

Photo- and electroluminescent properties europium complexes using bistriazole ligands

Alexey N. Gusev^{a,*}, Victor F. Shul'gin^a, Galina Nishimenko^a, Miki Hasegawa^b, Wolfgang Linert^{c,*}

^a Taurida National V.I. Vernadsky University, Simferopol 95007, Ukraine

^b Department of Chemistry and Biological Science, College of Science and Technology, Aoyama Gakuin University, Kanagawa 252-5258, Japan

^c Institute for Applied Synthetic Chemistry, Vienna University of Technology, Getreidemarkt 9/163, A-1060 Vienna, Austria

ARTICLE INFO

Article history:

Received 7 November 2012

Received in revised form

10 December 2012

Accepted 17 December 2012

Available online 22 January 2013

Keywords:

Eu(III) complex

1,2,4-triazole derivatives

Photoluminescence

Electroluminescence

ABSTRACT

Luminescent properties of two heteroleptic dibenzoylmethanate europium(III) complexes with 1,3-bis(5-pyridin-2-yl-1,2,4-triazol-3-yl)propane (H_2L^1) and 1,4-bis(5-pyridin-2-yl-1,2,4-triazol-3-yl)butane (H_2L^2) as ancillary ligands are described. The two double-layer-type electroluminescent cells with the structures: (1) ITO/NPB(40 nm)/Eu(DBM)₂HL¹ (40 nm)/LiF (1 nm)/Al (100 nm) and (2) ITO/NPB(40 nm)/Eu(DBM)₂HL² (40 nm)/LiF (1 nm)/Al (100 nm) emit red light originating from the europium complexes. The device 2 gives the maximum brightness of 455 cd/m² at 19.2 V.

© 2012 Elsevier B.V. All rights reserved.

1. Introduction

The search for new materials for organic light-emitting diodes (OLEDs) is one of the actual problems of both chemistry and materials science [1–3]. Despite the significant progress achieved in this field for the last decade, the production of brightness luminescent materials that can be used as active layers in OLEDs remains important. There are three main classes of luminophore that are most suitable for producing of electroluminescent devices: rigid organic molecules, d-metals complexes, and lanthanide complexes [1,4–6]. Until now first two classes are more popular as electroluminophore due to very high quantum efficiency of luminescence, high chemical stability and electronic conductivity. However, despite all the advantages, obtaining the luminescence spectrum with a small half-width at half-maximum remains an open issue for the phosphor of this type. In contrast lanthanide complexes with organic ligands can provide potential solutions for such issue due to the central lanthanide metal ions exhibit extremely sharp emission bands as results of their specific electronic structure. Unfortunately till now the most efficient Ln(III) phosphors doesn't show high

electroefficiency. One of the important reasons is the poor carrier transporting properties (especially electron-transporting) of these complexes [7]. Unbalanced injection and transport of charge carriers would cause their recombination at locations other than the emitting layer, leading to low OLEDs efficiency and reduced lifetime. There are two main approaches to improve carrier-transporting properties of the europium complexes. The first is doping europium complexes into polymers or small molecular compounds with high hole or electron mobility. The second one is grafting hole- or electron-transporting units on ligands. It is well known that 1,3,4-oxadiazole and 1,2,4-triazole derivatives are the most widely employed as electron-transporting and hole-blocking materials [8]. Several groups have been focused on the design and synthesis of oxadiazole-functionalized β -diketonate ligands and corresponding lanthanide complexes. The literature contains several interesting results which show the effectiveness of such direction of investigation for improving carrier transporting properties of Eu(III) complexes [9–11]. However, we could not find any mention about employing triazole derivatives as ligands for design luminescent europium complexes. Recently we reported about new pyridyltriazole ancillary ligands which effectively enhance photoluminescence of Eu(III) with respect to Eu(DBM)₃·2H₂O (HDBM – dibenzoylmethane) [12]. Here we give detailed description of photo- and electroluminescent properties of europium complexes based on bis(pyridyltriazolyl)alkanes and DBM[−] presented in Fig. 1.

* Corresponding authors. Tel.: +43 1 58801 163613.

E-mail address: wlinert@mail.zserv.tuwien.ac.at (W. Linert).

