

MAGNETO-OPTICAL STUDIES OF π - d EXCHANGE IN ORGANIC ANALOGUES OF DILUTED MAGNETIC SEMICONDUCTORS

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Organic semiconductors are emerging as a leading area of research as they are expected to overcome limitations of inorganic semiconductor devices for certain applications where low cost manufacturing, device transparency in the visible range or mechanical flexibility are more important than fast switching times. Solution processing methods produce thin films with millimeter sized crystalline grains at very low cost manufacturing prices, ideally suited for optical spectroscopy investigations of long range many-body effects in organic systems. [1]

We present a series of magneto-optical studies on Phthalocyanine crystalline thin films, an organic semiconductor family that exhibits interesting low temperature magnetic properties. [2] An entire family of organo-soluble $3-d$ transition metal Pc's was synthesized in-house and a novel solution-based pen-writing deposition technique [1,3] was employed to fabricate long range ordered thin films of mixtures of metal-free (H_2Pc) molecule and organometallic phthalocyanines (MPc's). Magnetic Circular Dichroism (MCD) experiments in high magnetic fields indicate the presence of a π - d spin-dependent exchange interaction that facilitates the nearest neighbor exchange between the localized spins in analogy to the RKKY mechanism encountered in diluted magnetic semiconductors.

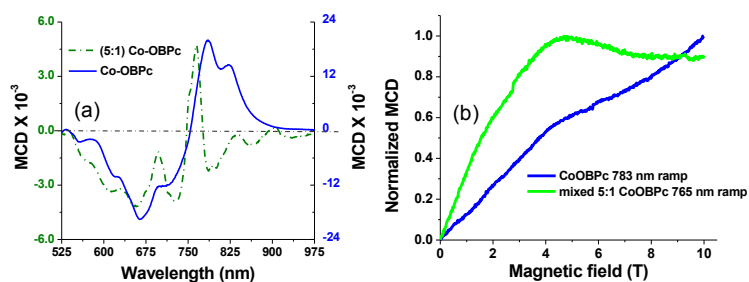


Figure 1. (a) MCD spectra from CoPc (blue curve) and 5:1 H_2Pc :CoPc (green curve) thin films at $B = 5$ T and $T = 5$ K (b) Non-linear evolution of MCD(B) for the samples in part (a) is indicative of an enhancement in π - d exchange interaction in the mixed film.

The sign and magnitude of this exchange can be tuned by mixing MnPc or CoPc and H_2Pc in different ratios ranging from 1:1 to 10:1 H_2Pc :MPc. For example, the introduction of additional delocalized π -electrons in the 5:1 H_2Pc :CoPc films results in a completely different bandgap states manifold (Figure 1(a)) and an enhancement of magnetic interactions that is reflected in the strong MCD (B) saturation. (Figure 1(b)) Furthermore, high magnetic field ($B < 25$ T) MCD and magneto-photoluminescence show evidence of spin-polarized band-edge excitons in the same materials.

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[2] S. Heutz et al, Adv. Mater. 19, 3618-3622 (2007).

[3] N. Rawat et al, J. Phys. Chem. Lett. 6, 1834-1840 (2015)

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