Measurement of Visual Performance of Scintillating Film for Locating an Ir-192 Gamma-ray Source

K. J. Lee, J. I. Yun, B. G. Park, Y. M. Hwang, S. Kim*, B. S. Lee**
*Institute of Future Energy Technology , *Cheju National University, **Konkuk University*
cagelee@fnctech.com

1. Introduction

In the domestic NDT(nondestructive testing) field, radiation exposure accidents have been forming more than once a year according to the KINS(Korea Institute of Nuclear Safety). The major cause for these accidents was reported that the operators didn't observe the legal regulations. And moreover, they disregarded the appropriate procedures that they have to check the isotope source status with protective and monitoring devices during their works. Nevertheless, if the radiographic NDT apparatus equipped with a monitoring system, which indicate the exposure status of the source, it could have prevented the accidents or reduced radiation exposure dose for the operators.

This work intends to develop a scintillating film to monitor the exposure status of a radiation source in a radiographic NDT apparatus like an Ir-192 gamma-ray projector. The film indicates the exposure status as emitting visual light on the position of a radiation source in an opaque guide tube when the apparatus works. In this work, we fabricated various samples of scintillating film, which have different compositions and thickness, and measured their luminance to evaluate their visual performance.

2. Methods and Results

2.1 Configuration of Scintillating Film

Scintillating materials produce light by interaction with ionizing radiation. The scintillation process remains one of the most useful methods available for the detection and spectroscopy of a wide assortment of radiations [1]. Scintillating film has basically the same mechanism of the scintillation. And we introduced a special design for the scintillating film focused on enhancing the visual performance. Fig. 1 shows the configuration of scintillating film with 4 layers: base, reflective, active, and protective layer. Each layer functions as followings.

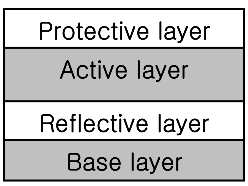

Figure 1. Configuration of scintillating film

- Base layer supports the structure of the film.
- Reflective layer increases light output by reflecting the light forward from the active layer.
- Active layer including scintillation materials emits visual light to react to radiations.
- Protective layer protects active layer from and film's surface.

2.2 Fabrication of Scintillating Film

One of the most important tasks for fabrication of the scintillating film is the choice of scintillation materials composed of the active layer. There are generally two types of scintillator: organic and inorganic materials. As we known well, the quantum efficiency of inorganic scintillators is better than that of organics. In our previous research on comparing their performances between organic and inorganic scintillating film, it was reconfirmed [2]. The used inorganic scintillation materials in this work were Gd_2O_2S:Tb, Gd_2O_2S:Eu, Gd_2O_2S:Pr, La_2O_2S:Eu, La_2O_2S:Tb, CsI:Tl, and their visual performances were measured and compared.

The substance of the used inorganic scintillators is a powder. The powders were mixed with acrylic transparent dispersant as a binding material. And then the mixtures were spread on a plastic base with uniform thickness. To evaluate the effect of the thickness of the film, several samples with 100~300 [μm] were made. And to investigate the effect of their density in the active layer, the mixing ratios of the mixtures (scintillator: dispersant) were changed from 1:1 to 5:1 in weight ratio.

2.3 Evaluation of Visual Performance

A measure of evaluation of visual performance is visibility. Visibility defines how well a target can be seen by the eye. Many factors influence visibility. The factors affecting visibility are contrast, size, time, luminance (or brightness), and color (or wavelength of light). One of the most important factors affecting visibility is luminance contrast. The higher luminance, the better visibility is if the environment luminance is not changed [3]. So we measured the brightness of the samples with a luminance meter (Minolta LS-100) to evaluate the samples.

2.4 Measurement of brightness

Experiment for the measurements of brightness was performed with an actual Ir-192 gamma-ray projector. According to the radiographic testing process, the apparatus was installed. The remote controller and the guide tube were connected into the source container. And scintillating film samples stuck on the surface of the guide tube. The operator controlled to move the radiation source through the guide tube between the container and the source stop by the remote controller.

The most important roll of the film is to figure out the source position in the guide tube. To confirm it by naked eye, the output light has to have a detectable brightness and contrast to the illuminance. Figure 2 is the scene that the scintillating film stuck to the guide tube emits visual light when the source moves between the locations. The bright area makes about a ϕ 25 [mm] circle, and moves simultaneously along to the moving source. As the bright area exists locally by radioactive source, the film can indicate the source position in the guide tube.

