SYNTHESIS AND PHOTOPHYSICAL STUDY OF ALQ$_3$: P ORGANIC PHOSPHORS

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A B S T R A C T

Phosphorus doped alumium-8-hydroxyquinoline metal complex is synthesized using simple precipitation route in order to reduce the cost and time of material. It is characterized by X-ray Diffractogram of P doped Alq$_3$ complex exhibits well defined X-ray diffraction lines, confirming its crystalline nature. Photo luminescence spectra of Alq$_3$: P reveals intensity in green region. The synthesized P doped Alq$_3$ organic phosphor is promising material for optical or optoelectronic applications.

Keywords:organic phosphor, Alq$_3$, Xrd, Photoluminescence, P doped Alq$_3$

1. Introduction

Now days Organic light-emitting diodes (OLEDs) constitute a rapidly developing field. Many believe that they represent the future of flat panel display technology. The main focus of OLED research is to address these issues. Two types of compounds: conjugated organic polymers, such as poly (1, 4-phenylenevinylene) (PPV) and molecular species such as aluminum tris-(8-hydroxyquinolate) (Alq$_3$) are used frequently. Organic have attracted tremendous interests for application in functional nanoscale electronic and optoelectronic devices, the crystalline and molecular arrangement of which have a great influence on the performance of these devices. [1–4] However, compared with the overwhelming majority of inorganic nonmaterial, only a few successful preparations of organic one-dimensional (1D) nonmaterial such as nanowires and nanotubes are reported. [3, 5–7]

Since the first efficient low-voltage-driven organic light-emitting diodes (OLEDs) based on tris (8-hydroxyquinoline) aluminum (Alq$_3$) were reported [8]. Alq$_3$ has become a important prototypical electron transport and emitting material for OLED devices because of its excellent stability and electro-luminescence properties. Therefore lumophores based on Aluminum metallo-8-hydroxyquinolate prepared from wet Chemical method and co-doped with Phosphorus non metal element are prepared and characterization of the material by X-Ray diffraction spectrographic is carried out. Alumium-8-hydroxyquinoline and co-doped materials with varying concentrations of dopants [9, 10, 11, 12] are synthesized by simple wet Chemical route in order to reduce the cost and time of synthesized material. In the synthesis technique when Phosphorus non metal is added which contribute an electron, withdrawing constituent at the 5-position in 8-hydroxyquinoline, increasing the solubility of the corresponding metal quinolate complexes in non polar solvents.

2. Experimental

Alq$_3$ was prepared as follows: firstly take 25 ml double distilled water and 25 ml acetic acid in beaker. Dissolve 5 gm of 8-hydroxyquinoline in a mixture of double distilled water, acetic acid and stir it still the orange transparent solution was obtained say solution I.Take 5gm Al $(NO_3)_3.9H_2O$ and dissolve in double distilled water. Stir it till clear solution was obtained say solution II. Mix the solution I and II and stir for 10 min and add N_4OH solution by drop by drop to this mixture of solution with continuous stirring. Filter the yellow green precipitate and wash the precipitate with double distilled water for 8 to 10 times. Place the precipitate for drying 40-50^{o}C. The other derivative of 8-hydroxyquinoline metal complex is prepared by Simple precipitation method same as Alq$_3$. Aluminium nitrate is replaced by ammonium dihydrogen phosphate $(NH4)H_2PO_4$. For the

preparation of Alq_3 host lattice, aluminium nitrate and 8-hydroxyquinoline as raw materials and for Alq_3: P, ammonium dihydrogen phosphate is used as other material to dope phosphorus with proportion 5%,3%,2%and 1% mixed in an appropriate molar ratio mentioned in equation 1.