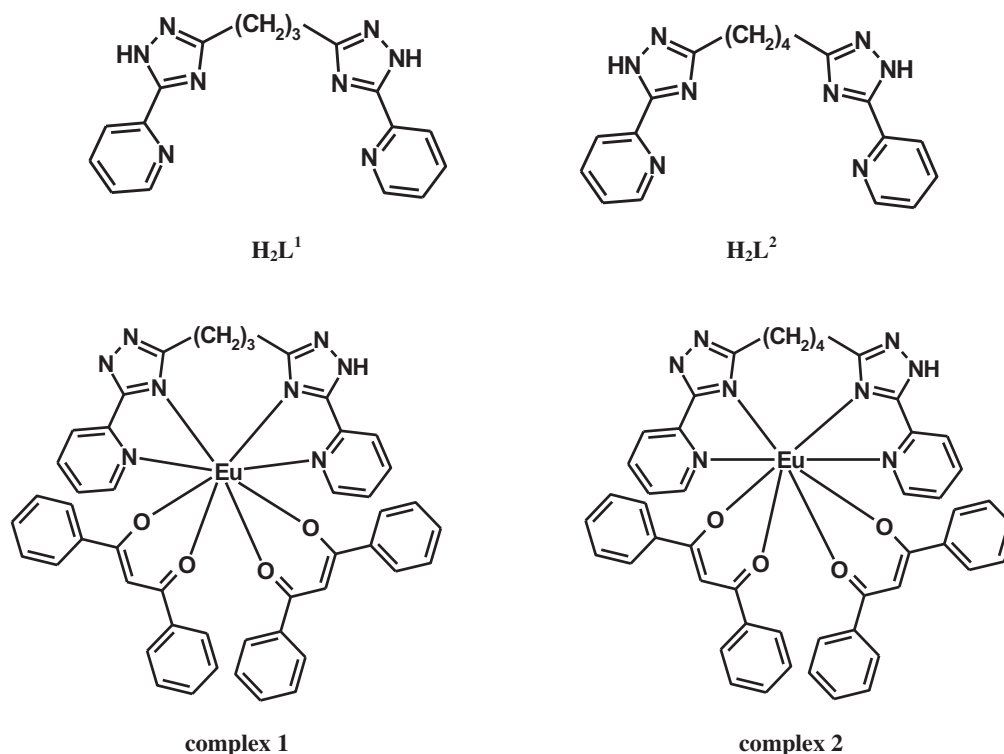


Fig. 1. Drawing of the bis(pyridyltriazolyl)alkanes and Eu complexes.

2. Experimental

2.1. General information and instrumentation

Chemicals and reagents were obtained from commercial sources, and used without further purification unless otherwise noted. Synthesis of title complexes (unsolvated form) and molecular structure of $\text{Eu}(\text{DBM})_2 \cdot \text{HL}^1$ (as solvate with two benzene molecules) we described in our previous paper [12]. Absorption spectra were recorded on a Perkin-Elmer Lambda-9 UV/VIS/NIR spectrophotometer. Solid-state excitation and photoluminescence spectra were recorded on a Horiba Jobin-Yvon Fluorolog FL-3-22 spectrofluorometer equipped with a 450 W Xe lamp, quantum yields were determined under ligand excitation on the same instrument, and using absolute method using a home-modified integrating sphere. Lifetime measurements were performed on a Horiba Fluorocube lifetime instrument by a time-correlated single-photon counting method using a 365 nm LED excitation source. The current density–luminance–voltage characteristics of the OLEDs were measured by Keithley source measurement unit with a calibrated silicon photodiode. Electroluminescence spectra were taken by a multichannel S2000 Ocean Optics spectrometer. All measurements were carried out in ambient atmosphere at room temperature.

2.2. Fabrication OLED devices

The double-layer-type OLED devices with structure (1) ITO/NPB(40 nm)/ $\text{Eu}(\text{DBM})_2 \cdot \text{HL}^1$ (40 nm)/LiF (1 nm)/Al (100 nm) and (2) ITO/NPB(40 nm)/ $\text{Eu}(\text{DBM})_2 \cdot \text{HL}^2$ (40 nm)/LiF (1 nm)/Al (100 nm) were fabricated on glass substrates with 100 nm thickness ITO. *N'*-Diphenyl-*N*,*N'*-bis(1-naphthyl)(1,1'-biphenyl)-4,4'-diamine–NPB was used as hole-transporting materials. Organic layers were sequentially deposited at a rate in the range of 0.1–0.3 nm/s onto the substrates by high-vacuum (10^{-5} mbar)

thermal evaporation techniques. The shadow mask with 5 mm × 5 mm openings was used to define the cathodes. The evaporating speeds and thickness were monitored by quartz oscillators. All of the measurements were carried out in ambient atmosphere at room temperature after vacuum break.

3. Results and discussion

3.1. Photophysical properties

In our previous paper [12] we demonstrated only general features of the photoluminescence of europium complexes with DBM^- and HL^- anions with an indication possibility of using europium complexes with triazole ligands for creating electroluminescent cells. In this article we focused on detailed description of the photophysical properties of title complexes and characterization of electroluminescent cells based on its.

It is well known that for high luminescence efficiency lanthanide–ligand pair should meet the following conditions, energy of the resonance level of Ln(III) should be lower than the energy of the triplet level ligands. To substantiate abilities of title bistriazoles to enhance luminescence of europium complexes the lowest triplet state energy level of the ligands were determined firstly. Phosphorescence spectra for solid samples of the Gd(III) complexes with the ligands H_2L^1 and H_2L^2 were measured at 77 K. Gd(III) complexes show broad phosphorescence with maximum at 433 and 435 nm for H_2L^1 and H_2L^2 complexes respectively. These data give the values of the triplet levels of ligands as 22,989 and 23,095 cm^{-1} respectively. According to Latva's empirical rule, an optimal ligand-to-metal transfer process for Eu(III) needs energy gaps $>2500 \text{ cm}^{-1}$ [13]; therefore, the ligand-to-metal transfer processes are effective for both ancillary triazole ligands. The most probable stepwise energy transfer from pyridyltriazole ligands to Dbm ($20,400 \text{ cm}^{-1}$) and further the emitting level of the europium ion.

Download English Version:

<https://daneshyari.com/en/article/7873974>

Download Persian Version:

<https://daneshyari.com/article/7873974>

[Daneshyari.com](https://daneshyari.com)