

SYNTHESIS AND CHARACTERIZATION OF IRIIDIUM COMPLEX FOR GREEN ORGANIC LIGHT EMITTING DEVICES

Ritu Srivastava, Suman Anand, Kanchan Saxena, Aparana Misra, Pankaj Kumar, Mahipal Meena, Depankar Singh, S. K. Dhawan, M.N. Kamalasanan and S. Chandra

Polymeric & Soft Material Division, OLED lab National Physical Laboratory, Dr. K.S. Krishnan Marg, New Delhi-110012

ABSTRACT

The rapid growth of Organic Light Emitting devices is of considerable interest due to their potential application in flexible, cost-competitive and large screen flat-panel displays. So, there has been much effort put into the development of novel emitters for use in OLED applications. Unlike fluorescence, phosphorescence makes use of both singlet and triplet excited states, suggesting the potential for reaching a maximum internal efficiency of 100%. Recently, there has been interest in the use of triplet emitting compounds primarily focusing on trivalent iridium complexes.

In this work we report the synthesis of Ir(ppy)₃ and its characterization by different techniques like DTA/TGA, FTIR, UV-Visible absorption, PL measurements etc. For making OLED, Ir(ppy)₃ is doped in different host materials like TPD etc. The device configuration is ITO/TPD-5% Ir(ppy)₃/Alq₃/LiF/Al. The EL and I-V characteristics have also been measured.

1. INTRODUCTION

Much attention has been paid to the phosphorescent materials in recent years for their potential application as highly efficient electrophosphorescent emitters in organic light emitting device (OLEDs). In fluorescent small molecules the electroluminescence is taking place only due to transition between singlet states. The triplet states were unused. Statistically it is found that the ratio of singlet to triplet state is 1:3 i.e. the maximum internal quantum efficiency η_{EL} in fluorescent molecules is 25%. Whereas in the electrophosphorescence the transition from excited triplet state is also allowed, thus making the maximum η_{EL} as 100%. Heavy metal complexes, particularly those containing Pt(II) and Ir(III), where strong spin orbit coupling leads to singlet-triplet state mixing, can result in high efficient electrophosphorescence in OLED [1-5]. Among the many kinds of metal complexes, iridium complexes are the most effective and show intense phosphorescence at room temperature [6]. The basic concept to fabricate a device by doping a phosphorescent molecule into host matrix is that the triplet energy of the host matrix must be higher than that of triplet energy of the phosphorescent dopant as to confine the triplet excited state on the guest. In this paper we report the synthesis and characterization of Ir(ppy)₃ complex and the device was fabricated by doping Ir(ppy)₃ in host material TPD.

2. EXPERIMENTAL

2.1 Synthesis of Ir(ppy)₃

In a typical reaction, (50mg) of Ir(acac)₃ (Aldrich) and (0.09 ml) of Hppy (Aldrich) were dissolved in degassed glycerol (5ml), and the solution was heated and refluxed under nitrogen for 24hr. Addition of 1M HCl (30 ml) after cooling resulted in precipitation of the product, which was collected on a filter paper. This product was dissolved in hot dichloromethane, the mixture was filtered, and the filtrate was flash-chromatographed on a silica gel column to remove impurities. Addition of methanol to the chromatographed solution followed by heating to boiling to evaporate dichloromethane resulted in precipitation of the product as a flocculant yellow powder in approximately 55% yield. The compound was then further purified by sublimation at a pressure of $\sim 10^{-6}$ Torr. The FTIR, Mass spectral analysis and NMR data confirm the formula fac-Ir(ppy)₃. TGA shows thermal stability of the complex up to 350°C. Prepared complex is optically characterized by UV-vis spectroscopy and PL. Device was fabricated by using this complex and its EL and I-V characteristics have been measured.

