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Luminescence of Eu^{3+} in Some Scandium Phosphates

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ABSTRACT

Lanthanide ions are very efficient activators. Due to the presence of shielded 4f shell, the energy levels can be predicted with relative ease. Interaction with the surrounding lattice is minimum and luminescence efficiency is high. For this reason, many important phosphors having various applications have been discovered which use lanthanide activators.

For obtaining efficient phosphors, it is important to find a suitable host for lanthanide activators which can accommodate these ions without concentration quenching. The hosts must be transparent to the emitted light. Lanthanides, most commonly occur as trivalent. Thus, hosts constituted by trivalent metals can be suitable. Yttrium compounds have been extensively studied as hosts. Scandium is another trivalent metal. Compared to the yttrium compounds, Scandium compounds have been very scarcely studied as hosts. We are investigating Scandium compounds as luminescence hosts.

Synthesis and photoluminescence properties of $Sr_9 Sc (PO_4)_7 : Eu^{3+}$ and $Sr_8MgSc(PO_4)_7:Eu^{3+}$ phosphor are described in this work. The phosphors were prepared by solid state reaction. Usually, these phosphors are reduced and results on Eu^{2+} photoluminescence are reported. However, we have recorded photoluminescence before reduction and thus new results on Eu^{3+} emission could be obtained.

Keywords: Scandium Compound, Phosphor, Photoluminescence, Phosphate

I. INTRODUCTION

Lanthanide ions are very efficient activators. Due to the presence of shielded 4f shell, the energy levels can be predicted with relative ease. Interaction with the surrounding lattice is minimum and luminescence efficiency is high. For this reason, many important phosphors having various applications have been discovered which use lanthanide activators.

For obtaining efficient phosphors, it is important to find a suitable host for lanthanide activators which can accommodate these ions without concentration quenching. The hosts must be transparent to the emitted light. Lanthanides, most commonly occur as

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trivalent. Thus, hosts constituted by trivalent metals can be suitable. Yttrium compounds have been extensively studied as hosts. Scandium is another trivalent metal. Compared to the yttrium compounds, Scandium compounds have been very scarcely studied as hosts. We are investigating Scandium compounds as luminescence hosts. Synthesis and photoluminescence properties of $Sr_9Sc(PO_4)_7:Eu^{3+}$ and $Sr_8MgSc(PO_4)_7:Eu^{3+}$ phosphor are described in this work.

II. METHODS AND MATERIAL

The phosphors were prepared by solid state reaction. Analar grade Strontium carbonate, magnesium carbonate, scandium oxide, ammonium hydrogen phosphate, europium oxide were weighed in stoichiometric proportions, and thoroughly mixed in mortar and pestle. Alumina crucible containing the mixed ingredients were placed in a furnace and heated for 6 hours at 1250 C. After that the furnace was switched off and the formed compounds were allowed to cool naturally. The compounds so formed were again ground to fine powders for further characterization. Photoluminescence spectra were recorded in the range 220-700 nm on Hitachi F-7000 spectro-fluorimeter with spectral slit widths of 1 nm.

III. RESULTS AND DISCUSSION

In the literature, luminescence of Pr^{3+} [1], Eu^{2+} [2] and Ce^{3+} [3] had been described in $Sr_9Sc(PO_4)_7$ host. There are not many studies apart from these.

Usually, these phosphors are reduced and results on Eu^{2+} photoluminescence are reported. However, we have recorded photoluminescence before reduction and thus new results on Eu^{3+} emission could be obtained.

For $Sr_9Sc(PO_4)_7:Eu^{3+}$, emission lines are observed at 580,591 and 613,615 nm corresponding to transitions $^5D_0 \rightarrow {}^7F_1$ (magnetic dipole transition) and $^5D_0 \rightarrow {}^7F_2$ (electric dipole transition), respectively (Fig.1). In the corresponding excitation spectrum, a weak broad band around 250 nm attributable to charge transfer excitation was observed. On the longer wavelength side, there are several sharp lines corresponding to f-f transitions of Eu^{3+}.