3. Results & Discussion

3.1. XRD OF Alq_3: P

Diffraction data has historically provided information regarding the structures of crystalline solids. Such data can be used to determine molecular structures, ranging from Simple to complex, since the relative atomic positions of atoms can be determined. X-ray Diffraction provides important evidence and indirect proof of atoms. The Symmetry of the diffraction patterns corresponds to the symmetry of the atomic packing. It is the simplest way to determine inter atomic lattice spacing that exists. The intensity of the diffracted beams also depends on the arrangement and atomic number of the atoms in the repeating motif, called the unit cell. Thus, the intensities of diffracted spots calculated for trial atomic positions can be compared with the experimental diffraction intensities to obtain the positions of the atoms themselves. The XRD pattern did not indicate presence of the constituents like nitrates, ammonia and other likely phases. This result indicates the final product formed is in crystalline and homogeneous form.

The synthesized complex have been characterized by XRD on the 'Expert pro' Automated power Diffractometer system company name Analytical, Netherland taken at 'SAIF' Punjab University, Chandigarh as shown in Fig.1.

3.2. PL properties of Alq_3 and Alq_3: P

Excitation and emission spectra exhibit Photo luminescence properties of Alq_3 powder by excitation wavelength is 384 and 455 nm. The prominent PL emission peak is observed at 531 nm in green region of the spectrum well matched with the green emission of yellowish green powder earlier reported attributed to α-phase of meridianal isomer of Alq_3. The PL excitation spectrum at 455nm of prepared Alq_3 powder reveals that prepared phosphors is not only suitable for organic light emitting diode but also for photoluminescence liquid crystal display (PLLCD) and solid state lighting applications. See Fig. 2(a) and (b). Jablonski diagram illustrating possible electronic processes following absorption of a photon for Alq_3 K_r and K_{nr} indicate the radiative and non-radiative transitions and here only singlet to singlet (S_1, S_0) is radiative and remaining transitions are non-radiative. See Fig. 3(a). This electronic transition is supported by adiabatic potential model of dynamical relaxation process for electroluminescence in Alq_3 reported by Akai et.al. S_1 S_0. See Fig. 3(b).

Photo luminescence (PL) excitation spectrum of Alq_3: P having excitation wavelength is 440 nm exhibits the prominent PL excitation peak of Alq_3: P is observed at 438 nm See Fig. 4(a). PL emission spectrum of prepared Alq_3: P powder shows the prominent shoulder at 500nm Alq_3: P (3%) with higher intensity, 500nm Alq_3: P (5 %), 502nm Alq_3: P (1%), and 502nm Alq_3: P (2%) with decreasing intensity in green region. See Fig. 4(b) Hence the emission peak reveals that prepared phosphors is not only suitable for organic light emitting diode but also for photoluminescence liquid crystal display (PLLCD) and solid state lighting application as their no significant change in the emission peaks but there is an increase in the intensity. See table 1.

4. Conclusion

Alq_3: P hybrid organic phosphor is synthesized by the precipitation wet chemical method. Phosphor is characterized by XRD spectrograph. X-ray spectrograph of P doped Alq_3 complex displays well defined X-ray diffraction lines, confirming its crystalline nature and its grain size. Photo luminescence excitation spectra observed at 440nm violet region whereas emission spectra reveals at 500nm in the green region for combination Alq_3: P (3%). So Alq_3: P organic phosphor is suitable in the green region for PLLCD and OLED, nano rods, nano wires and solid state lighting application devices.

1.1. Table 1-

Organic phosphors	Excitation Wavelength(nm)	Emission Wavelength(nm)	Emission Intensity (arb. unit)
Alq_3	384 nm	531 nm	241
	455 nm	531 nm	450
AlQ_3: P (O.5%)	438 nm	500nm	233
AlQ_3: P (3%)	438 nm	500 nm	**305**
AlQ_3: P (1%)	433nm	502 nm	112
AlQ_3: P (2%)	436 nm	502nm	85

