Piano di attività e progetto di ricerca

This reaserch project is centered on the preparation of foldamers for quantum-induced spin selectivity, that will be studied in the PRIN 2017 project "Quantum detection of chiral-induced spin selectivity at the molecular level".

The chiral-induced spin selectivity effect (CISS), opens interesting perspectives to shed further light on spin effects in chemistry and biology as well as to design new avenues towards magnetless spintronics and more efficient molecular electronics. When charge transport occurs through a chiral molecule, electrons with one spin orientation with respect to their velocity (parallel or antiparallel) are preferentially transmitted, yielding a spin polarized current. The preferred orientation depends on the particular molecular structure considered, but reverts upon changing molecular handedness. This spin filtering ability of chiral systems appears in the low-transmission tunneling regime typical of nonconjugated molecules and was indeed discovered working on chiral layers made of L- or D-stearoyl lysine and double-stranded DNA. Building on this, it has been conjectured that CISS effect may explain why evolution has selected chiral saturated macromolecules (peptides) for long range electron transfer processes.

While DNA strands continue to attract attention, the pool of CISS-active molecules has now much expanded to include conductive polymers, proteins like bacteriorhodopsin (bR), Photosystem I (PSI) or cytochrome c, as well as the modular structures of synthetic oligopeptides and foldamers. Studies on DNA, oligopeptides and foldamers were crucial to prove the expected increase of spin filtering efficiency with molecular length. Foldamers are an especially versatile family of medium size molecules (about 500-5000 Dalton) that adopt specific and stable conformations, like those seen among proteins and nucleic acids (i.e. helices, turns and sheets). They are classified as biotic or abiotic depending on their chemical structure and folding principles. Abiotic foldamers are mainly aromatic rich sequences that contain no chiral centers and easily fold forming stable helices, but with no preference for a left- or a right-handed helix. By contrast, biotic foldamers (e.g. Aib-Ala oligomers) are based on amino acids (or their derivatives), are naturally endowed with chiral centers and are thus easily prepared in homochiral form. They offer myriad possibilities for the construction of sophisticated folded architectures with applications ranging from biomedicine to material science.

The CISS response has been so far detected by organizing such chiral molecules as a self-assembled monolayer on a solid substrate and using a variety of experimental approaches. In spin-resolved photoemission, electrons photoemitted by a nonmagnetic substrate are transmitted through the chiral monolayer and their spin polarization is measured directly. Hall-effect measurements were also used to probe CISS effect in a device containing no magnetic materials. However, the largest number of studies were based on magnetoresistance measurements (in devices or by using scanning probe methods), on capacitive detection of photoinduced charge-separation, and on spin dependent electrochemistry (SDE). In all these cases, electrons are injected in a monolayer of chiral molecules through a ferromagnetic electrode, whose magnetic polarization is inverted with an external magnetic field causing changes in electric transport.