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EDXRF Study of $Pb(NO_3)_2$ –PVA-PVP Composite

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Abstract. Lead nitrate ($Pb(NO_3)_2$) doped polyvinylalcohol (PVA)- polyvinylpyrrolidone (PVP) blend films were prepared and studied using energy dispersive X-ray fluorescence (EDXRF) spectrometry. The doping level of $Pb(NO_3)_2$ in PVA-PVP blend varied from 2.7 wt% to 26.4 wt% and EDXRF spectra were recorded using 2 π geometrical configuration, with cobalt-57 radio-isotope (of activity few μCi) as the source of incident radiation and NaI(Tl) scintillation system as the detector of both incident gamma rays and the $K_{\alpha\beta}$ x rays of lead (Pb). The area under the $K_{\alpha\beta}$ fluorescence peak of lead is measured at different doping levels.

Introduction

High energy radiation like gamma (γ) rays, neutrons, protons and electrons are dangerous to personnel managing facilities involving use of radio-isotopes. Hence, there is a need of placing an absorber of radiation (called shielding material) between the radioactive sources and human users. Radiation shielding materials like steel, lead (Pb) and concrete have been used. Among these, Pb has attracted the attention of researchers due to its easy availability, significant x-ray and gamma radiation shielding ability and low cost. However, there is a need to replace Pb with other materials which are less toxic. At least, the amount of lead used in the shielding material could be optimized for specific applications. In this direction, lead nitrate [$Pb(NO_3)_2$] doped polyvinyl alcohol (PVA)-polyvinyl-pyrrolidone (PVP) blend films were prepared and characterized. PVA has excellent complex formation ability and good mechanical properties. PVP has electron releasing ability, which on interacting with Pb ions from $Pb(NO)_3)_2$ results in formation of Pb clusters, nano-structures, micro-structures and aggregates in the sample. The extent of incorporation of Pb from the dopant salt in the PVA-PVP blend is an important parameter which determines the ability of resulting composite to shield against x-rays and high energy gamma radiation. Hence, an efficient tool to estimate the amount of Pb in the prepared composite is necessary. In a radiation laboratory, weak sources of low energy gamma radiation and NaI(Tl) scintillators coupled to multi-channel analyzers are available. Hence, the use of 2π geometrical configuration, with cobalt-57 radio-isotope (of activity few μCi) as the source of incident radiation and NaI(Tl) scintillation system as the detector of both incident gamma rays and the $K_{\alpha\beta}$ x rays of lead (Pb) from the composite samples were studied. Details are presented in this paper.

Experimental

The radioactive source cobalt-57 (Co^{57}) has been used as the source of incident low energy gamma rays (122 keV and 136 keV). The NaI(Tl) scintillation detector system consists of the NaI(Tl) scintillator coupled to a Photomultiplier Tube (PMT), a pre-amplifier, followed by linear amplifier and a PC based Multichannel Analyzer (MCA). The figure (1) is a schematic block diagram of the apparatus (see figure 1). The GSPEC portable Gamma Ray Spectrometer with 1k MCA has been used. The Bicron PMT optically coupled to a 2 inch × 2 inch NaI(Tl) Scintillator (Saint- Gobain Crystals) detector has been utilized to detect the incident low energy gamma rays as well as the fluorescent x-rays from the sample. A 2π geometrical configuration is used, wherein the target is sandwiched between the source and the detector. The detector offers a large solid angle, approximately 2π, to the target as well as to the source and thus facilitates high-intensity data collection. Secondly, the target thickness is chosen so as to best exploit the 2π geometry. SAAS (software) is used for spectrum acquisition and its analysis.

Results and Discussion

Figure (2) shows the x-ray fluorescence spectra of the $Pb(NO_3)_2$ doped PVA-PVP blend, obtained by varying the dopant concentration from 2.7wt% up to 26.4 wt%. The calculated unresolved X-ray fluorescence peak energy, $E_{k\alpha\beta}$, of Pb is 76.2 keV which is in good agreement with the experimental value, which is ranging from 75.7keV to 76.3keV.

