Characteristics of Luminescence and Its Parameters in Rare Earth Activated Compounds

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Abstract: *The luminescence and phosphors has assumed ever more significance in the overall scheme of scientific progress. Solid-state luminescence is now set to significantly displace gas discharge luminescence in many areas, in much the same way as gas discharges have already displaced tungsten filament incandescence. One of the objectives of is to better understand the mechanism of energy transfer and photoluminescence behavior of some phosphate phosphors.*

INTRODUCTION

The materials of inorganic luminescent are currently in these days broadly utilized in numerous quotidian devises and for this studies on their acquisition, spectroscopic conduct and applications have been noteworthy. The mixed uncommon earth ortho phosphates is extremely fascinating class of host lattices for ions of activator because of their physic-chemical inercy (insolubility which is high, steadiness against high excitations of energy or against temperature which is also high) and thereby giving phosphors which are durable. Also, these materials can introduce excitabilities in region of ultraviolet, which empowers them in fluorescent lamps of new era (with no mercury), field emission displays, projection televisions (PTVS) and cathode ray tubes etc.

In the recent years, much consideration has been centered around on luminescent materials which are based on oxide because of their business applications in scintillations, Xray phosphors and fluorescent tubes. As of late different phosphor materials have been effectively explored for enhancing their properties of luminescent and to meet the advancement of various luminescence and display devices. Inorganic compounds doped with rare ions of earth form a critical class of phosphors as they have a couple of fascinating attributes, for example, flexible colors of emission with various activators, high efficiency of luminescence and incredible chemical stability. There is developing enthusiasm for the improvement of new full shading emitting materials of phosphor that join chemical and thermal stability in air with high outflow yield of quantum at room temperature. [1]

The compounds based on phosphate are an essential host, which can deliver a lot of precious crystal field situations forced on outflow centres. The ions of rare earth doped phosphates have outstanding thermal stability. The phosphors based on phosphates actuated with Eu3+ ions for diodes which emit white light have been broadly studied. The Eu doped materials at solid state generally show strong broadband luminescence with a short time of the request of somewhere in the range of ten nano seconds. The luminescence is unequivocally subject to the host lattice and can happen in the region from ultraviolet to red of electromagnetic spectrum. The emission of Eu is sufficiently enough to discover important applications related to industry. [2]

The materials of luminescence have turned into the materials that could not fall short in our day to day life. They have been broadly applied in numerous fields like flat panel display devices, triphosphor fluorescent powder, CRTs (cathode ray tubes) and lighting etc. The optical materials based on rare earth have exceptional properties like captivating and discharging light in all wavelengths of visible range with stable chemical and physics properties and high purity color which play a part to the position of the electrons 4f of the ions of rare earth. They have been the main theme of rigorous enthusiasm among wide range of materials of luminescence. Yet pure materials of rare-earth are costly; it is necessary to search for attractive host substance for ions of rare-earth at less cost rather than materials of pure rare-earth. [3]

LUMINESCENCE

The classification of light can be done in mainly two ways: first one is incandescence and second one is luminescence. Incandescence is the glow of light by materials heating and then bright light is produced. Luminescence is the aggregate term for various phenomena in which substance give out light without being heated strongly. This definition is likewise reflected by term “cold light”. The word luminescence was initially utilized in 1888, by a German physicist EilhardtWiedemann. In Latin, “Lumen” implies “light”. The materials showing this phenomenon are called Luminescent materials or in Greek, Phosphors implies light bearer. The term phosphor was authored in seventeenth century by an alchemist who is Italian named Vicentinus Casciarlo of Bologona. [4]

A hot body that transmits radiation exclusively due to its high temperature is said to demonstrate incandescence. Every other types of emission of light are known as luminescence. At the point when luminescence happens, the energy is lost by system and if there is continuous emission, some type of energy ought to be supplied from somewhere else. Hence the radioluminescence transmitted from clock face which is luminous is given by particles of high energy from the material which is radioactive in the phosphor and the electroluminescence of discharge lamp of gas is gotten from electric current’s passage via gas which is ionized. Other such type of phenomena incorporate chemiluminescence, gotten from chemical reaction’s energy and it is known as bioluminescence when the reactions happen inside living organisms, such as fireflies and glow-worms. [5]

