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Gd^{3+} Phosphors in Treatment of Psoriasis and Vitiligo

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Abstract

In 20th century, PUVA photochemotherapy was the only available modality at large to cure the most severe skin diseases like psoriasis, and vitiligo. Efforts were devoted to get UVA emitting phosphors to get optimized wavelength at 365 nm at low cost, so as to reach this therapy to larger population. Today, targeted phototherapy using NB-UVB particularly at 311 nm has numerous advantages and is getting popular. In targetted phototherapy, only lesion is treated. Since the healthy tissues are not exposed to UV, and the fact that diseased tissue can tolerate radiation dose several times that of MED, keeps treatment undergoing patient safe from the threat of carcinoma, erythema, ageing of the skin and so many detrimental effects. Alternatively cost effective apparatus which employ non-laser, non-coherent but intense, monochromatic light sources at 311 nm using Gd^{3+} phosphors can be made commercially available and can be used by patient even at home. Very short duration of exposure is required as intense 311 nm beam is involved. This saves time of patient and the physician too. Also, the methods and systems greatly reduce the number of treatments necessary to clear the psoriasis, from about 25 to about 5 to 10. The cost of psoriasis phototherapy is dominated by the number of treatments needed for clearing. As a result, in the United States, for example, the invention could save over one half of the annual phototherapy cost of about one billion dollars.

Keywords: PUVA photochemotherapy, targetted phototherapy, NB-UVB.

TREATMENT OF PSORIASIS:

Psoriasis is a chronic, incurable, inflammatory skin condition affecting two to four percent of the world's population[1]. Although the underlying mechanisms of psoriasis are not yet perfectly understood, the disease involves abnormally rapid cell proliferation in the basal layer of the skin. Pathogenesis is unknown, but involves hereditary abnormalities of the immune system, with lymphocyte and neutrophil-mediated inflammation combined with hyperplasia of the epidermis. Natural solar treatments have mostly given way to modern booths or chambers known cabinets that provide artificial UVA and/ UVB radiation as per requirements. PUVA was found more effective than Broad Band (BB-UVB) in the treatment of most skin diseases[2]. PUVA, however, has side effects that include increased skin cancer and stomach upset (due to oral psoralen) and hence (Narrow–Band) NB-UVB, particularly 311 nm wavelength is most effective to clear Psoriasis.

TREATMENT OF VITILIGO: (Synonyms: leukoderma , piebald skin)

M. El Mofty suggested that vitiligo is derived from the Latin word 'Vitelius' whis means 'calf', white patches resembling to the white patches of a spotted calf. In the Sanskrit dictionary Sweta Kushtha refers to white patches that are in vitiligo. In vitiligo, sharply bordered milk-white irregular patches surrounded by areas of normal pigmentation is observed. An acquired localized depigmentation of skin (macule) characterized by complete loss of melanocytes. Etiology is not well understood. PUVA therapy (Psoralen + UVA) is the standard and established therapy for vitiligo and is widely employed through out the world. Mofty in 2001 showed that the use of psoralen (oral 8-MOP) plus broadband UVB is as effective as PUVA in the treatment of vitiligo[3]. Recently, it has been established that UVB lamps with a peak emission of around 311 nm (NB- UVB) is successfully used in treating Vitiligo[4] . Phosphors $LaF_3:Ce^{3+},Gd^{3+}$ and $SrAlF_5:Ce^{3+}Gd^{3+}$ presented here show the intense peak centered at 311 nm and serves the better material for phototherapy lamp preparation.

EXPERIMENTAL

Fluorides doped with Gadolinium (Gd^{3+}) give sharp emission at 311 nm (as our vested interest is in narrow band UVB). Fluoride phosphors are prepared by precipitation method only. Since fluorides are highly hygroscopic and susceptible to hydrolysis, the conventional solid-state route is prohibited[5].The stoichiometry can be preserved by preparing the crystals in 'reactive' atmosphere instead of the inert atmosphere. For example preparation of fluoride crystals in fluorine atmosphere will prohibit the substitution of F− by other impurity ions.