2.2 OLED fabrication

The OLED devices were fabricated in the configuration ITO/TPD-5%Ir(ppy)₃ (35nm)/ Alq₃(30nm) / LiF(1nm)/Al(100nm). The glass substrate pre-coated with indium-tin-oxide was cleaned. Surface treatment was carried out by exposing ITO to oxygen plasma. TPD-5%Ir(ppy)₃ was thermally deposited on the ITO coated glass in which TPD act as host and Ir(ppy)₃ act as dopant respectively. Alq₃, LiF and Al were also thermally deposited under vacuum

which act as electron transport, electron injection and cathode respectively. Finally, the device was hermetically sealed under pure nitrogen in a glove box with 150 μm thick glass slide using UV curable epoxy. The voltage was applied between these two electrodes to get green emission under forward bias condition. Current–Voltage characteristics were measured by using a Kithley 2400 Source Measurement Unit. All the measurements were performed at room temperature in air.

3. RESULTS AND DISCUSSION

The FTIR spectrum of the complex has been taken in KBr. The spectrum shows prominent peaks at 1580, 1460 & 1412 cm^{-1} [7] which is characteristic of transmittance of aromatic ring skeleton and suggested that conjugation of aromatic ring is very strong. The peak at 1266 cm^{-1} is due to aromatic C-N stretching. The peaks at 1057 & 1030 cm^{-1} are due to C-H in plane bending & peak at 736 cm^{-1} is due to C-H out of plane bending in aromatic ring.

Thermogravimetric analysis of the $\text{Ir}(\text{ppy})_3$ (Fig 1) shows that the complex was thermally stable up to 350 $^{\circ}\text{C}$. A weight loss (3.1926%) at 300 $^{\circ}\text{C}$ might be attributed to the loss of some absorbed water molecules. In the second step a huge weight loss of about 34.6% were taken place. The weight loss start at 350 $^{\circ}\text{C}$ and completed at 450 $^{\circ}\text{C}$. This huge weight loss suggests that the decomposition of complex start in this range, hence complex was stable up to this temperature.

Absorption spectrum of $\text{Ir}(\text{ppy})_3$ was recorded by Shimadzu UV-2401 pc spectrophotometer. The sample was prepared on fused silica substrate by thermal evaporation under vacuum. The absorption spectrum of $\text{Ir}(\text{ppy})_3$ film shows a peak in UV region due to $\pi-\pi^*$ transition whereas the peak centred at 375 nm in the absorption spectrum corresponds to the metal to ligand charge transfer (MLCT) transition as shown in the Fig [2].