Rare Earth Elements: There are 17 rare earth elements (REEs), 15 within the chemical group called lanthanides, plus yttrium and scandium. The lanthanides consist of the following: lanthanum, cerium, praseodymium, neodymium, promethium, samarium, europium, gadolinium, terbium, dysprosium, holmium, erbium, thulium, ytterbium, and lutetium. Rare earths are moderately abundant in the earth’s crust, some even more abundant than copper, lead, gold, and platinum. While some are more abundant than many other minerals, most REEs are not concentrated enough to make them easily exploitable economically.2 The United States was once self-reliant in domestically produced REEs, but over the past 15 years has become 100% reliant on imports, primarily from China, because of lower-cost operations.3 The lanthanides are often broken into two groups: light rare earth elements (LREEs)—lanthanum through europium (atomic numbers 57-63) and the heavier rare earth elements (HREEs)—gadolinium through lutetium (atomic numbers 64-71). [7]

Light Rare Earths (more abundant)	Major End Use	Heavy Rare Earth (less abundant)	Major End Use
Lanthanum	Hybrid engines, metal alloys	Terbium	Phosphors, permanent magnets
Cerium	Auto catalyst, petroleum refining, metal alloys	Dysprosium	Permanent magnets, hybrid engines
Praseodymium	Magnets	Erbium	Phosphors
Neodymium	Auto catalyst, petroleum refining, hard drives in laptops, headphones, hybrid engines	Yttrium	Red color, fluorescent lamps, ceramics, metal alloy agent
Samarium	Magnets	Holmium	Glass coloring, lasers
Europium	Red color for television and computer screens	Thulium	Medical x-ray units

Table 1: Rare earth elements (Lanthanides): Selected End Uses [7]

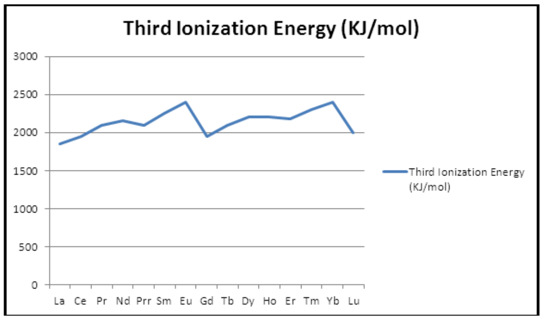

Fig. 1: Plot of third ionization energy vs. atomic number for lanthanide elements with arrows denoting the location of quarter, half, three quarter and completely filled 4f electron shell.

Phosphate Compounds

In display, phosphor is regarded as likeness of an eye in the body of human. The phosphors utilized in different displays for a particular application ought to meet standards of NTSC/PAL. Till today, not many phosphors are suitable for manufacturing of display.

Physical Requirements

The morphology (shape and size of particle of phosphor), rheology and body color and particle and particle size distribution (PSD) are the main physical requirements as display phosphors. The rheology of slurry or paste relies upon particles shape and size, vehicles and binders utilized in past formulations. Recently, majority of displays are fabricated by deposition of particles of phosphor by dusting, slurry, settling, ink jet or screen printing process. The thickness of phosphor, PSD and morphology not only influence the process of manufacturing of display, but also the display's performance. Preparing phosphor in the vicinity of different materials of flux such as can alter its morphology and enhance the luminescent properties. The shape which is spherical of the particles of phosphor helps for minimization of binder's quantity and also vehicles needed in the process of coating. It is additionally known that screens having particles of phosphor having size smaller have better performance and high density of packing.

Phosphor Parameters

Purity of raw materials: Even a small amount of impurities, sometimes change phosphor characteristic drastically, therefore the raw materials used must be of high purity. One must exercise all cautions to choose pure raw materials to form the phosphor and prevent further contamination from occurring during the preparation processing to form the phosphor. For example in case of Y2O3 the most frequently used rare earth compound, the rare earth other than 'Yttrium' should be kept below 10 ppm and the total amount of heavy metals below 10 ppm. In the present work the rare earth oxides used are procured from Indian Rare Earth's Limited and were of 99.9% purity and other chemicals from Chemical Center and Du Cat chemicals.

