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Photoluminescence characterization of (KNa)F:Ce^{3+} phosphor.

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ABSTRACT
In the present work, (KNa)F:Ce^{3+}phosphor was synthesized by wet chemical method and the photoluminescence (PL) characteristics have been studied. The photoluminescence spectrum comprises of a main peak in the range 255 nm which may be ascribed to transitions from 5d–4f levels of cerium in the host lattice (KNa)F. The PL intensity is found to dependent on concentration of Ce^{3+} doped in the host material.

Keywords: Photoluminescence, excitation and emission spectra, (KNa)F:Ce^{3+}.

INTRODUCTION

In recent years, energy crisis and environmental pollution exert great pressure on the sustainable development of the modern society. In response to the ever-increasing energy demands coupled with serious concerns for global warming, there has been an immense interest in new sources of white light that can reduce electrical energy consumption and operating expenses while providing accurate colors [1, 2]. The department of energy in the USA has announced its goal to reduce energy consumed by lighting to 50 % by 2020 using high efficiency light emitting diodes (LEDs) [3]. The conventional fluorescent lamps were replaced by LED for lighting applications to decrease the worldwide electricity utilization for lighting by at least 50 %. The efficiency of white LEDs have already greater than that of fluorescent lamps, for that reason white LEDs can be considered as the next-generation of lighting system [4-8].

However, the efficiency of the present LEDs are limited and there is need to develop the new energy saving devices by selecting the suitable host and rare-earth ion.

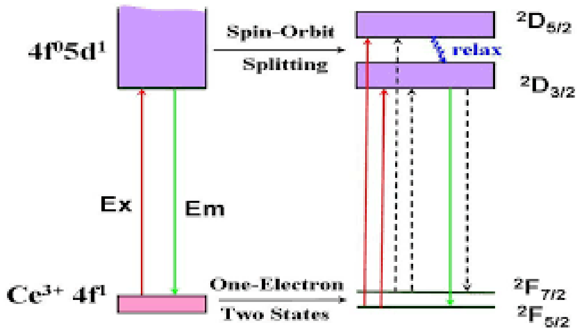
Efforts have been made on finding new materials with low phonon energy in order to reduce the multi phonon non-radiative excitation and improve cross-sections of the RE ions, being the fluoride based matrices are the common choices. Wet chemical method is relatively cost-effective, quick and can be easily exploited to prepare phosphors with enhanced optical properties. Preparation of complex fluorides involving several constituent fluorides is still not an easy task. The constituents may have vastly differing melting points, and loss of one or more constituents during crystal growth is inevitable. In modern years, some wet chemical methods for preparation of OH-free fluorides have been described [**9, 10**]. Recently, rare earth based materials developed for wide application due to high potential characteristics of rare earth ions **[11-15]** therefore development of spectroscopic study of these materials is new challenges in the field of inorganic materials. The PL characteristic of the new material, (KNa)F:Ce^{3+} are reported in the paper.

METHODOLOGY

All chemicals used in this experiment were analytical grade and used as received. Distilled water was used in the preparation of solutions. In the typical synthesis of (KNa)F:Ce^{3+}(0.1- 3 mol %), NaF, KF and $CeCl_3$ were dissolved in distilled water and stirred to prepare clear solution of NaF, KF and $CeCl_3$ and then for the required sample desired $CeCl_3$ solution were mixed in the equimolar (KNa)F solution. The mixtures were appeared as chemically homogenous transparent liquid. These mixtures then were kept in hot air oven at 80 ^{0}C for 4-5 days till the solutions were completely dry. The crystal structure of the product was slightly crushed to powder. The prepared residue was used for further study. Unquenched samples were used for the study of photoluminescence with Spectroflurophotometer RF-5301 PC

RESULTS AND DISCUSSION

The photoluminescence (PL) emission spectra of the samples were recorded using Fluorescence spectrometer (RF-5301 PC). The same amount of sample was used in each case. Emission and excitation spectra were recorded using a spectral slit width of 1.5 nm. Ce^{3+} is a very good candidate as activator as well as sensitizer, for studying the behavior of 5d electrons. Ce^{3+} has only one outer electron and only two spin-orbital splitting 4f states ($^2F_{5/2}$, $^2F_{7/2}$). Thus, its excited state energy structure is simpler than that of the other trivalent rare-earth ions.



