Preparation of a Thin Polysulfone Phosphor Sheet for the Detection of Alpha Particles Using Adhesive Process

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1. Introduction

According to atomic energy law and connection regs, the surface contamination of nuclear facilities should be monitored routinely. Surface contamination is divided into removable and fixed contamination. Fixed contamination is measured by a direct method with a survey meter. And removable contamination is measured by an indirect method using smear paper and a low background proportional counter.

Also, in the decommissioning process of a nuclear research facilities, such as Korean Research Reactor 1&2 and Uranium Conversion Plant, a significant amount of nuclear wastes is produced. The wastes contaminated must be surveyed for the disposal and reuse in the future.

In the previous study[1] the medium, scintillator-embedded polymer membrane for detecting the alpha-ray, was prepared by impregnating organic scintillators in a membrane structure. The plastic scintillator consists of polysulfone(PSF) as a matrix with PPO as an organic scintillator and POPOP as a wave shifting agent dissolved in the matrix. But, an organic plastic scintillator was inadequate to detect the alpha particle in the alpha-beta mixing field because its light output is smaller than beta ray one[2]. So, a thin phosphor sheet was prepared, which consisted of a very uniform deposit of silver activated zinc sulfide (ZnS(Ag)) phosphor applied to on side of clear polysulfone plastic sheet.

2. Methods and Results

In this section the method used to prepare the phosphor sheet is described. The optical and radiological properties of the polysulfone sheet are measured.

2.1 Preparation of the Phosphor sheet

Polysulfone phosphor sheet consisting of PSF as polymer matrix and ZnS(Ag) as a phosphor were prepared through the solidification of polymeric solutions and application the ZnS(Ag) on the polysulfone sheet. To formulate a base sheet, PSF were dissolved in MC (methylene chloride) and then cast on the glass plate with doctor blade.

Also, phosphor solution was prepared by dissolving PSF or cyano resin into Dimethylformamide(DMF) and adding the phosphor ZnS(Ag). The prepared one was sifted on a base sheet with a screen flame. All of the preparation procedure was shown in Figure 1.

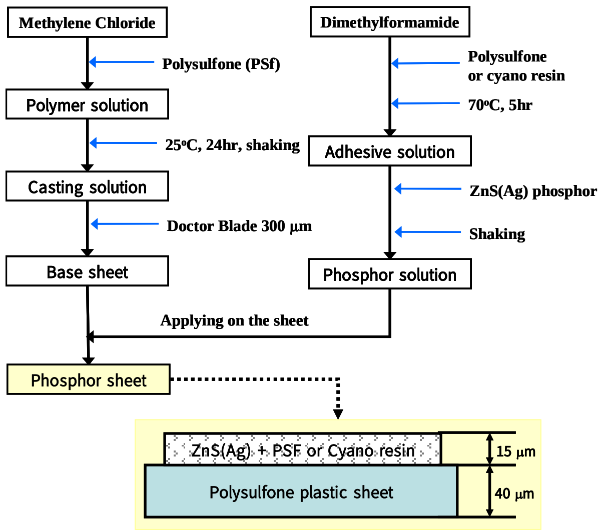

Figure 1. Preparation procedure of the polysulfone phosphor sheet using ZnS(Ag) adhesive process.

An alpha-particle's range in a material is very short. The alpha-particle-detection efficiencies of ZnS(Ag) layers are considerably more variable because this material is available only in the form of microcrystalline powder that must be deposited as a thin layer (often with a binder) to form a suitable detector. Therefore, the zinc sulfide (silver) layers' thickness is critical for optimizing its detection efficiency. The thickness should be thick enough to react with most of the deposited alpha-particles, but also thin enough not to induce a significant absorption of the produced scintillation. Its optimum thickness of the ZnS(Ag) layer is about 15 μm. Also, after solidification, the thickness of the base polysulfone plastic sheet was about 40 μm.

2.2 Optical property of the phosphor sheet

The PMT, for detecting the produced scintillation, reacts effectively near a blue wave (wave length : about 400 – 450 nm) . So, the wavelength of maximum emission of the ZnS(Ag) phosphor sheet was measured.

It is shown Figure 2. The peak of ZnS(Ag) was detected near 450 nm, revealing that they can be highly efficient for a PMT measurement.