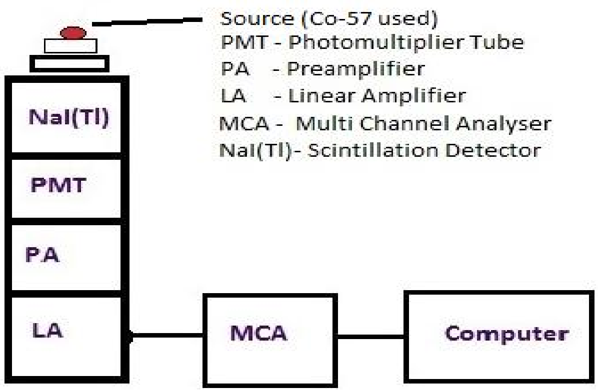

Fig. 1: A schematic diagram of experimental set-up used

The recorded spectra were then analysed by finding the area under the x-ray fluorescence peak. The data extracted from the EDXRF scans are listed in table1.The area under the x-ray fluorescence peak corresponding to K x-rays from Pb gradually increases as the concentration of the dopant is increased.

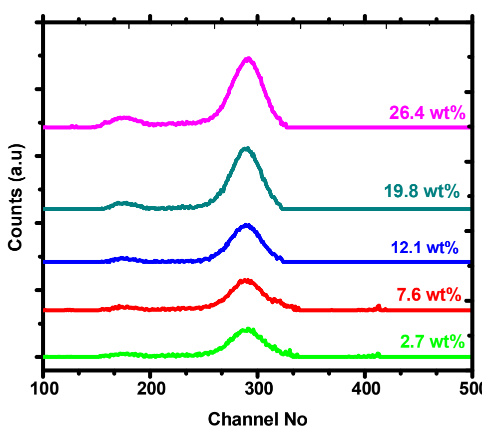

Fig. 2: Energy Dispersive X-ray fluorescence spectra of $Pb(NO_3)_2$ doped PVA-PVP blend. The calibration for x-axis is 0.263 keV/channel.

The calibration data is obtained for estimation of lead in the composite films. The same is presented graphically in figure (3).

Conclusion

The 2π geometry of EDXRF, with a low activity radio-isotope (Co-57) as the source of incident radiation, coupled to a NaI(Tl) scintillation detector system is effective in the detection and determination of concentration of Pb in $Pb(NO_3)_2$-PVA-PVP composite films.

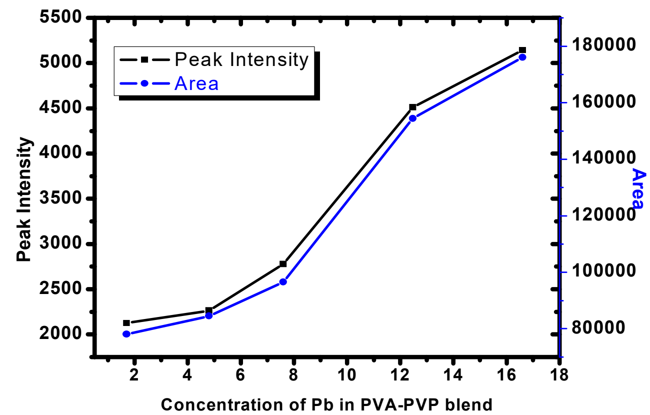

Fig. 3: X-ray fluorescence peak intensity and area under the fluorescence peak v/s the concentration of Pb in $Pb(NO_3)_2$-PVA-PVP composite films.

Table 1. Table showing the results analyzed from the EDXRF spectra.

Doping Level (wt%)	Centroid (keV)	Area			Peak Intensity
		Integral	Bkd.	Net	
1.7	76.3	85148	7063	78086	81877
4.8	76.7	94901	10377	84524	92927
7.6	75.7	100892	4369	96522	101873
12.5	75.7	161537	7119	154418	113134
16.6	76	194057	18004	176052	156638

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