

# Er<sup>3+</sup>- emission from organic complexes embedded in thin polymer films

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## Abstract

Soluble Er<sup>3+</sup> complexes with 2,2'-Bipyridine, 1,10-Phenanthroline, 2-dithienyl-2,2'-bipyridazine ligands, embedded in thin films of poly-(methyl-methacrylate) (PMMA) as well as in films of a conjugated polymer, poly[2-methoxy, 5-(3',7' – dimethyl-octyloxy)]-p-phenylene vinylene (MDMO-PPV), were studied by luminescence spectroscopy. The characteristic Er<sup>3+</sup> emission at ~1.55 μm is clearly observed in μm thick polymer films for two of the complexes.

**Keywords:** Er complexes, rare earth complexes, infrared emission, organic thin films

## 1. Introduction

In the optical telecommunication network Er<sup>3+</sup> emission at ~1.55 μm is used for signal transmission. In this work we propose the use of organic Er complexes for the development of a polymer based optical amplifier in which the complexes are directly incorporated into the fiber.

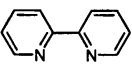
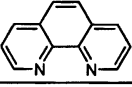
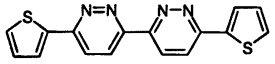
	2,2'-Bipyridine (BIP)
	1,10-Phenanthroline (PHE)
	2-Dithienyl-2,2'-bipyridazine (DITHI)

Table 1: Chemical Structures of the investigated ligands.

## 2. Experimental

Three different Er<sup>3+</sup>- complexes [1], formed from the ligands shown in Table 1, were embedded in polymeric host matrices and studied by luminescence spectroscopy. For all preparations (solvation of complexes and polymers)

tetrachloroethane (TCE) (p.a., Sigma Aldrich, purum > 98.5%) was used.

## 3. Results

### 3.1 Absorption

Absorption measurements were carried out on a Varian Cary 3G UV-VIS – spectrophotometer (double beam) in 1 cm cuvettes (Hellma 6030-UV). The absorption of the ligands as well as of the complexes was measured in TCE (0,0012 wt/vol % to 0,06 wt/vol % ). The absorption maxima were detected for BIP at 300 nm, for PHE at 275 nm and finally for DITHI at 350 nm.

### 3.2 Er<sup>3+</sup> Complexes In PMMA – Thin Films

Er<sup>3+</sup> complexes embedded in PMMA were excited with an Argon laser at 514 nm, 488, 457 nm and with UV-multiline at different temperatures. Figure 1 shows the temperature dependence of the emission of the DITHI complex excited by UV radiation. For this complex, it was observed, that the spectrum became narrower with lower temperatures. Contrary to this, the 1.54 μm emission of the BIP complex spectrum became weaker and broader at lower temperatures.

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In Figure 2 the dependence of the emission of the DITHI complex on various excitation lines of the Argon ion laser is plotted. For the BIP complex no  $\text{Er}^{3+}$  emission could be observed upon excitation at 457 nm. Only excitation with UV multiline and at 514 nm (close to a direct  $\text{Er}^{3+}$  transition) resulted in observable  $\text{Er}^{3+}$  emission. No  $\text{Er}^{3+}$  emission was observed for the complex with PHE.

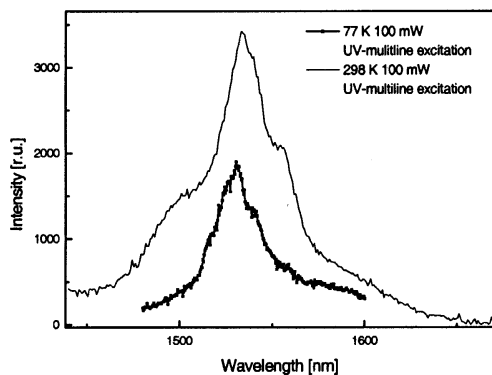


Figure 1: IR emission of the DITHI complex, excited with UV multiline at liquid nitrogen and at room temperature.

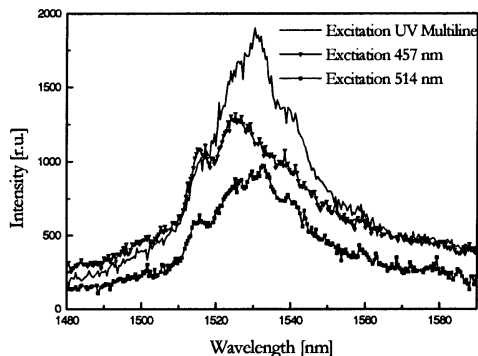


Figure 2: Dependence of the emission of the DITHI complex on various excitation lines.

### 3.3 $\text{Er}^{3+}$ Complexes In MDMO-PPV – Thin Films

From all results (measurements of  $\text{Er}^{3+}$ -Complexes embedded in PMMA), the DITHI complex seemed to be the most promising. In order to investigate possible sensitization of this complex via energy transfer from a conjugated polymer to the ligand, MDMO-PPV (same wt. ratio as for the PMMA films) was used instead of PMMA as host matrix (Figure 3).

No enhancement of  $\text{Er}^{3+}$  emission was observed compared to the PMMA matrix. Figure 4 shows, that the strong luminescence of MDMO-PPV is quenched by ~ factor 100. Photoinduced absorption spectroscopy suggests, that MDMO-PPV undergoes an electron transfer upon resonant

excitation to the ligand as well as to the complex. Since this process is efficiently competing with luminescence, it is suggested that it occurs in ps time scale. Further investigation are necessary to investigate the nature of this photoinduced charge transfer reaction.

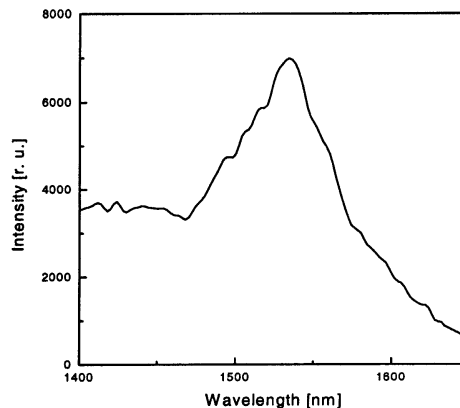


Figure 3: Emission of DITHI complex in MDMO-PPV matrix, pumped at 488 nm at 77K.

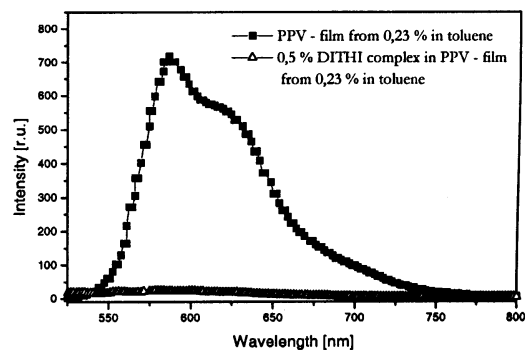


Figure 4: Luminescence quenching of MDMO-PPV doped with the DITHI Er complex .

## 4. Conclusion

$\text{Er}^{3+}$  emission was clearly observed in thin polymeric films from two different Er complexes. The spectral width of this emission is comparable to Er doped glasses (ZBLAN). No sensitization of the Er emission via energy transfer from a conjugated polymer was observed due to alternative reaction path, namely a fast photoinduced charge transfer. Further investigations will concentrate on ligands with a better match of the electronic niveaus to MDMO-PPV.

## References

- [1] Y.H. Kim; G. Nakhmanovich; O. Epshtein; V. Gorelik; Y. Eichen; E. Ehrenfreund: Synthetic Metals, 1999, 101:240-241