Spin specific electron transmission through helical organic molecules

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In electron transfer processes, usually electron-spin effects are seen either in magnetic materials or in systems containing heavy atoms that facilitate spin-orbit coupling. Here we present spin-selective transmission of electrons through organic molecules with helical symmetry.

Electron dichroism, namely different interactions of longitudinally spin-polarized electrons with chiral molecules, has been reported for vapors of various chiral molecules. In those experiments, spin-polarized electron beams are attenuated differently, depending on the longitudinal spin polarization of the electrons and the enantiomer of the molecules. Asymmetries of the attenuation in the gas phase for electrons of opposite longitudinal spin polarization have been measured to be in the order of 10^{-4}[1], which could be rationalized theoretically in terms of a spin-dependent differential cross-section based on spin-orbit interaction.

More recently, the transmission of low-energy photoelectrons through ordered self-assembled layers of chiral molecules has been studied, showing an intensity dichroism for the two circular polarizations. This observation has been interpreted as a spin-dependent transmission through these ordered layers. We extend these studies by directly measuring the electron spin polarization using a calibrated Mott detector. The observed spin selectivity at room temperature is extremely high as compared with other known spin filters. A systematic study on self-assembled monolayers of DNA shows that the spin filtration efficiency depends on the length of the molecules adsorbed on the gold surface [2]. In addition, the organization of the adsorbed molecules has an important influence: single-stranded DNA molecules, which form a rather floppy instead of an ordered layer, show almost no spin-filtering effect. In addition, the spin transmission studies have been extended to bacteriorhodopsin membrane protein physisorbed on surfaces. The protein consists of 248 amino acids arranged in a configuration with 7 alpha helices. Spin polarization measurements yield up 15% spin polarization for transmitted electron ensembles with a dependency on the preparation scheme. Since the constituents of the organic molecules (P, N, C, H) used in the experiments have low atomic numbers, spin-orbit-coupling is not sufficient to explain the observation of the quite large spin-specific interaction. Even though very recently different models were published aiming to rationalize the observed effect it is not understood so far.

References:
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