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Preparation and spectroscopic properties of PMMA/$GdAlO_3:RE^{3+}$ (RE = Pr, Eu or Tb) composite films for application in scintillation devices

H. H. S. Oliveira(1), A. A. Da Silva(1), M. A. Cebim(1) and M. R. Davolos(1)*

(1) UNESP - São Paulo State University, Institute of Chemistry, Luminescent Materials Laboratory, Araraquara, Brazil.

* davolos@iq.unesp.br

Abstract – The conformation of the materials for scintillation applications is very important because it determines the applicability and cost of ionizing radiation detectors devices. Polymeric composite films have been studied due to their properties like flexibility and control of shape and dimensions. In this work, we related the preparation and optical properties of $GdAlO_3:RE^{3+}$ scintillator materials dispersed in PMMA films. The mean thickness of the films is 235 µm and its UV-vis transmittance and intensity emission depend on the weight ratio between scintillator material and PMMA, being possible to mold these properties controlling this ratio.

Conformation of the scintillators materials is an important factor in the search for efficient scintillation systems because it has direct impact in the application of these materials in ionizing radiation detectors and in the final cost of the devices. The preparation of single crystals and compact ceramics involves high temperatures and pressures and the employ of these conformations require significant amount of the phosphor material [1]. The use of polymeric composite films of inorganic phosphors/polymethylmethacrylate (PMMA) is an interesting alternative for construction of scintillation devices [2]. Polymeric composite films present properties like flexibility, high transmission in the visible region of the electromagnetic spectrum and control of shape, dimensions and thickness, generating the possibility of to development new and improved devices. Furthermore, the use of films allows the maintenance of optical properties and a significant decrease of the phosphor amount used in relation to ceramic or single crystals samples. In this work, we analyze the spectroscopic properties of Pr^{3+}, Eu^{3+} and Tb^{3+}-doped $GdAlO_3$ scintillators dispersed in PMMA. Gadolinium aluminates samples were prepared by the Pechini method, with the resin fired at 1100°C for 4 hours [3]. Nanopowders obtained were dispersed in PMMA solution in dichloromethane 10% (wt/vol) using an ultrasonic processor (5 min) and the films were assembled by the evaporation of the solvent. The films were characterized by perfilometry and infrared (FT-IR), UV-vis and photoluminescence spectroscopies. FT-IR spectra indicate the absence of chemical interactions between the dispersed gadolinium aluminates powders and PMMA, minimizing its influence in the luminescent properties of the scintillator material. The films have a mean thickness of 235 µm and the transmission in the 400-800 nm range can be controlled by weight ratio (χ) between the scintillator material and PMMA (Fig. 1). The emission spectra of $GdAlO_3:Eu^{3+}$/PMMA films present the $^5D_0 \rightarrow {}^7F_J$ transitions of Eu^{3+} ions with emission maxima at 614 nm ($^5D_0 \rightarrow {}^7F_2$) and its intensity increases with the amount of dispersed material in the film (Fig. 2). For the $GdAlO_3:Pr^{3+}$/PMMA and $GdAlO_3:Tb^{3+}$/PMMA composite films were also observed the principal transitions of each dopant ion and, like $GdAlO_3:Eu^{3+}$/PMMA films, the luminescent properties are similar to bulk materials. The thickness, transmittance (400-800 nm) and the intensity of emission depend of the weight ratio scintillator material/PMMA used in the preparation of the films. Thus, it is possible to mold films with high performance for the development of ionizing radiation detectors according to desired characteristics for the determined application.

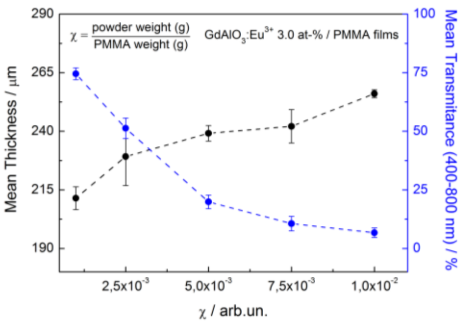

Figure 1: Mean thickness and transmittance of $GdAlO_3:Eu^{3+}$ 3.0 at-%/PMMA composite films.

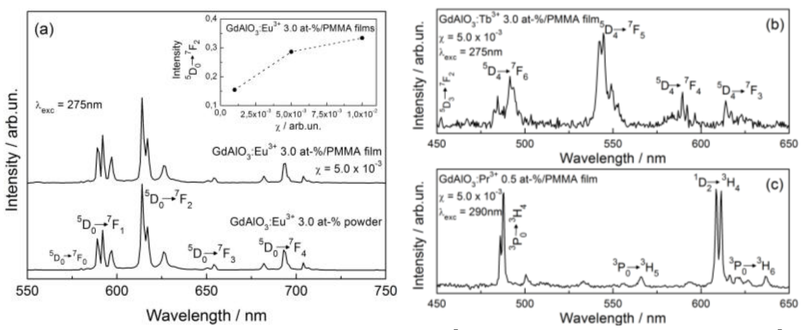

Figure 2: Emission spectra of **(a)** $GdAlO_3:Eu^{3+}$ 3.0 at-%/PMMA, **(b)** $GdAlO_3:Tb^{3+}$ 3.0 at-%/PMMA and **(c)** $GdAlO_3:Pr^{3+}$ 0.5 at-%/PMMA composite films.

References

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