Summary

Luminescence is the emission of light from matter for reason other than temperature. Depending upon the type of excitation, Luminescence is categorised into several types viz. Photoluminescence, Electroluminescence, Cathodoluminescence, etc. This work deals with Photoluminescence (excitation by photons) and Thermally Stimulated Luminescence (luminescence due to heating of matter, which is subjected to prior irradiation)

The work is basically on Lamp phosphors, which are used in low pressure mercury vapour lamps i.e. Tubular fluorescent lamps and Compact fluorescent lamps. The low pressure gas discharge in these lamps generate ultraviolet radiation, a large amount of which is at 253.7 nm. The lamp phosphor layer inside the lamp absorbs this radiation and converts it into visible light. Hence the efficiency of tthe phosphor material to convert UV into visible, called ' Quantum Efficiency ' is the most significant parameter. Moreover, the spectral distribution of the visible light that is generated by the phosphor is also significant. For the colour of light to have a desirable ' white ' appearance, the spectral distribution should cover the entire visible range. This characteristic can be verified by its emission spectra. The excitation spectra should be such that maximum amount of the 253.7 nm radiation is absorbed. Another aspect of the phosphor powder, which is very significant is its particle size distribution. The lumen output of the lamp depends on the Quantumm efficiency of the phosphor used, while the colour coordinates are mostly the fallout of emission characteristics of the phosphor material. Hence, these parameters can be corelated.

For the study and corelation of these parameters and characteristics which determine the quality of the lamp, commercial lamp phosphor samples were collected from prominent lamp manufacturers like Osram (Germany), Philips (

Holland & India), G.E. (USA), Cona (Holland) and Solichem (India). They have been coded to mantain confidentiality. All these phosphors were found to be Calcium halophosphate doped with Antimony and Manganese. Tubular fluorescent lamps were made out of these samples. The Quantum efficiency of the samples were found between 80 % and 90 %. The lumen output of lamps made out of these samples do not show a strictly linear relation with Quantum efficiency. Although the theoratical maximum of lumen output is about 3200 lumens, the maximum that was observed in this study was just more than 2500 lumens. The ISI requirement is 2450 lumens. The non linearity of the above relation suggests the dependence of lumen output on some other factors.

Colour rendering properties of the lamps also make some contribution to the lumen output. This is because human eye has different sensitivity in different region of the spectrum. It is highest in the green region around 555 nm. However, more than the contribution to the lumens, the colour characteristics of a lamp determine the quality of the light that is emitted. Ideally, this should be like the white sunlight, which is given by a set of coordinates in the chromaticity diagram. The colour coordinates of a given lamp should be near to this ' white ' point. TFL are categorised on the basis of their colour coordinates and their proximity to the colur temperature points on the black body locus. Based on this, the lamps studied were found to be of ' Cool daylight ' varietywith a colour temperature of around 6750° K having colour coordinates around $x = 0.315$ and $y = 0.345$, corresponding to a Colour rendition index of about 72.

Particle size analysis of the phosphor sample shows that the average diameter of the particles is around 12 microns. This is a bit on the higher side. Finer powders with average particle size of around 5 microns give better lumen output and save upon the cost of phosphor too. However, preparation of powder of such low particle size is tedious, but can be done using wet chemical methods. The particle size also determines the amount of reflection of the incident radiation.

Apart from the above, the lamp performance also depends upon the coating thickness of the phosphor material, which ensures the optimum absorption of the incident radiation. The pressure of the gas and the electrical characteristics are also important.

The phosphor coating inside the tube is bombarded by electrons, ions and UV photons generated by the gas discharge. The incidence of these particles and photons can give rise to defects in the crystal structure of the phosphor material. If these defects involve the dopant ions which are the fluorescence centres, then there is likely to be a change in the energy levels of these ions. This can in turn affect the fluorescence properties of the dopants and thus the phosphor material itself. Hence, the study of the defects was undertaken. TSL and EPR techniques were employed for the purpose and their corelation was undertaken. Difficulty was encountered in taking the EPR spectra due to the presence of Mn^{2+} paramagnetic ions, the signal from which dominated the spectra However, available literature suggests the role of several radicals in the TSL process. The glow peaks may be due to the thermal bleaching of radicals. like O^-, $(ClO)^{2-}$, $(FO)^{2-}$, PO_4^{2-}, H° etc The radicals containing Oxygen may be a consequence of the preparation process. Those phosphors which are fired in air are contaminated by Oxygen atoms. The presence of H° radical is attributed to the moisture absorption characteristics of one of the raw materials used in the preparation of phosphors The radical responsible for the glow peaks has been proposed to be PO_4^{2-}. The TSL spectra indicates that the luminescence centre is the Mn^{2+} ion. It has been proposed that the two peaks in the TSL spectra around 410 and 550 nm be attributed to the two Manganese sites in the crystal lattice. The TSL centres formed due to UV irradiation have been proposed to be the dopant ions and their aggregates.

Although Calcium halophosphates are still the most widely used phosphor material, there are certain limitations about its lumen output capacity and colour rendering properties. Better phosphors have been made using rare - earth materials

It was predicted in the early seventies that better lumen output as well as colour rendering properties can be obtained by using phosphor blends with the components having narrow band emission characteristics in the blue, green and red region. Due to their electronic properties, the rare - earth ions exhibit narrow band characteristics and are hence suitable for the purpose. However, the cost of these materials is quite high.

Terbium as dopant in several host matrices gives green emission. One of them is Lanthanum Phosphate, which is comparatively cheaper. The cost of Terbium is much higher in comparison to Cerium. Hence, partial replacement of Terbium by Cerium can reduce the cost. $LaPO_4$:Ce,Tb was prepared using high temperature solid state synthesis method. The bulk material was characterised by XRD, while the dopants were characterised by the emission spectra for an excitation wavelength of 254 nm. The emission spectra shows the most prominent peak at 545 nm with two smaller peaks at 585 and 620 nm.

Out of the four samples prepared, the one with only Cerium ($LaPO_4:Ce_{0.01}$) shows very poor Quantum efficiency. $LaPO_4:Ce_{0.02}Tb_{0.01}$ gave the highest Quantum efficiency. Cerium plays the role of a sensitiser, while Terbium is the activator.

The TSL - EPR corelation shows the association of PO_4^{2-} radical and F^{++} centre (an electron in an anion vacancy) with the TSL glow peaks. Based on the TSL spectrum, the luminescence centres have been proposed to be the dopant ions. TSL glow peaks due to UV irradiation has been proposed to be associated with the dopant ions either isolated or in aggregates.