IRJSE International Research Journal of Science & Engineering
*Int. Res. J. of Science & Engineering,* 2020; Special Issue A7: 288-291 SJIF Impact Factor 6.68
ISSN: 2322-0015
**RESEARCH ARTICLE** **OPEN ACCESS**

# Synthesis and Photolumenescence Charecterisation of $CO^{2+}$ Doped $Alq_3$

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**Manuscript Details**
Available online on http://www.irjse.in
ISSN: 2322-0015

**Cite this article as:**
Bhagat SA. Synthesis and Photolumenescence Charecterisation of $CO^{2+}$ Doped $Alq_3$ , *Int. Res. Journal of Science & Engineering,* February, 2020, Special Issue A7 : 288-291.



**ABSTRACT**

$Alq_3$ phosphor was doped by divalent $Co^{2+}$ ion, which has been synthesized by the wet chemical route. These organic phosphors were characterized by photolumine-scence measurements. The photoluminescence characterization revealed the presence of $Co^{2+}$ ion changes the photoluminescence of $Alq_3$ phosphor. The prepared phosphors are suitable for PLLCD, OLED and solid state lighting application devices reported in this paper.

**Keywords:** $Alq_3$, $Alq_3$: $Co^{2+}$ organic phosphor, photoluminescence, OLED.

## INTRODUCTION

The rapid progress in performance and lifetime make organic light – emitting diodes (OLED) suitable candidates for flat panel display applications. Since the first report of efficient and stable OLED [1, 2] , tri (8-hydroxyquinoline) aluminum ($Alq_3$) which is used as the emission and electron transport layer, the interest in this archetype material is persistent. Properties such as relative stability, easy synthesis, good electrons, an emitting properties result in extensive applications of $Alq_3$ in OLED design. Tang and coworkers discovered $Alq_3$- based multilayer thin film electroluminescent devices in 1987. $Alq_3$ still continues to be the workhorse among the class of low molecular weight materials for OLED. Research into organic materials for use in OLED has mostly focused on conjugated or low molecular weight materials [3]. However, so far comparatively few investigations have been devoted to the electronic and optical properties of material, in particular in the

crystalline state. Recently, a systematic study of the optical properties of solution, amorphous films, and different polymorphic crystalline phases of $Alq_3$ was published. Organic light-emitting diodes (OLED) constitute a rapidly developing field that many believe represents the future of flat panel display technology [4]. To date, the main focus of OLED research has been to address these issues using two types of compounds: conjugated organic polymers, such as poly (1, 4-phenylenevinylene) (PPV) [5, 6] and molecular species such as aluminum tri-(8-hydroxyquinolate) ($Alq_3$) [7]. Some elements doped in $Alq_3$ play important role in changing or enhancing PL intensity of $Alq_3$ [8, 9, 10, and 11]. The transition metal $Co^{2+}$ doped exhibits vital role in the enhancement of PL intensity with small change in PL emission wavelength which was reported in this paper.

## METHODOLOGY

**Synthesis of $Alq_3$ and $Co^{2+}$ doped $Alq_3$**

By adding the acid solution, and distilled water, the solution was heated on magnetic stirrer at $100^0$C. Due to temperature effect, nucleation produces a notable increase in the total free energy and a process of primary aggregation of the nascent particles. The prepared crystalline floppy powder was washed and dried till it takes a form of dry crystalline floppy powder of $Alq_3$. Alq3: Co2+ was prepared by wet chemical method. In this preparation of Alq3 act as a host lattice, aluminium nitrate Al(NO3)3.9H2O, Co (NO3)2 and 1, 8-hydroxyquinoline (C9H7NO) are used as raw materials. AR grade Aluminium nitrate and 8- hydroxyquinoline are mixed in an appropriate molar ratio in the 100ml distilled water and followed by the acid base precipitation method. In the synthesis process, when cobalt metal is added, it contributes an electron, withdrawing constituent at the position in 8-hydroxyquinoline, thereby increasing the solubility of the corresponding metal quinolate complexes in non-polar solvents.

## RESULTS AND DISCUSSION

The synthesized complexes have been characterized by XRD on The 'Expert pro' Automated power Diffractometer system company name "Analytical", taken at 'SAIF' Punjab University, Chandigarh. Photoluminescence (PL) emission spectra of the samples were recorded by using the RF-5301PC SHIMADZU Spectrofluorometer (RF-5301 PC).

**X-ray Diffraction**

X- Ray Diffractogram of $Co^{2+}$ doped $Alq_3$ exhibits well defined X-ray diffraction lines for the powder sample that confirm its crystalline nature. Although the phases have been clearly distinguished by X-ray diffraction measurement, some small admixture of a few percent cannot be excluded. The presence of distinct lines confirmed the polycrystalline nature of the synthesized complex as shown in Fig. 1.

