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Development of the Dual Phosphor Detector for simultaneous alpha- and beta-ray counting in a Pipe

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1. Introduction

There are two decommissioning sites in Korea, Korea Research Reactor 1&2 (KRR-1&2) and uranium conversion facility (UCF). Generally a great amount of wastes are generated during the decommissioning of nuclear facilities. These wastes are contaminated with various types of nuclides emitting alpha- and beta(gamma)-rays. The contamination level of the decommissioning wastes must be surveyed for free release.

The surface contamination of the alpha and beta-ray should be simultaneously measured and estimated in the nuclear facilities. Such a contamination measurement could be conducted by proportional counter or phoswich detectors. But the proportional counter is very difficult to make the small size for inserting in the pipe. The phoswich detector is convenient for monitoring alpha and beta contamination using only a single detector, composed of a ZnS(Ag) scintillator for counting the alpha particles and a plastic detector for beta particles [1-5].

In this study, a phoswich detector for simultaneous counting of alpha- and beta-particles in a pipe was developed. The scintillator for counting an alpha and beta-particles has been applied to a cylindrical polymer composite sheet having a double layer structure of an inorganic scintillator ZnS(Ag) layer adhered onto a plastic scintillator sheet. The ZnS(Ag) layer is formed by coating a ternary mixture of ZnS(Ag), polysulfone as a binder and solvent onto the top of a sub-layer via the screen printing method. The overall counting results reveal that the developed phoswich detector is efficient for simultaneous counting of alpha- and beta-particles in a pipe.

2. Methods and Results

2.1. Preparation of the dual phosphor detector

The preparation procedure of the dual phosphor is shown in Fig. 1. The preparation is divided into two processes : a casting method to prepare a plastic sheet for beta particle measurement and a screen printing method to prepare a ZnS(Ag) layer for alpha particle measurement.

The plastic scintillator sheet for counting beta particle measurement was composed of PPO and POPOP as scintillator and polysulfone as polymer. And, the ZnS(Ag) scintillator sheet for counting the alpha-particle, consisting of polysulfone(PSf) as a polymer matrix and ZnS(Ag) as a scintillator, were prepared through the solidification of polymeric.

To formulate a plastic sheet, polymers were dissolved in methylene chloride(MC) and cast onto the glass plate with a doctor blade(Sheen, Egland). Then, a scintillator solution, prepared by dissolving PSf into dimethylformamide(DMF) and adding the ZnS(Ag), was coated onto a solidified base sheet via the screen printing method.

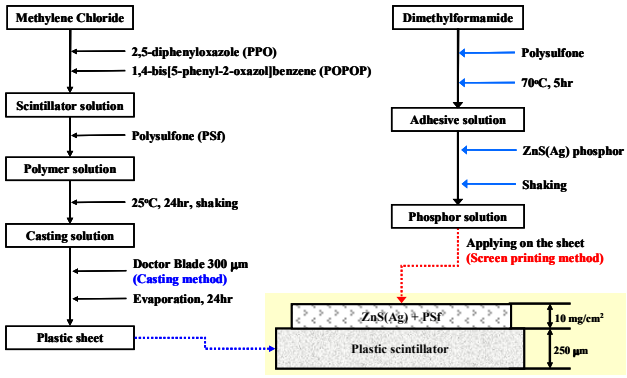

Figure 1. Preparation procedure of the dual phosphor for simultaneous alpha- and beta-ray counting.

2.2. Phoswich detector for simultaneous alpha and beta counting

A conceptual diagram of the phoswich detector for simultaneous counting of alpha- and beta-rays in a pipe is shown in Fig. 2. The detecting part was constructed in phoswich type for simultaneous counting of alpha- and beta-rays in a pipe. The prepared dual phosphor detector was formed in cylinder type.

Each radiation must be discriminated in a phoswich detector to allow simultaneous measurement of different type radiations using single-detector system. The pulse-shaped discrimination and pulse-height discrimination were generally used to discriminate each radiation. Pulse heights generated by alpha- and beta-rays were discriminated using the energy level discriminator for the pulse-height discrimination method. But, the accurate measurements can't be performed because of overlap of alpha and beta events for low level activity. Therefore, the pulse-shape discrimination method is generally used to discriminate each other. The pulse-

shape discrimination is the method discriminating rise-time of scintillation formed in each scintillator. The pulse-shape distribution spectrum for alpha- and beta-rays were measured with the phoswich detector as Fig. 3.

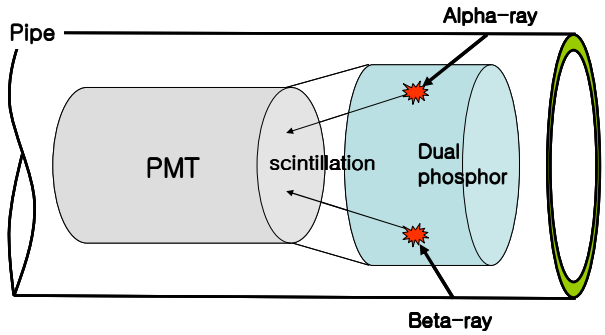

Figure 2. Conceptual diagram of the phoswich detector for simultaneous alpha- and beta-particles counting in a pipe

For the detection ability of the phoswich detector, alpha-particle emitting nuclide, Am-241, and beta emitting nuclide, Sr/Y-90, were used. The scintillations produced by interaction between radiation and scintillator were measured by PMT.

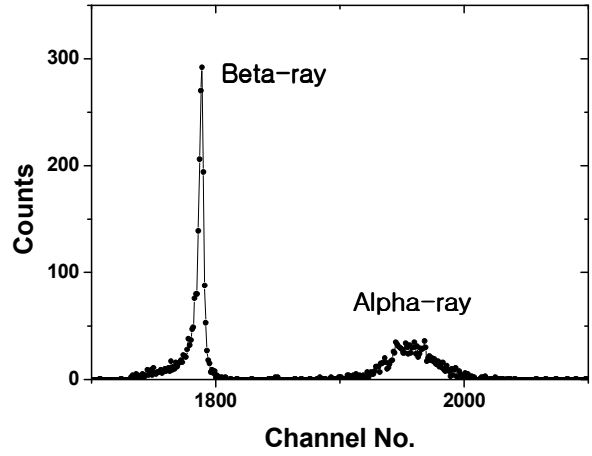

Figure 3. Pulse-shape distribution of alpha- and beta-rays measured with dual phosphor phoswich detector in a pipe.

3. Conclusion

A sheet type of dual phosphor detector for simultaneous alpha- and beta-rays was prepared. And the dual phosphor detector was fabricated with phoswich detector for monitoring the in-pipe alpha- and beta-rays contamination. In order to apply pipe inside, two types of phoswich detectors such as sheet and cylindrical type were fabricated. For in-pipe monitoring, it was found that cylindrical type was excellent.

In the near future the phoswich detector will be tested in the decommissioning site of the Korea Research Reactor 1&2 and uranium conversion facility.

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