Spectroscopic and time-resolved study of novel molecular compounds for on-chip integrated quantum light sources

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Abstract. The ARTEMIS project aims to develop integrable quantum sources based on metal-organic compounds with transition metal and/or lanthanide ions. These materials exhibit tunable linear emission and nonlinear optical properties, enabling on-demand generation of single photons and entangled photon pairs or triplets. When integrated with plasmonic supernanostructured cavities, these molecular emitters achieve strong optical enhancement. Our group focuses on the quantum characterisation of the light emitted by these sources to explore their potential for new metrology and sensing applications in the quantum regime. Spectroscopic and time-resolved measurements on newly synthesized compounds $Tb{-}N(Bzlm)3$ and $Eu{-}N(Bzlm)3$ dissolved in DMSO at high concentration reveal narrow emission bands and relatively long decay times.

1 Introduction

Quantum states of light are essential for secure communication, metrology, and other quantum technologies. Current quantum light sources are limited and molecules have been proposed as promising quantum emitters and nonlinear elements, offering competitive coherence, scalability, and compatibility with integrated photonic systems [1]. The ARTEMIS project focuses on metal-organic molecules as on-demand sources of single and entangled photons for applications in sensing, metrology, and telecommunications [2]. Given that the project is in its early phase, initial spectroscopic and time-resolved measurements were conducted to assess the efficiency of the fluorescent signal.

1.1 Materials and experimental setup

The complex molecular compounds, $[Tb(III) - tris((1H - benzo[d]imidazole - 2 - yl)methyl)amine]$ and $[Eu(III){-}tris((1H{-}benzo[d]imidazole{-}2{-}yl)methyl)amine]$, demonstrate an energy transfer from the ligand with a broad absorption band to the lanthanide. The compounds were dissolved in dimethyl sulfoxide (DMSO) at a high concentration of

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3.4×10^{-3} mol/l. A 355 nm Nd:YAG pulsed laser was used for excitation of the liquid sample, placed in a quartz cuvette. Fluorescence was collected at a normal angle to the laser beam and detected with a spectrograph equipped with an ICCD camera, such that energy-resolved lifetime was measured.

2 Results

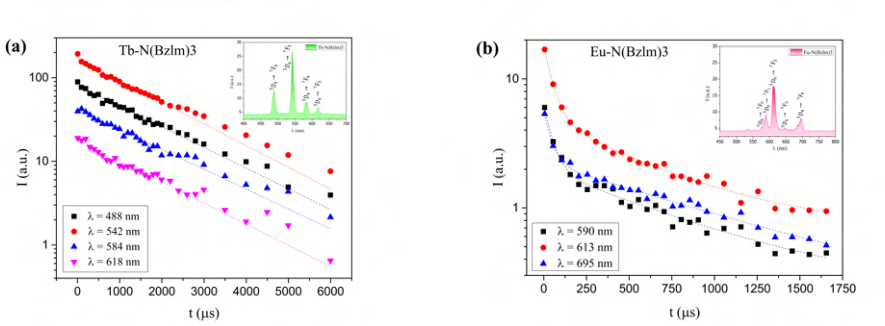

Figure 1: Fluorescent lifetimes of $Tb - N(Bzlm)3$ (a) and $Eu - N(Bzlm)3$ (b) solutions were extracted and presented in tables 1 and 2, respectively. Recorded emission spectra and the corresponding energy level transitions of the emission lines are shown in the insets.

Table 1: Decay time of $Tb - N(Bzlm)3$

$\lambda[nm]$	$\tau[\mu s]$
488	1760 ± 60
542	1670 ± 60
584	1830 ± 60
618	1720 ± 80

Table 2: Decay time of $Eu - N(Bzlm)3$

$\lambda[nm]$	$\tau_1[\mu s]$	$\tau_2[\mu s]$
590	50 ± 5	760 ± 190
613	50 ± 3	580 ± 70
695	50 ± 5	990 ± 230

3 Conclusion and Outlook

Spectroscopic and time-resolved results show intrinsically narrow emission bands originating from d-f transitions of Tb^{3+} and Eu^{3+} ions, with long decay times. Fluctuations are attributed to a low signal-to-noise ratio. A biexponential decay of $Eu - N(Bzlm)3$ indicates two concurrent emissive processes. Future research will focus on optimizing ligand design, using plasmonic supernanostructures to enhance fluorescence as well as investigating single-molecule emission and observing single-photon generation.

References

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