Preparation of $La_{.8}F_3$: $Ce_{.1}Gd_{.1}$

Chemical Reaction:

$0.8\ LaCl_3 + 0.1\ CeCl_3 + 0.1\ GdCl_3 + 3HF \rightarrow La_{.8}F_3: Ce_{.1}Gd_{.1}$

The ingredients required are calculated following stoichiometric considerations as under:
[A] Required La_2O_3 = 1.30328 gm
[B] Required Gd_2O_3 = 0.18125 gm
[C] Required $Ce_2(CO_3)_3$ = 0.27519 gm

PROCEDURE:
Step (1):In order to dissolve [C], initially dilute HCl (1:1) was added and mixed well in a glass beaker. Then excess of Conc. HCl was added. The mixture was boiled till $Ce_2(CO_3)_3$ was dissolved completely and a transparent solution was obtained.
Step (2): In another glass beaker, [A] and [B] were mixed (powder form) together. To this, nearly 30 ml dil. HCl was added. The mixture was heated slightly to dissolve it completely.
Step (3) : Then (1) and (2) were mixed together. The mixture was stirred well. The volume was reduced by boiling it off in the glass beaker. Now to this sufficient quantity of Conc. HCl was added. The mixture was then poured in Teflon beaker and was heated up to 80 ^{0}C by keeping it on a magnetic stirrer. At maintained temperature at 80 ^{0}C, HF acid was then added drop by drop till further precipitate formation stops. The precipitation was collected in a filter paper taken on a funnel. The precipitation was washed by double distilled water. The precipitation was then heated to dryness. The material obtained was crushed to powder. The sample $La_{.8}F_3$: $Ce_{.1}Gd_{.1}$ was ready for PL characterization. The PL was carried out on Hitachi F-4000 Spectro-Fluorometer.

Similar calculations for $SrAlF_5$:Ce^{3+},Gd^{3+}

RESULT AND DISCUSSION

1. PL Spectra of LaF_3 :Ce^{3+},Gd^{3+}

PL spectra of Ce^{3+} activated LaF_3 has been examined and broad emission peak at 307 nm was observed. The corresponding excitation spectrum has a prominent maxima at 254 nm which overlaps very well with Hg emission (253.7 nm). When Gd^{3+} is further doped in this LaF_3:Ce^{3+}, an efficient energy transfer takes place from $Ce^{3+} \rightarrow Gd^{3+}$ peaking at 311 nm resulting into an intense emission as shown in fig.1.

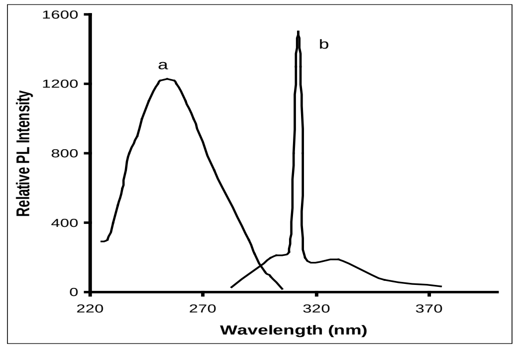

Fig.1: PL spectra of LaF_3 : Ce^{3+},Gd^{3+}

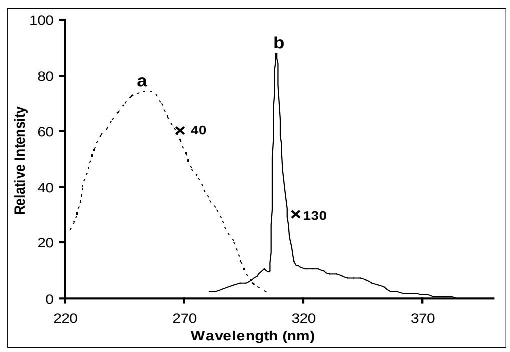

Fig.2: PL spectra of $SrAlF_5$: Ce^{3+},Gd^{3+}

Energy Transfer From $Ce^{3+} \rightarrow Gd^{3+}$

On energy transfer, the broad emission spectrum of LaF_3:Ce^{3+} centered at 307 nm now changes into a very sharp and well intense peak in LaF_3:$Ce^{3+}Gd^{3+}$ at 311 nm [Fig. 1(b)]. Since the emission peak wavelength (307 nm) of LaF_3:Ce^{3+} is smaller than the characteristic emission wavelength (311 nm) of Gd^{3+}, the energy transfer from $Ce^{3+} \rightarrow Gd^{3+}$ takes place and an intense and very narrow peak results.

2. PL Spectra of $SrAlF_5$:Ce^{3+},Gd^{3+}

When Gd^{3+} is doped in $SrAlF_5$:Ce^{3+}, an efficient energy transfer takes place from $Ce^{3+} \rightarrow Gd^{3+}$ peaking at 311 nm results into an intense emission as shown in fig.2.

CONCLUSION

Both the phosphors LaF_3:$Ce^{3+}Gd^{3+}$ and $SrAlF_5$:Ce^{3+},Gd^{3+} exhibit sharp emission at 311 nm which is well fitted for the treatment of Psoriasis and Vitiligo.

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