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Poly methyl methacrylate films containing metallophthalocyanines in the presence of CdTe quantum dots: Non-linear optical behaviour and triplet state lifetimes

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HIGHLIGHTS

- Non-linear optical (NLO) parameters were determined for phthalocyanine complexes containing In, Ga and Zn as central metals.
- The phthalocyanines were embedded in poly (methyl methacrylate) polymer.
- The parameters were studied in the absence and presence of CdTe quantum dots.
- The parameters generally improved in the presence of quantum dots.

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ABSTRACT

Non-linear optical (NLO) parameters were determined for phthalocyanine complexes containing In, Ga and Zn as central metals when embedded in poly (methyl methacrylate) polymer in the absence and presence of quantum dots (QDs) in an effort to create the most optimal optical limiting material. The QDs employed were CdTe–TGA (TGA = thioglylcolic acid). Triplet lifetimes generally increased as the value of the ratio of absorption cross sections of the excited state to that of the ground state (k) decreased on addition of CdTe–TGA to the phthalocyanines. The saturation energy density (F_{sat}) values were generally smaller in the films when compared to the solutions. F_{sat}, I_{lim}, $\mathrm{Im}[\chi^{(3)}]/\alpha$ and γ all gave values which were of optimal range (i.e. the $\mathrm{Im}[\chi^{(3)}]/\alpha$ and γ values were high enough to ensure adequate optical limiting but not too high to make the compounds behave like optical filters. Also, the F_{sat} and I_{lim} values were small enough to mean that the optical limiting process started at an intensity which was not too high) for complex **10** containing Zn central metal and tetrasubstituted with amino groups.

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1. Introduction

The use of nanomaterials (NM) as optical limiting materials has attracted considerable attention [1,2]. A wide range of NM with strong non-linear optical (NLO) properties contributing to optical limiting (OL) have been investigated. Quantum dots (QDs) show OL behaviour [3]. On the other hand metallophthalocyanines (MPcs) have also been shown to be excellent OL materials with high absorption cross section ratio of excited triplet to ground states in the absorption range 400–600 nm [4]. Combining MPc complexes with QDs is expected to result in enhanced OL behaviour due to the synergistic effect and this is the aim of the current work. This work reports on the threshold limit intensity (I_{lim}), saturation energy density (F_{sat}) and the excited state (σ_{ex}) to ground state (σ_g) absorption cross section ratio (k) for MPcs in the absence and presence of QDs and as thin films. The effects of the triplet state lifetime on these parameters in the presence of quantum dots are explored.

Studies of the NLO parameters of MPcs have predominantly been in solution [5–8]. Embedding the phthalocyanines within a transparent polymer thin film for OL applications adds some protection to the phthalocyanines against degradation. Also practical optical limiting devices require the casting of the optically active compounds in the solid state. Poly (methyl methacrylate) (PMMA) has been used as the preferred polymer for embedding Pcs for studying NLO parameters [9,10]. This work compares the NLO parameters of phthalocyanine complexes (**1**–**10** [10–16], phthalocyanines' structures shown in Fig. 1) embedded in PMMA in the presence of CdTe quantum dots (QDs). The reason for the inclusion of the QDs in the polymer film was to see whether their presence would improve the NLO parameters.

This work reports for the first time on the triplet state lifetimes of phthalocyanines within a polymer matrix and relates them to

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