NJC

PAPER

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Cite this: *New J. Chem.*, 2016, 40, 6505

Photoluminescent polymer composites with R, G, B emission and their potential applications in LCD displays

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Received (in Montpellier, France) 4th February 2016,
Accepted 18th May 2016

DOI: 10.1039/c6nj00386a

www.rsc.org/njc

In this work, red, green and blue emitting composites with remarkable photoluminescence properties were obtained through embedding Eu^{3+}, Tb^{3+} and Y^{3+} complexes with 2-(1*H*-1,2,4-triazol-3-yl)pyridine in poly(vinyl alcohol) and poly(*n*-vinyl pyrrolidone) matrices which were processed in thin or thick films. Interestingly, through embedding in the polymer matrices, their luminescence properties are markedly enhanced compared to the free complexes. PLQY values were enhanced from an average 25–30% to 52–69%, while the emission purity, especially in the case of Eu^{3+} containing composites, was greatly improved. The prepared composites were investigated through FT-IR analysis while the emphasis on fluorescence spectroscopy provided important details regarding the impact of embedding the complexes in the polymer matrices; luminescence lifetime, absolute PLQY and chromaticity parameters were investigated in detail. The morphology of the composite films was investigated through AFM and SEM. Based on their remarkable photoluminescence properties we are suggesting their implementation in AMLCD displays in a new approach which could replace the RGB colour filters, thus bringing several potential advantages over the current approach. The facile preparation and emission characteristics should be important arguments for their implementation as photonic conversion media in various optoelectronic devices. Other applications like full colour watermarks in special purpose papers could easily take advantage of the prepared composites.

1. Introduction

Photoluminescent materials have constantly been the focus of the scientific research due to their wide range of applications ranging from optoelectronics to medical investigation techniques. Among various classes of photoluminescent compounds, lanthanide and transition metal complexes are arguably one of the most promising materials due to their luminescence properties and facile preparation paths. Eu^{3+} and Tb^{3+} cations are well known for their narrow emission bands located in the red,[1,2] respectively green[3,4] areas of the visible spectrum due to their radiative transitions within 4f orbitals partially shielded by the 5s and 5p orbitals.[5,6] In particular, sharp emission bands located around 620 nm of Eu^{3+} and 540 nm specific to Tb^{3+} cations are highly considered in applications where warm/cold tinted white light emission or accurate color reproduction is obtained by mixing the three fundamental colors (R, G, B), for example, LED or color displays. When properly sensitized with an appropriate ligand capable of energy absorption, which is subsequently transferred to the lanthanide center, the results are impressive in terms of efficiency of the radiative processes and spectral characteristics of their photoluminescence emission. Unfortunately, only a few lanthanide complexes with blue emission are reported[7] thus limiting a practical implementation entirely based on photoluminescent complexes. In most cases Eu and Tb complexes are used for red and green emission layers while the limited availability of a blue emitting complex is overcome by using an organic fluorophore.[8] The situation could be further complicated when various ligands are used to obtain complexes with RGB emission due to the inherent differences between their excitation energy absorption efficiency or proper sensitization of the central cation. Therefore a "unified" solution based on the same ligand is advantageous for applications where RGB photoemissive layers are required. In a previous work[9] we reported the preparation and investigation of several new luminescent complexes with the same 2-(1*H*-1,2,4-triazol-3-yl)pyridine ligand. Among them, the Eu^{3+}, Tb^{3+} and Y^{3+} complexes are especially interesting due to

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