Magnetic Interactions in Crystalline Thin Film Organic Semiconductors

N. Rawat, L. Manning, M. Furis (U. of Vermont, Physics); R. Waterman (U. of Vermont, Chemistry);
T. D. Tokumoto, D. Semenov, and S. A. McGill (NHMFL-FSU)

Introduction

Magnetic Circular Dichroism(MCD) is extremely useful in understanding the electronic structure [1,2] of porphyrins and phthalocyanines. In Metal Phthalocyanines (MPc' s), the electrons that are responsible for magnetism are the unpaired electrons in the ***d***-shells of the metal and the excitons in thin films of these molecules depend on the symmetry of the ordered state. The mechanisms for long-range order magnetic interactions in such crystalline films is still uncertain. Previously, we have performed MCD in the Split-Helix magnet up to 25 T and temperatures as low as 100K [3]. However, lower temperatures are required to observe carrier mediated exchange interactions [4] in MPc and the experiment below was designed for such purpose.

Experimental

Figure 1 illustrates the setup employed in MCD for thin films in transmission mode. The details of the experiment are described elsewhere [3] with a few modifications. The light source used was a Tungsten Halogen lamp. MCD signal in the entire visible range and infrared wavelengths as high as *1.3 µm* was detected by switching from a Si detector to an InGaAs detector in the same setup. The sample investigated is an organic crystalline thin film of Manganese Octa-Butoxy Phthalocyanine (MnOBPc) with macroscopic order (see inset in **Figure 2** (a)) deposited on a sapphire substrate. The technique used to form thin films is a solution processing method [5] developed at UVM.

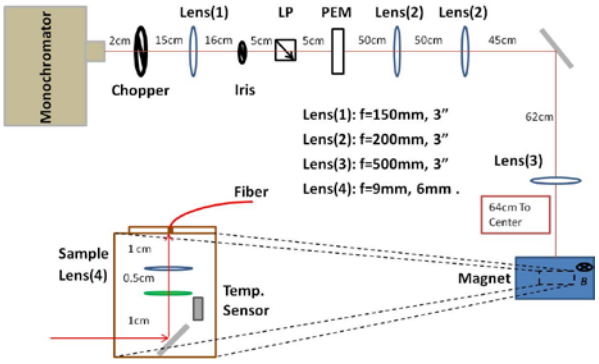

Figure 1: MCD Setup in 25T Split Helix magnet

Results and Discussion

Fig. 2(a) shows the MCD spectrum of MnOBPc obtained at 25 T. To the best of our knowledge, this is the first observation of MCD active states beyond *1 µm* in solid state MnPc and these excitations are unique, as confirmed by recent electron energy-loss spectroscopy (EELS) experiments [6]. Furthermore, MnPc being a spin 3/2 system, we identified (see Fig. 2(b)) specific states that show saturation at high magnetic fields which is a direct indication of strong magnetic interaction of unpaired spins with excitonic states.

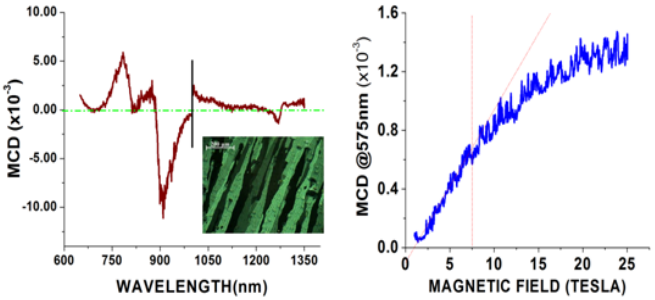

Figure 2: a) 25 T MCD spectrum of MNOBPc crystalline thin film. Inset: polarized microscope image of the same film(dark and bright grains correspond to different crystal orientations)
b) Magnetization evolution with field at 575 nm and 10K.

Conclusions

MCD experiment has been successfully developed in the entire visible and Near Infrared range up to *1.3 µm* and the states that are affected by intrinsic spin of unpaired ***d***-electrons are successfully identified.

Acknowledgements

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References

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