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Low Field, Large Magnetoresistance in Nonmagnetic Organic Semiconductors[1]

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Transport in various thin-film organic semiconductors has been shown to have an anomalously high sensitivity to low magnetic fields at room temperature (RT). Early experiments on polydiacetylene single crystals and poly(phenylenevinylene)s revealed increases in photoconductivity of a few percent at RT.[3] Further magnetotransport studies showed larger effects in π-conjugated backbone polymers and small molecules.[4] We report magnetoresistance (MR) for semiconducting oligomer and nonconjugated polymer materials in addition to small molecule and conjugated backbone polymer materials. For example, films of the light emitters poly(N-vinylcarbazole) and Alq_3 each have an MR response greater than 5% at an unusually low magnetic field of 100 Oe ($\mu_B H \sim 0.0006$ meV) at an unusually high temperature of 300 K ($k_B T \sim 26$ meV). Increasing the spin-orbit coupling in Alq_3 films by doping with the phosphorescent sensitizers $Ir(ppy)_3$ or PtOEP strongly suppresses the MR signal. MR in thin films of the oligomer α-sexithiophene can be negative, similar to the behavior of other organic semiconductors, or positive depending on the temperature, layer thickness, or applied voltage. We have developed a model, termed Magnetoresistance by the Interconversion of Singlets and Triplets (MIST), accounting for this anomalous MR.[5] At zero field, the singlet and triplet e-h pair states are degenerate and the states can readily interconvert due to hyperfine interaction. Finite magnetic fields lift triplet degeneracy which affects the hyperfine interconversion of e-h pairs between singlet and triplet states. By changing the carrier recombination the MIST mechanism gives rise to a space-charge-limited current that depends on magnetic field, producing MR.

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[2]In collaboration with V.N. Prigodin, D.M. Lincoln and A.J. Epstein.

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