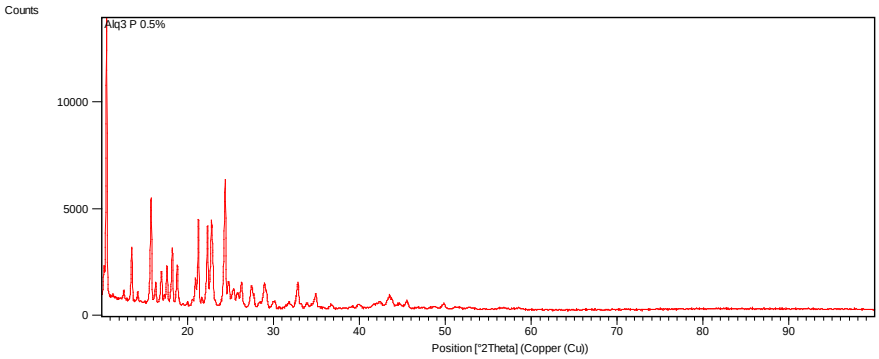

Fig. 1: XRD OF Alq_3: P

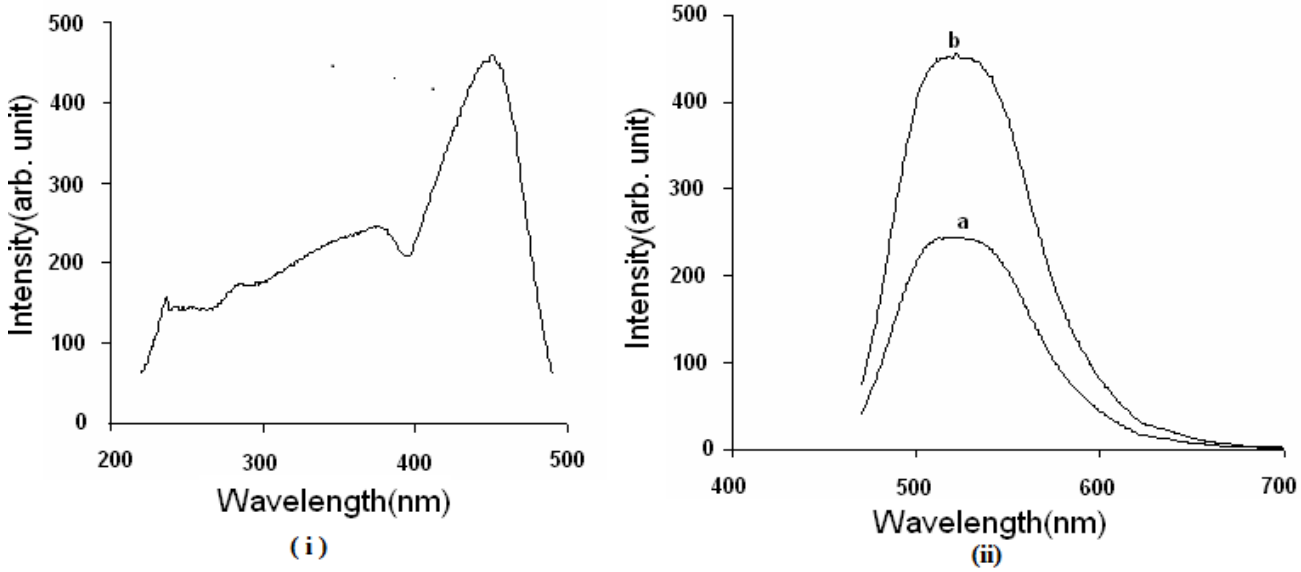

Fig 2: (i) Excitation and (ii) Emission spectra of Alq_3

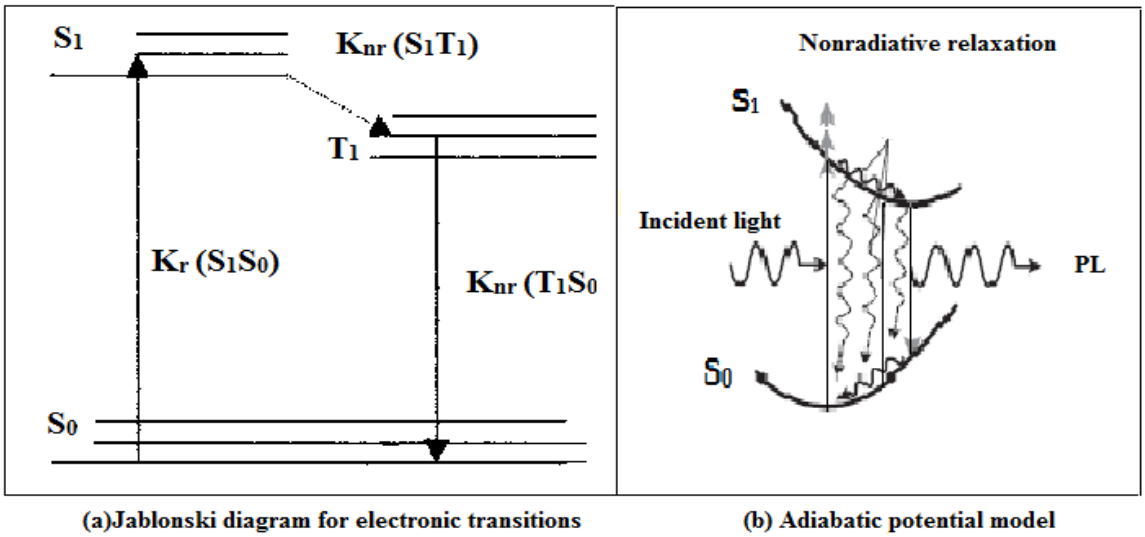

Fig 3 - (a): Jablonski diagram for electronic transitions (b): Adiabatic potential model

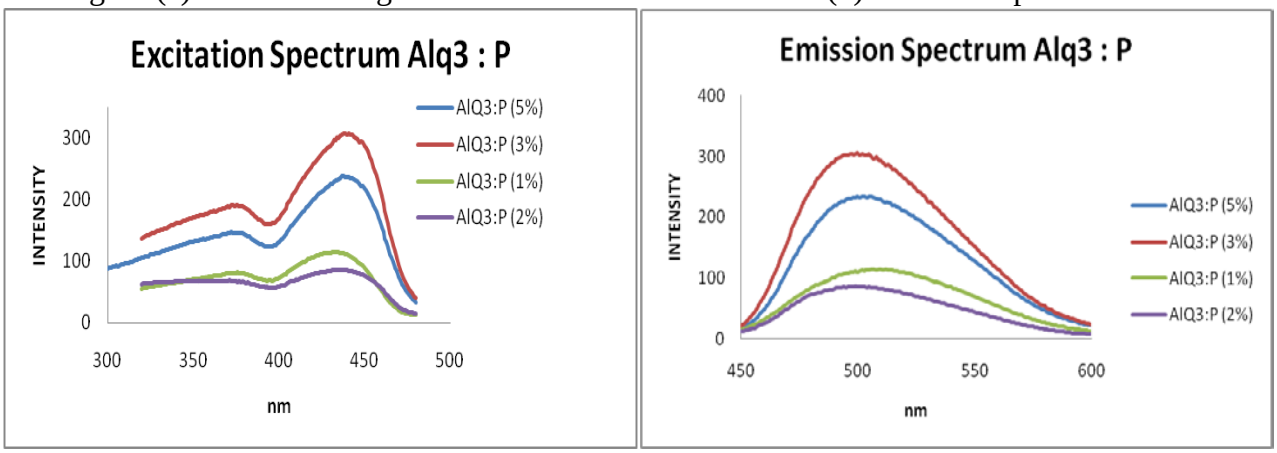

Fig. 4- (a) Excitation spectrum: Alq3: P (b) Emission spectrum: Alq_3: P

Equation

$$Al(NO3)3.9H2O + (C9H7NO) \rightarrow Al(C9H7NO)3 + 9H2O + 3(NO2)\uparrow$$

$$Al(NO3)39H2O + (NH4)H2PO4 + 4(C9H7NO) \rightarrow Al\,P(C9H7)O4 + 9H2O + NH3 + HNO3$$

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