**Excitation and emission photoluminescence of $Alq_3$ and $Co^{2+}$ doped $Alq_3$**

Fig. 2 (a) and (b) show the photoluminescent (PL) emission spectrum of $Alq_3$ powder by excitation wavelength is 430 nm. The prominent PL emission peak is observed at 500 nm in green region of the spectrum well matched with T. A. Hopkins et. al. [8] reported the green emission of yellowish green powder is attributed to α-phase of meridonal isomer of $Alq_3$. In this work, Lumophores based on Aluminium metallo-8-hydroxyquinolate prepared from co-precipitation method and co-doped with $Co^{2+}$ transition metal element. Characterization of materials is carried out by photoluminescence spectrographs. Alumium-8-hydroxyquinoline and co-doped materials with varying concentration of host were synthesized by simple co-precipitation route in order to reduce the cost and time of synthesized materials. In the synthesis technique when cobalt 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 produced an intense green-emission at the excitation around 378–430 nm wavelength (i.e. Blue OLED excitation wavelength).

The co-doped $Co^{2+}$ transition metal element plays vital role in the enhancement of PL intensity with small change in PL emission wavelength which was observed as shown in fig. 3(a) and (b). Fig. 3(a) shows PL excitation spectrum 'a' of 2% $Co^{2+}$ doped $Alq_3$

phosphor powder having excitation wavelength two peaks at 369nm with intensity 165.43 and 418nm with intensity169.58. It is monitored at 500nm. Its prominent PL emission peak is observed at 493 nm, monitored at 430nm in bluish green region of spectrum as shown in fig. 3(b) in 'a'.