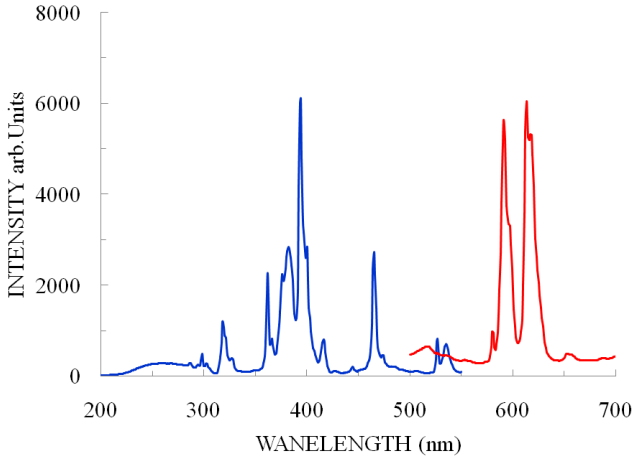

Figure 1: PL emission and excitation spectra for $Sr_9Sc(PO_4)_7:Eu^{3+}$

These lines are observed at 284,289,298,300 ($^7F_0 \rightarrow {}^5F_4$), 318,323 ($^7F_0 \rightarrow {}^5H_6$), 362,366 ($^7F_0 \rightarrow {}^5D_4$), 376,381 ($^7F_0 \rightarrow {}^5L_7$), 394,398 ($^7F_0 \rightarrow {}^5L_6$), 415,422 ($^7F_0 \rightarrow {}^5D_3$), 465,470 ($^7F_0 \rightarrow {}^5D_2$), 526 and 534 nm ($^7F_0 \rightarrow {}^5D_1$).

$Sr_8MgSc(PO_4)_7$ is known to "crystallize in a monoclinic unit cell with space group I2/a and lattice constants a = 18.0115 Å, b = 10.6006 Å, c = 18.3659 Å, beta = 132.976 and cell volume = 2565.6(8) $Å^3$. The Sr^{2+} ions have five different coordination numbers. Sr(1) is defined as being eight-coordinated; Sr(2), Sr(3), and Sr(4) are defined as being nine-coordinated; and Sr(5) is defined as being ten-coordinated [4]".

Strong orange-red emission was observed for $Sr_8MgSc(PO_4)_7:Eu^{3+}$ also (Fig.2). In this case, emission lines were observed at 579,589, 599 nm ($^5D_0 \rightarrow {}^7F_1$) and 612,617 nm ($^5D_0 \rightarrow {}^7F_2$). In the excitation spectrum, a weak charge transfer band appears around 285 nm. f-f excitation lines appear at 298 ($^7F_0 \rightarrow {}^5F_4$), 318,327 ($^7F_0 \rightarrow {}^5H_6$), 362,365 ($^7F_0 \rightarrow {}^5D_4$), 376,380,383 ($^7F_0 \rightarrow {}^5L_7$), 394,398 ($^7F_0 \rightarrow {}^5L_6$), 415,422 ($^7F_0 \rightarrow {}^5D_3$), 464,470 ($^7F_0 \rightarrow {}^5D_2$), 526 and 533 nm ($^7F_0 \rightarrow {}^5D_1$).

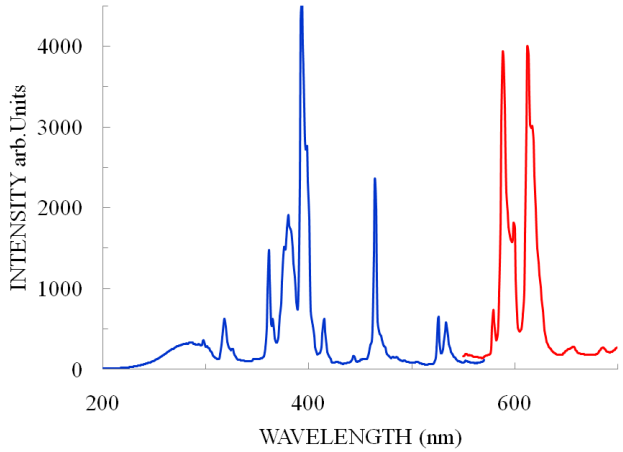

Figure 2: PL emission and excitation spectra for $Sr_8MgSc(PO_4)_7 : Eu^{3+}$

IV. CONCLUSION

By preparing the samples in air, we could maintain Europium in trivalent form in $Sr_9Sc(PO_4)_7:Eu^{3+}$, and $Sr_8MgSc(PO_4)_7:Eu^{3+}$ hosts. These new results show that the f-f excitations are much stronger than the CT band around 250/285 nm. The emission shows both the characteristic lines in the orange and red region.

V. REFERENCES

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