Raw materials blend ratio: The completeness of the solid state reaction depends on the relative diffusion rate of the reacting species. The rate of reaction between the two solids is an exponential one, rapid in the beginning but slowing as the components are used up. An asymptote is gradually approached but the reaction never becomes 100 % complete. Thus we always end up with a un reacted components. Any such impurity affects the efficiency of the so-produced phosphor. Therefore in formulating a phosphor composition, one always employs a small excess of the anion reactant so as to avoid the presence of strongly absorbing cationic species in the end product. The excess components either vaporize during the firing or are consumed to create bi-product. They can sometimes be washed away after the reaction and we get the resulting phosphors very close to the stoichimetric composition.

Impurities and additives: The presence of some impurity ions reduces luminescence efficiency, sometimes to a very great extent. On the contrary, there are some additives that influence phosphor characteristics in a positive way; they improve efficiency or decrease deterioration. The kind and quantity of the ions that change phosphor characteristics differ from phosphor to phosphor. Some examples are presented in the following. It is well known that the iron group ions drastically reduce the luminescence efficiency of ZnS phosphors, and hence are called killers.

OBJECTIVES

The energy transfer phenomenon has been studied extensively in inorganic phosphors, crystals, solutions, and glasses. Hence, an attempt wiil be made to consider efficient phosphors based on rare earth-activated phosphates, to study their luminescence properties, and to explore potential new materials and applications.

There is a need to continue research in this field because excitation sources have changed and it is known that a good phosphor for electronic or ultraviolet excitation is not necessarily a good choice for excitation in vacuum ultraviolet (VUV). Till date, in order to produce light with a fluorescent lamp it was necessary to put mercury inside the lamp to generate ultraviolet photons at k = 254 nm. These would subsequently excite the phosphor-coated inner surface of the lamp. However, in the near future, it will be mandatory to replace/reduce the use of mercury in lighting devices, because mercury is very harmful for the environment. The past few decades have seen spectacular developments in research on luminescence. There has been phenomenal growth in the subject and significant progress has been made. Rare earth ion-activated phosphors have numerous applications in the display, lighting, and medical industries. In recent years, the luminescent properties of phosphate materials have been widely investigated for their many advantages, such as excellent thermal and chemical stability, and the development of optical devices based on rare earth (RE) ion-doped materials has proven to be one of the most interesting fields of research. In this context, phosphates are investigated because of their low cost, their high stability for use in lamp applications, and their important crystallographic possibilities with regard to the accommodation of luminescent ions.

RESULTS AND DISCUSSIONS

1. XRD analysis

Fig. 2 demonstrates the X-ray diffraction pattern of Li_2BPO_5 phosphor. It indicate that end product was created in the form which is homogeneous.

