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Rational design of bi-functional RE^{3+} (RE = Tb, Ce) and alkali metals (M^{+} = Li, Na, K) co-doped $CaAl_2O_4$ nanophosphors for solid state lighting and advanced forensic applications

B.S. Shashikala[a,b], H.B. Premkumar[c,*], G.P. Darshan[d], H. Nagabhushana[e,*], S.C. Sharma[f], S.C. Prashantha[g]

[a] Department of Physics, Sapthagiri College of Engineering, Bangalore, 560 057, India
[b] Visvesvaraya Technological University, RRC, Bangalore, 560 091, India
[c] Department of Physics, FMPS, M.S. Ramaiah University of Applied Sciences, Bangalore, 560 054, India
[d] Department of Physics, Acharya Institute of Graduate Studies, Bangalore, 560 107, India
[e] Prof. C.N.R. Rao Centre for Advanced Materials, Tumkur University, Tumkur, 572 103, India
[f] Director - National Assessment and Accreditation Council, Bangalore, 560 072 (Work carried out as honorary professor, Jain University, Bangalore, 562 112, India)
[g] Department of Science, East West Institute of Technology, Bangalore, 560 091, India

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ABSTRACT

Novel $CaAl_2O_4$:Tb^{3+}, Ce^{3+}, M^{+} (M^{+} = K, Na, Li) nanophosphor was fabricated by bio-inspired solution combustion route by using lemon juice as a fuel. PXRD profiles endorse monoclinic phase in all samples irrespective of the dopants. The photoluminescence emission spectra exhibit peaks in the range at ~450–650 nm, which were attributed to $^5D_4 \rightarrow {}^7F_J$ (J = 6, 5, 4 and 3) transitions of Tb^{3+} ions. With increases of concentration of co-dopant Ce^{3+} ions, the rate of energy transfers from Ce^{3+} to Tb^{3+} ions also increase, which may lead to enhanced emission. Moreover, the two-fold enhancement of the PLE intensity was noticed in M^{+} co-doped $CaAl_2O_4$: Tb^{3+}, Ce^{3+} nanophosphor. The high purity green color emission was confirmed from photometric characterization. The visualized LFPs using optimized sample exhibit high sensitivity, selectivity without background hindrance. Aforementioned results confirm that the prepared nanophosphor might be a classical material for WLEDs and advanced forensic applications.

1. Introduction

In the past decade, blending of Nanoscience and nanotechnology encompasses most promising breakthroughs in wide range of fields, namely materials and production, medical, energy, nano electronics, information technology, biotechnology and security [1–8]. This offers marvelous impact on the socio-economic status of the global world. Hence, this super blending will be considered as the next industrial revolution [9]. The applications of nanomaterials in the area of luminescence, exciting the research community due to their significant electronic, optical and structural properties [10–14]. From last years, white light emitting diodes (WLED's) was considered as the typical form of solid state lighting, due to their outstanding advantages, including higher energy efficiency, longer lifetime, rapid response and eco-friendly nature [15–18]. Traditional lightning sources, such as incandescent and fluorescent lamps were suffering from fewer luminous efficacy and hence they suffer from reduced sensitive to human eyes. Consequently, nanophosphors with efficient excitement in UV and emit in visible range plays a pivotal role. Hence, continuous efforts were attempted by the research community to explore efficient nanophosphors with stable properties [19–22]. Much research literature was available on nanophosphors, including aluminates, silicates, alumino-silicates, nitrides, borates, sulfides, etc. [23–29]. Among various materials, aluminate based calcium aluminate ($CaAl_2O_4$) creates much interest for the research community due to its outstanding applications, including WLED's, catalysts, medical, lasers, communication, bio-sensors, labeling agents, etc. [30–38].

Fingerprints (FPs) were the prints left by the fingers or palms once touching a surface, that were used as necessary physical proof and cornerstone within the crime science to identify the individuals [39,40]. In most cases, the FPs were invisible to naked eyes owing to their poor optical distinction, called latent fingerprints (LFPs). Therefore, there has been intense interest in developing improved or new routes to enrich clear image of LFPs. For this purpose, nanomaterials

* Corresponding authors.
E-mail address: premhb@gmail.com (H.B. Premkumar).

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