Photoluminescence excitation spectra of (KNa)F:Ce^{3+} phosphor is shown in **Fig. 1**. A broad band is observed peaking at 255 nm. The variation in peak PL intensity with different concentrations of Ce^{3+} doped in (KNa)F is shown in **Figure 2**. The intensity of excitation spectra of the prepared samples were found to be dependent on the concentrations of Ce^{3+} doped in the (KNa)F material. The intensity is decreases linearly from 1 mol% to 3mol% in the prepared (KNa)F:Ce^{3+} sample. **Fig. 3** shows the emission spectra of Ce^{3+} ions in (KNa)F phosphor with different concentrations under the same excitation (i.e. 255 nm) wavelengths of light. On exciting the unirradiated crystal with 255 nm light, emission bands at 330-340 nm were observed. The highest intensity observed at 330 nm for 1 mole % Ce in the host material. All further increase of Ce^{3+} ion in the host material the intensity gets reduced. This indicates a change of the surrounding of the Ce^{3+} ions at higher concentration in the (KNa)F lattice. Variations observed in emission intensities, may be due to cross relaxation between Ce^{3+} ions in the case of heavy concentration of Ce^{3+}.

The Ce^{3+} ion can be used as sensitizer as well as an activator, depending on the splitting of 5d excited levels by the crystal field symmetry. Much work has been done on the Ce^{3+} to different activator ions in different host lattice The variation in peak PL intensity of emission spectra with different concentrations of Ce^{3+} doped in (KNa)F is shown in **Figure 4**. The curve is sub linear which show that the intensity of emission spectra the prepared samples were also found to be dependent on the concentrations of Ce^{3+} doped in the (KNa)F material. The intensity of emission spectra too decreases linearly from 1 mol% to 3 mol% in the prepared (KNa)F:Ce^{3+} sample.

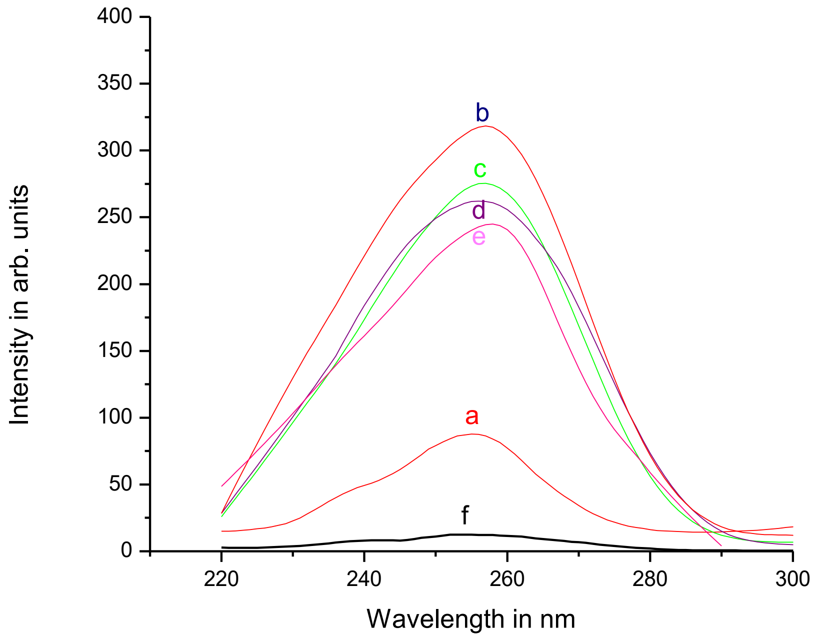


Figure 1: Photoluminescence excitation spectra of (KNa)F:Ce^{3+} phosphor, a=(KNa)F :Ce^{3+}(0.5 mol%), b= (KNa)F :Ce^{3+}(0.5 mol%), c= (KNa)F :Ce^{3+}(1 mol%), d= (KNa)F:Ce^{3+}(1.5 mol%), e= (KNa)F :Ce^{3+}(2 mol%), f= (KNa)F :Ce^{3+}(2.5 mol%),

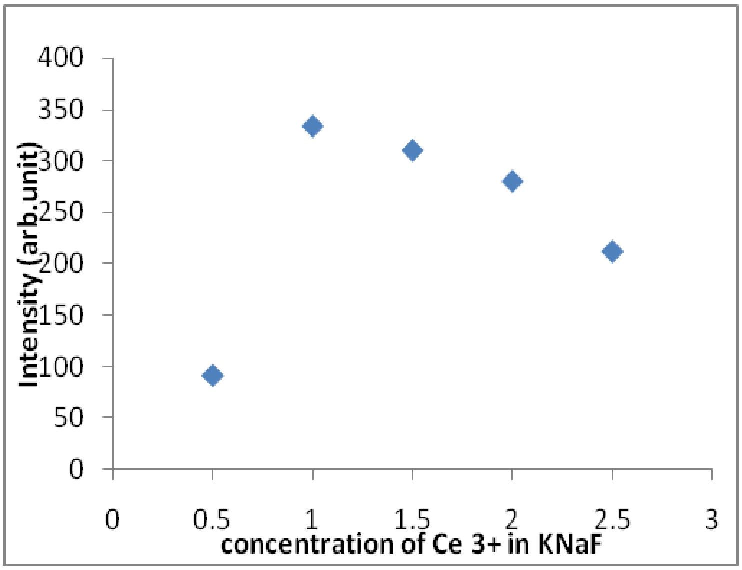


Figure 2: Variation of peak Intensity of excitation spectra with different concentrations of Ce^{3+} doped in (KNa)F