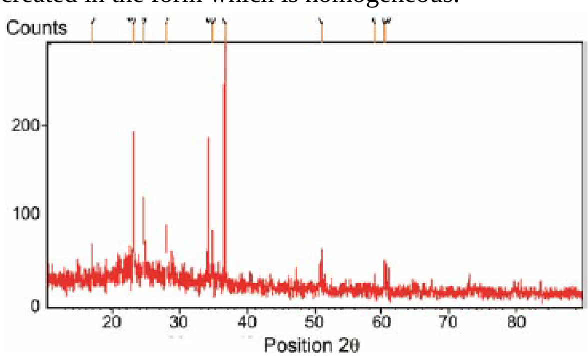

Fig. 2 X-ray diffraction (XRD) pattern of Li_2BPO_5

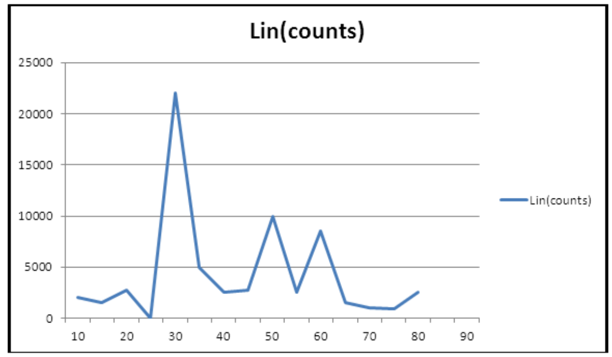

Fig.3: XRD of Eu doped LAG phosphor

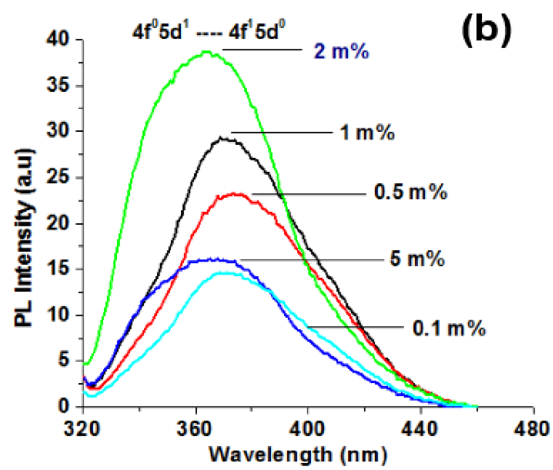

Fig. 4 (b) PL emission spectra of $Na_2CaP_2O_7:Ce^{3+}$phosphor

2. Optical properties

The photoluminescence emission spectrum of Dy^{3+} doped Li_2BPO_5 phosphor, which is acquired under the wavelengths of excitation between 300 nm to 400 nm is demnstrated in Fig. 3

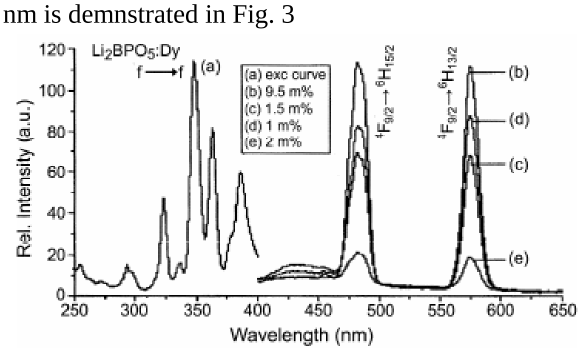

Fig. 5: PL emission spectra of Li_2BPO_5 Dy, emission peak at 576nm was monitored at 348 nm excitation

Fig.6 shows that when Li_2BPO_5 5 mole% was observed for 0.5 mole % concentration of Dy^{3+} ions at 345 nm in UV range, 484 nm in blue range and 576 nm in yellow range.

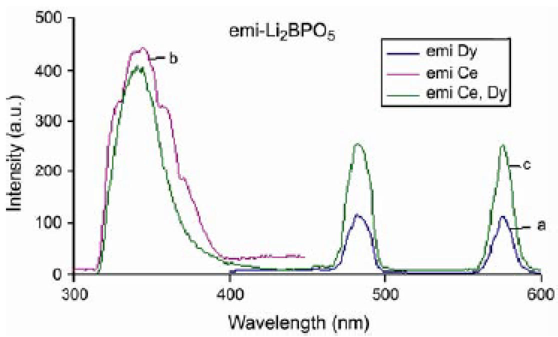

Fig. 6: PL emission spectra of various Li_2BPO_5 phosphors (a) Li_2BPO_5 Dy, λ_{ext}=348nm, (b)Li_2BPO_5 Ce, λ_{ext} = 238nm and (c) Li_2BPO_5 Ce, Dy, λ_{ext}=301nm

CONCLUSION

The luminescence and phosphors has assumed ever more significance in the overall scheme of scientific progress. The luminescent materials known as phosphors convert energy into electromagnetic radiation, usually in the visible energy range. Phosphors are solid luminescent materials that emit photons when excited by an external energy source. Luminescence continues to play a major technological role for mankind.

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