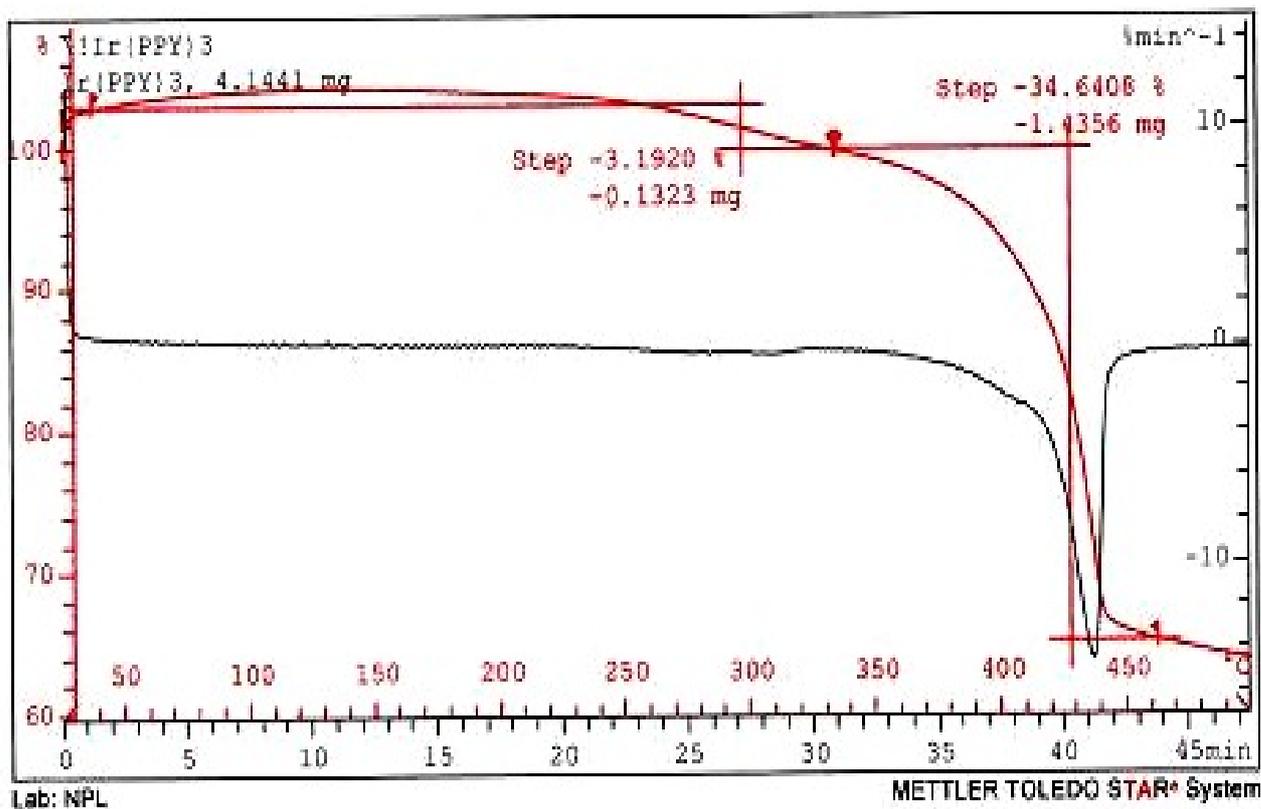


Fig 1: Thermogravimetric analysis curve of $\text{Ir}(\text{ppy})_3$

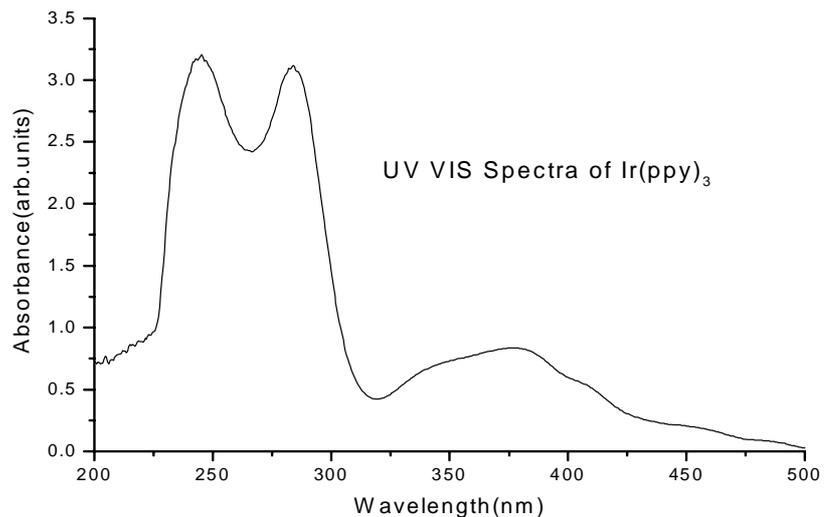


Fig 2: UV-vis absorption spectra of Ir(ppy)₃

The photoluminescence spectra of the Ir(ppy)₃ centred at 520 nm and which is due to the radiative decay from the triplet manifold to the ground state. This complex shows bright luminescence even in high illumination. The solid state complex is highly luminescent, but its emission spectrum shows red shift in solid state compared to the solution state spectrum. The electroluminescent (EL) spectrum of the device was measured at different potentials ranging from 5V to 15V. The peak maximum was obtained at 520 nm. The peak intensity increases due to the increased voltage as shown in the Fig [3].

The I-V characteristics of the device have been recorded as given in Fig 4. This shows that current rises steeply above 6 V indicating the onset of light emission (threshold voltage) and highly non-linear nature with ohmic conduction at low voltage and trap limited conduction at high voltages.