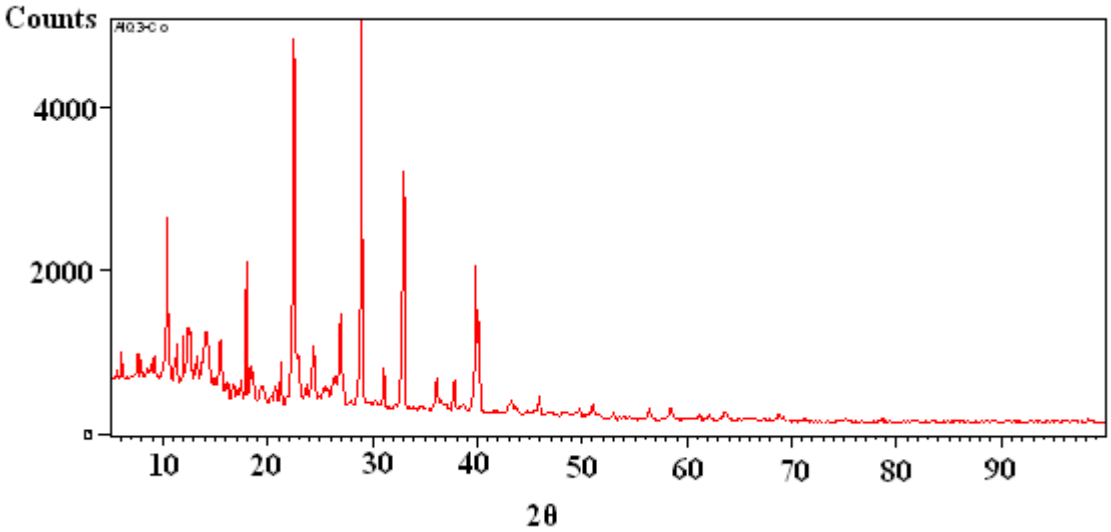


**Fig.1: X-Ray diffraction: $Co^{2+}$ doped $Alq_3$**

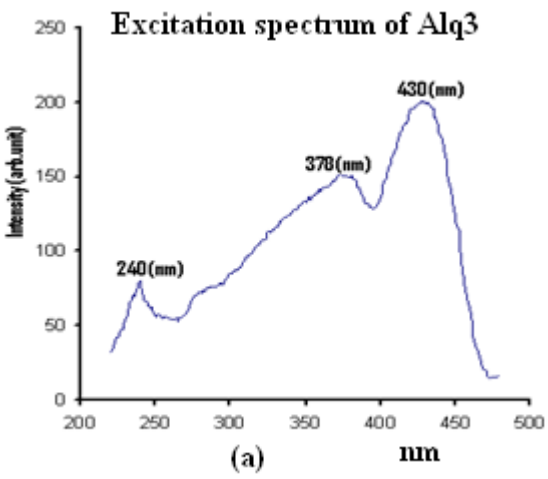


**Fig. 2(a): Excitation spectrum of $Alq_3$**

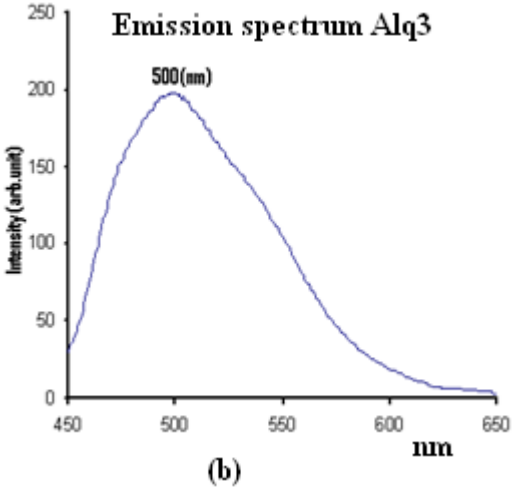


**Fig. 2(b): Emission spectrum $Alq_3$**

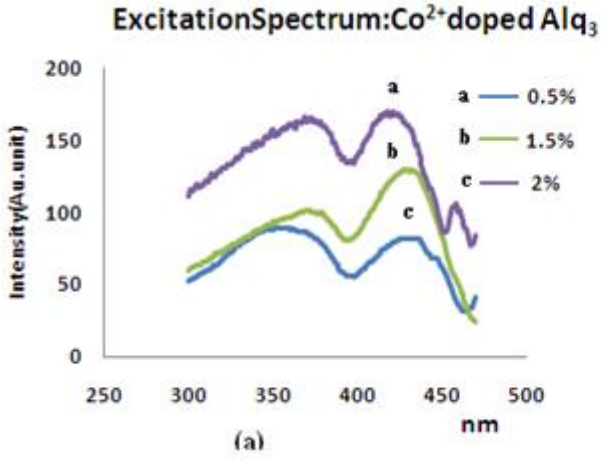


**Fig. 3(a): Excitation spectrum of $Co^{2+}$ doped $Alq_3$**

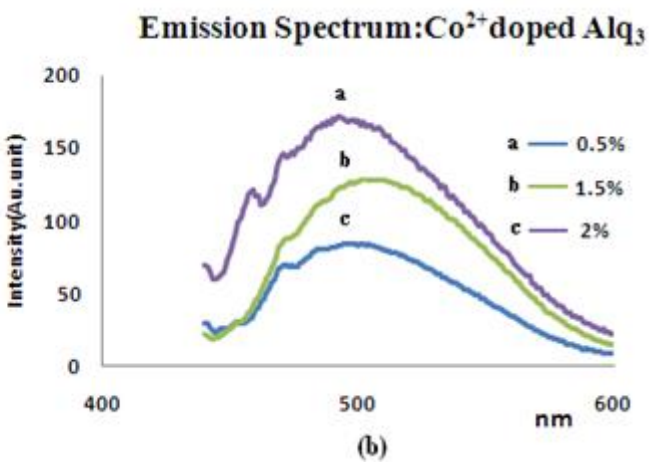


**Fig. 3(b): Emission spectrum $Co^{2+}$ doped $Alq_3$**

Figure 3(a) shows PL excitation spectrum 'b' of 1.5% $Co^{2+}$ doped $Alq_3$ phosphor powder having excitation wavelength two peaks at 369nm with intensity 100.9 and 432nm with intensity129.55. It is monitored at 503nm. Its prominent PL emission peak is observed at 503 nm, monitored at 430nm in green region of spectrum as shown in fig. 3(b) in 'b'.

Figure 3(a) shows PL excitation spectrum 'C' of 0.5% $Co^{2+}$ doped $Alq_3$ phosphor powder having excitation wavelength two peaks at 356nm with intensity 89.36 and 429nm with intensity81.89. It is monitored at 490nm. Its prominent PL emission peak is observed at 497nm, monitored at 430nm in bluish green region of spectrum as shown in fig. 3(b) in 'C'.

In this case $Co^{2+}$ ion may enter into host lattice $Alq_3$ to substitute Al atom in the phosphor. It is also observed that the peaks in the emission spectra of all the components of the polymers are at same wavelength region of light, i.e. in bluish green region. Variation in emission wavelength may be due to stochiometric compositions of the components.

The intensity of the emission spectrum of 2% $Co^{2+}$ doped $Alq_3$ phosphor is found to be changed as compare to that of $Alq_3$. Hence the intensity of $Alq_3$ can be changed by dopant $Co^{2+}$ ion. The emission spectrum of the $Co^{2+}$ doped $Alq_3$ is found in the green region, which can be used as lamp phosphor.

## CONCLUSION

$Alq_3$ phosphor was doped by divalent $Co^{2+}$ ion, which has been synthesized by the wet chemical route. These phosphors were characterized by photoluminescence measurements. The photoluminescence characterization showed the presence of $Co^{2+}$ ion changes the photoluminescence of $Alq_3$ phosphor. The emission spectra are observed at 493nm which is monitored at 430nm in bluish green region. The phosphor is excited at longer wavelength of small energy, may be used as lamp phosphor. It is observed that the prepared phosphors $Co^{2+}$ doped $Alq_3$ are suitable for PLLCD, OLED and solid state lighting application devices.

**Author Contributions**

The Author state and declare that the article sending for publication is no where sent for publication with best of true knowledge. The Author Contribute statement describe the contributions of individual author, referred to by their initials and, in doing so The author agree to be accountable for the content of the work.

**Conflicts of interest:** The authors stated that no conflicts of interest.

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