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Production of the Large-area Plastic Scintillator for Beta-ray Detection using Epoxy Resin

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1. Introduction

Radiation detection using scintillator light produced in materials is one of the oldest and most useful techniques for the detection of a variety of radiations [1]. A detector using plastic scintillators is well known to have an easy operation because it consists of a chemically stable material [2]. Several studies were conducted to include the features, such as neutron radiation hardness [3] and sensitivity [4], as well as reduced manufacturing costs [5]. The large-area plastic scintillator of affordable prices was required by many researchers of nuclear and high-energy physics fields [6].

In general, a plastic scintillator using a polymer such as polymethylmethacrylate (PMMA), polyvinyltoluene (PVT) or polystyrene (PS) is added to an organic scintillator. As an organic scintillator, the first solute is p-terphenyl or 2.5-diphenyloxazole (PPO), and the second solute is 1,4-bis [5-phenyl-2-oxazol] benzene (POPOP) [7]. A method for preparing a plastic scintillator is a mixture of a polymer and organic scintillators used for thermal polymerization.

In this study, we prepared a plastic scintillator whose manufacturing process is simple and can be freely shaped. A thin plate of the plastic scintillator was manufactured using epoxy resin as a polymer. The plastic scintillator was made by mixing epoxy resin and organic scintillators under various conditions. The optimal mixture ratio to prepare the plastic scintillator was derived from the above results. Using the derived results, we made the large-area plastic scintillator which can quickly measure the contamination site and evaluated characteristics of the large-area plastic scintillator in the laboratory.

2. Methods and Results

The polymer materials for the preparation of the plastic scintillator were used mainly for PMMA, PVT or PS. However, PMMA, PVT or PS generates a bad smell in the thermal polymerization process and requires a relatively long drying time. A polymer was used as an epoxy resin because no odor resulted from thermal polymerization, and the drying time is short. Organic scintillators were added to the PPO as the first solute and the POPOP as the second solute.

The substance of the plastic scintillator regarding the total weight of epoxy resin was 0.1~1 wt% and 0.01~0.05 wt% for PPO and POPOP, respectively. The optical properties such as emission spectra in the visible light of the prepared plastic scintillator measured using a spectrofluorometer. PMT as a light measuring device was used. The amplification of the scintillation light using PMT was achieved.

The optical properties such as emission spectra in the visible light (wavelength: 380~800 nm) of the prepared plastic scintillator were measured using a spectrofluorometer. The emission spectra were observed to derive the optimal mixture ratio of the plastic scintillator. Figure 1 show the emission spectra according to the amount of PPO and POPOP, respectively. Even if the amount of PPO increases, the emission spectra did not show a consistent trend. However, if the amount of POPOP increases, the emission spectra did show a growing trend. These results indicate that the amount of PPO is independent and the more the amount of POPOP is increasing, the more the quantity of light is increasing.

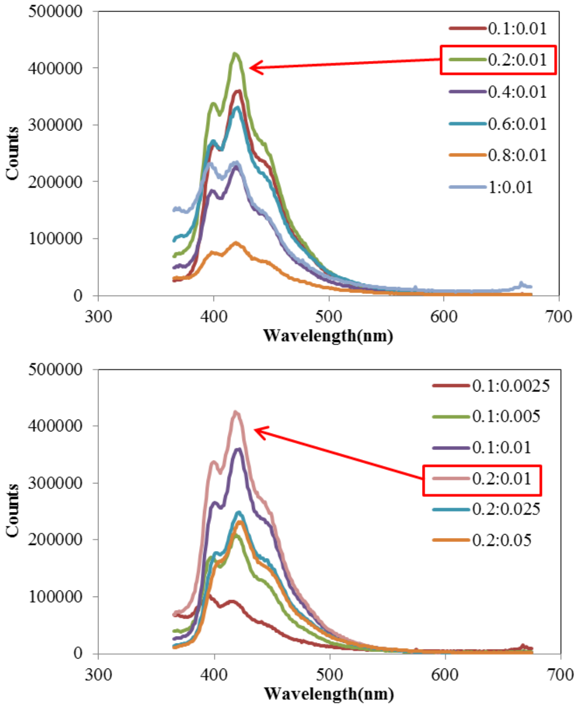

Fig. 1. Emission spectra according to the amount of PPO (up) and POPOP (down)

The weight percentage of PPO and POPOP in an organic scintillator was adjusted to 0.2 wt%:0.01 wt%. Based on the characteristics results, the large-area plastic scintillator was prepared. The size of a large-area plastic scintillator was similar to the window size of a typical pancake-type αβ surface contamination counter. The size of a large-area plastic scintillator is 240 mm (length) x 170 mm (width) x 3 mm (thickness) (Figure 2). In order to make a large-area plastic scintillator, it was produced above the metal mould of the same size. Polyethylene film was used as a releasing agent to ease the removal of the large-area plastic scintillator from the metal mould. The large-area plastic scintillator was pressing a metal lid to prevent twisting.

Fig. 2. The large-area plastic scintillator

3. Conclusions

A thin plate of a plastic scintillator with a simple preparation process can be freely shaped using epoxy resin and organic scintillators such as PPO and POPOP. PPO emits scintillation of light in the ultraviolet range, and POPOP is a wave shifter for moving the wavelength responsible for the PMT. The mixture ratio of PPO and POPOP was determined using their emission spectra. The optimal weight percentage of PPO and POPOP in an organic scintillator was determined to be 0.2 wt%:0.01 wt%.

Based on the above results, the large-area plastic scintillator of the window size of a typical pancake-type αβ surface contamination counter was prepared. We want to evaluate the characteristics of the large-area plastic scintillator. However, there were the difficulties in evaluating characteristics of the large-area plastic scintillator. The cross-sectional area of the large-area plastic scintillator is significantly different to PMT. The tool will be necessary to connect the large-area plastic scintillator and PMT. The tool for connecting them generally utilizes the light guide. Then, it has to be carried out characteristics evaluation of the large-area plastic scintillator.

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