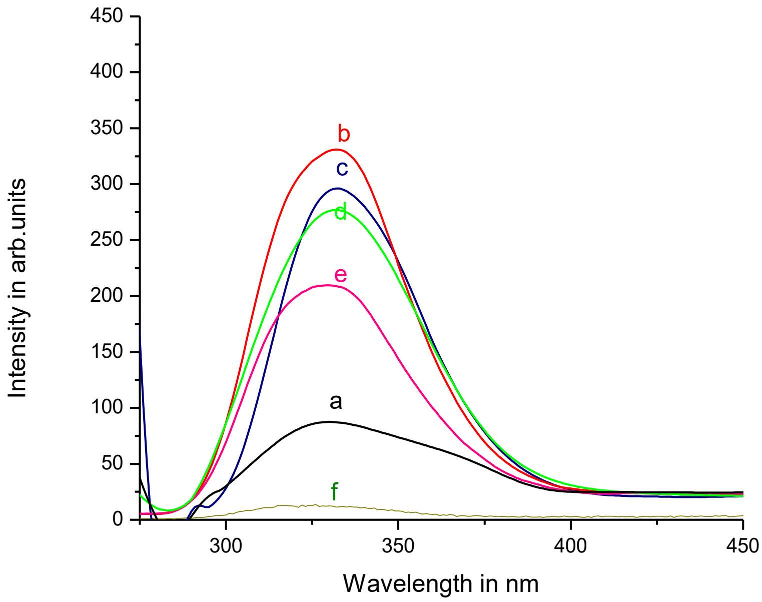


Figure 3: Photoluminescence emission spectra of Ce^{3+} ions in (KNa)F phosphor with different concentrations a=(KNa)F:Ce^{3+}(0.5 mol%), b= (KNa)F:Ce^{3+}(0.5 mol%), c= (KNa)F:Ce^{3+}(1 mol%), d= (KNa)F:Ce^{3+}(1.5 mol%), e= (KNa)F :Ce^{3+}(2 mol%), f= (KNa)F :Ce^{3+}(2.5 mol%),

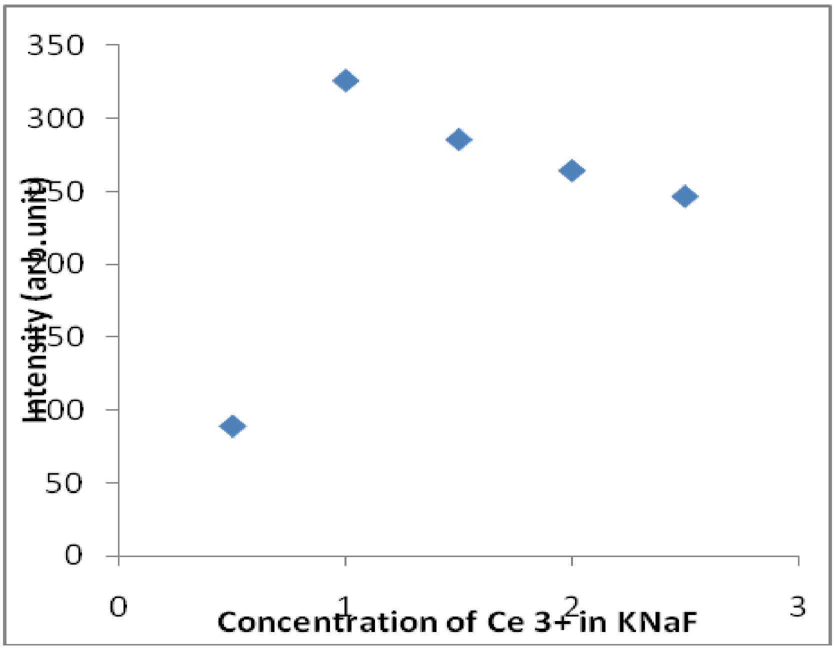


Figure 4: Variation of peak Intensity of emission spectra with different concentrations of Ce^{3+} doped in (KNa)F

CONCLUSION

(KNa)F:Ce^{3+} high potential phosphor has been synthesized by wet chemical method. The photoluminescence emission spectrum shows the main peak at 255nm which may be ascribed to transitions from 5d–4f levels of Ce^{3+} ion in the (KNa)F. The emission spectra show broad band around 330-340 nm. PL intensity is found to be dependent on doped concentration of Ce^{3+} ions in the host material. The effect of rare earth ion in the above system and its effect on the luminescence behavior of the materials were not focused by the researchers before and hence material is considered as the main attempt in the present investigation. (KNa)F:Ce^{3+} phosphor shows the near UV emission for development of energy transfer based co-activated advanced phosphors for lamp industry.

Acknowledgement: (if any) type in Text must be type in Book Antiqua font size 10.

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

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