

Managing the luminescence efficiency of the of Europium(III) organic compounds through preparation technology

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Abstract

A series of coordination organic compounds based on the trivalent Eu^{3+} ion were synthesized and optimized: $Eu(o-MBA)_3phen$, $Eu(DBM)_3(Ph_3PO)_1 \cdot H_2O$ and $Eu(TTA)_3(Ph_3PO)_2$. The efficiency of the photoluminescence (PL) emission of these coordination compounds depend on preparation technology, specifically on the optimal choice of the ligands. The photoluminescence spectrum measured in the range 500 – 750 nm exhibits a number of narrow (atomic-like) emission bands with the FWHM less than 10 nm. These PL emission bands are attributed to optical transitions $^5D_0 \rightarrow ^7F_j$, $j = 0..4$ in the $4f$ orbital of the ion. PL experimental results were analyzed in the framework of Judd-Ofelt theory and the characteristic luminescence parameters were obtained: PL lifetime constant, quantum yield, Ω coefficient, the probability A_{ij} for electric dipole transitions, etc.

Keywords: photoluminescence, coordinating organic compounds, ligands, Eu(III), Judd-Ofelt theory.

1. INTRODUCTION

The trivalent ion of *Europium* (Eu^{3+}) is very attractive for preparation of coordination compounds based on organic and inorganic ligands. One of its most interesting properties is its high luminescence efficiency (which theoretically can reach 100%). The Eu^{3+} based complexes have a good chemical stability, while the luminescence spectra are characterized by narrow emission bands and high color purity [1]. These properties favor the wide application of these materials in different fields of optoelectronics as: light sources [2], luminescent sensors [3], luminescent markers in medicine and biology [4], etc. The $4f$ orbital of the Eu^{3+} ion is shielded by the electrons with higher energies from the $5s^2$ and $5p^6$ orbital levels. This leads to the insignificant influence of the external environment of the compound and the crystalline electric field on the electronic transitions inside the $4f$ orbital. One way to overcome the problem of poor absorption of Europium ions and to obtain efficient luminescence emission is to surround the Eu^{3+} ion with compatible and optimal organic ligands that modify the spherical symmetry of the Eu^{3+} ion, absorb the excitation light and to transfer the absorbed energy to the energetic states $4f$ of the ion (the so-called “antenna effect”). In addition, the ligands around the Eu^{3+} ion provide rigid coordination protection to minimize non-radiative luminescence losses. The saturation (completion) of the coordinate sphere of the Eu^{3+} ion with ligands also allows the ion to be protected from the action of water molecules or other external media that can reduce (attenuate) the luminescence [5]. The right choice of ligands for the formation of coordinating compounds is very important for improving the luminescence efficiency of the Eu^{3+} ion. The aim of this research was to select the optimal ligand for coordination with the Eu^{3+} ion, synthesis of coordination mononuclear compounds $Eu(o-MBA)_3phen$ (1), $Eu(DBM)_3(Ph_3PO)_1 \cdot H_2O$ (2), $Eu(TTA)_3(Ph_3PO)_2$ (3) and the investigation of their luminescent properties.

Experimental methods

Powder samples were characterized by PL spectroscopy. Photoluminescence emission spectra were recorded using different excitation sources with a MDR-23 single emission monochromator. A pulsed *nitrogen* laser at 337 nm with repetition rate 10-100 Hz and the pulse width 10 ns was used for excitation of Eu^{3+} ions in the charge transfer band. Another excitation light source was a Thorlabs LD at 405 nm. PL signal was detected in a photon counting mode with a Hamamatsu module H8259-01 with a counting unit C8855-01 connected to a PC. The spectral resolution for PL measurements was as low as 0.125 nm. For both the PL spectra and the quantum yield measurements the emission spectra were corrected for the instrument spectral sensitivity. The luminescence time decay was recorded using a