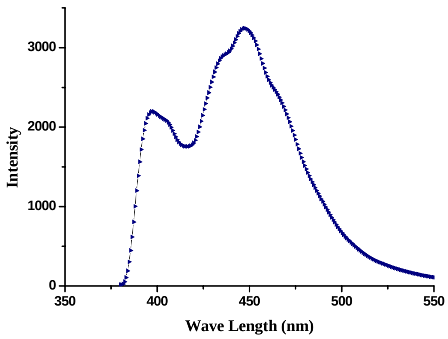

Figure 2. Emission spectrum of the ZnS(Ag) phosphor sheet.

The light transmission rate through a base sheet has a very significant impact on its scintillation detection efficiency, since the scintillated light has to travel through the membrane structure to reach a PMT. Therefore, the scintillation membrane itself needs to be transparent or highly transmittable. As shown in Figure 3, the transmission rate of the prepared sheet is about 90% near blue wavelength, thus revealing a high transparency.

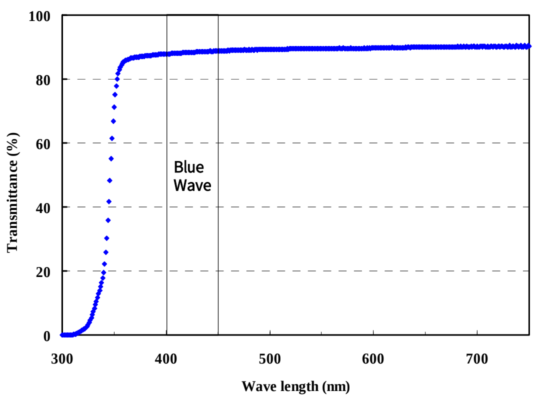

Figure 3. The transmission rate of the base polysulfone sheet in the visible light range.

2.3 The Alpha-ray Detection Ability of the Phosphor Sheet

For the alpha-ray detection test of the prepared phosphor sheet, a radioactive solution of a Am-241 emitting alpha particles was spotted on a phosphor sheet. The amount of scintillation produced by the interaction between the ZnS(Ag) and the alpha particles was measured using a PMT (photomultiplier tube). The alpha-ray spectrum measured using the ZnS(Ag) phosphor sheet was shown Figure 4. The measured spectrum showed excellent detection ability for the alpha particles.

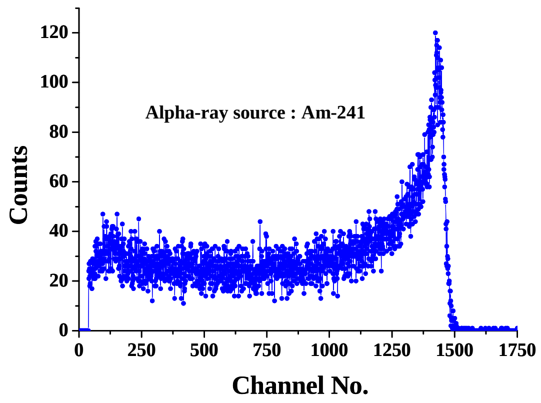

Figure 4. The alpha-ray spectrum of the ZnS(Ag) phosphor polysulfone sheet measured using Am-241 alpha source.

3. Conclusion

Thin phosphor polysulfone sheet were prepared to detect an alpha-particle. The phosphor sheet is composed of a polysulfone sheet coating an inorganic phosphor, ZnS(Ag), and the base polysulfone sheet being solidified from a homogeneous casting solution. And then, the ZnS(Ag) phosphor was adhered on the base sheet using screening method. Its optical property as a scintillation detector is excellent. And, the efficiency of the alpha-particle detection of the prepared phosphor sheet is measured with alpha-ray source Am-241. The thin ZnS(Ag) polysulfone sheet shows a reliable capacity for the detection of the alpha-particle, and can be applied to the measurement of a alpha-ray radioactive contamination.

REFERENCES

[1] B. K. Seo, Z. H. Woo, G. H. Kim, W. Z. Oh, K. W. Lee, and M. J. Han, Preparation and Property of the Polymer Scintillator for the Alpha Contamination Monitoring, WM’05 Conference, Feb. 27 – Mar. 3, 2004, Tucson, AZ.

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