of doping, being <u>both</u> an oxidizat polyacetylene and likewise commonly being hydrated.

Common classes of organic conductive polymers include poly(acetylene)s, poly(pyrrole)s, poly(thiophene)s, poly(aniline)s, poly(fluorene)s, poly(3-alkylthiophene)s, polytetrathiafulvalenes, polynaphthalenes, poly(phenylene sulfite), and poly(para-phenylene vinylene)s. classically, these linear backbone polymers are known as polyacetylene polyaniline, etc. "blacks" or melanins." the melanin pigments in animals is generally a mixed copolymer of polyacetylene, polypyrrole, and polyaniline.