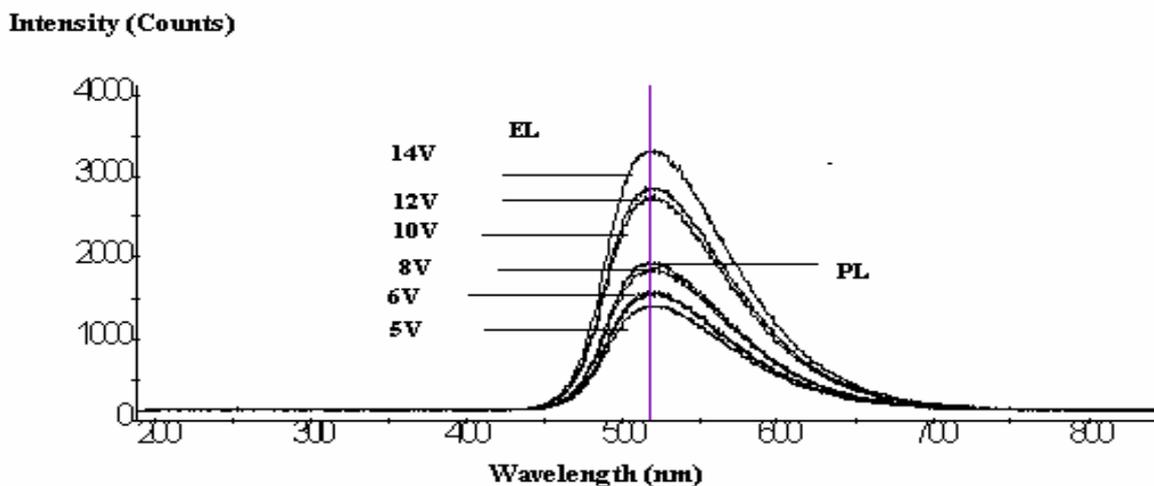


Fig 3: PL of Ir(ppy)₃ & EL of TPD+5%Ir(ppy)₃ device

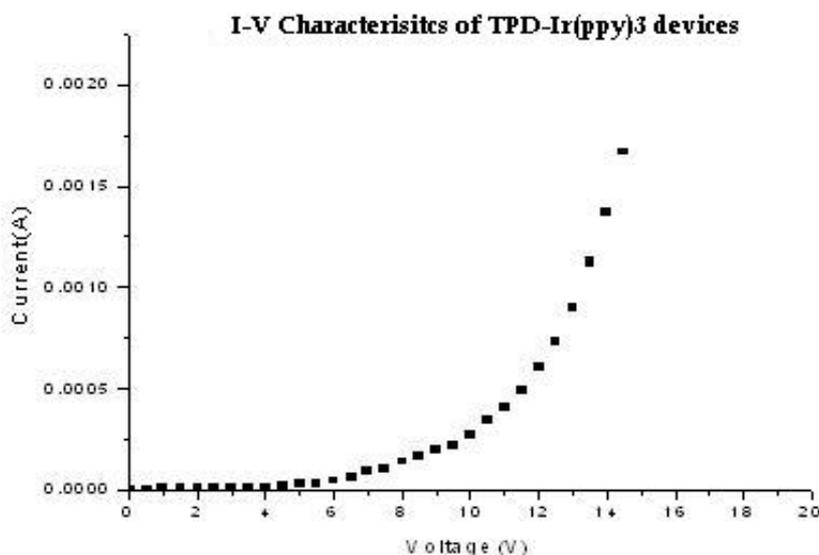


Fig 4: I-V Characteristics of TPD+5%Ir(ppy)₃ device

4. CONCLUSION

In conclusion, we have synthesized a green Ir(III) complex which has practical utility in the fabrication of OLEDs. The FTIR, NMR and Mass spectral analysis confirm the formula of fac-Ir(ppy)₃. TGA shows that material is stable up to 350°C. The PL and EL spectra of the device have confirmed that the introduction of the dopant Ir(ppy)₃ enhanced the intensity of the emission.

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