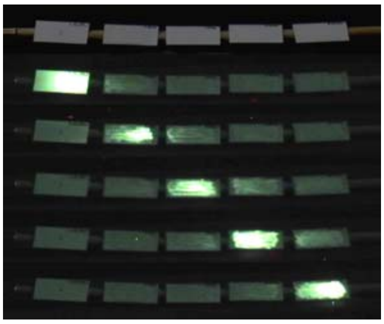

Figure 2. Light emitting scene from scintillating films along to the drift of Ir-192 radioisotope (10.5 [Ci]) in the guide tube.

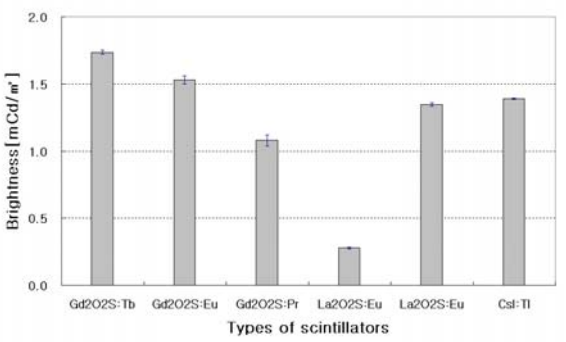

Figure 3. Comparison of luminance performance of the films composed of various scintillation materials for Ir-192 radioisotope irradiation (20 [Ci]).

The scintillation material composed of these films is a powder of gadolinium oxy-sulfide doped with terbium (Gd_2O_2S:Tb). Because not only it has a good fluorescence efficiencies but its emitting peak wavelength (545 [nm]) is good for visible sensitivity. The result of brightness measurement of the various inorganic scintillating films shows that the Gd_2O_2S:Tb scintillator is the best of them as shown in Figure 3.

Figure 4 shows the effects of the mixing ratio and thickness of the scintillating layer on the brightness of the scintillating film. As the ratio and the thickness of the film increase, its brightness steadily goes up. But the trend of increase becomes dull due to the self attenuation of the light. The mixing ratio, moreover, is restrained below 4:1 because further values make hard to mix them and decrease degree of dispersion of the mixtures.

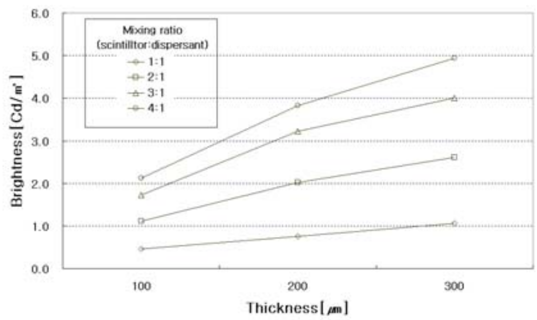

Figure 4. Measurements of luminance performance of the scintillating films with various thicknesses and mixing ratios for Ir-192 radioisotope irradiation (12 [Ci]).

3. Conclusion

We have been carrying out to develop a scintillating film which can indicate visually the position of radioactive source in an opaque guide tube of NDT apparatus. To find out the best composition of the film, the test samples were fabricated with various inorganic scintillation materials, mixing rates and thicknesses and evaluated in their luminance performances. In the results of experiment, the brightness of the scintillating films, which are fabricated with Gd_2O_2S:Tb inorganic powder of scintillation materials, was visible to figure out the source position by naked eyes. The higher mixing rate and the higher thickness in the active layer, the higher luminance was measured under the some conditions possible to mix and to fabricate the samples.

ACKNOWLEDGEMENTS

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REFERENCES

[1] G. F. Knoll, Radiation Detection and Measurement, Third Edition, John Wiley & Sons, New York, pp.219, 1999.
[2] K. J. Lee, J. I. Yun, Y. S. Kim, S. Kim and B. S. Lee, Experimental Evaluation of Luminance Performance of an Organic and an Inorganic Scintillating Film for Locating Radioactive Source in an NDT Apparatus, Proceeding of the Autumn Symposium of the Korean Association for Radiation Protection on radiation protection. pp.247, 2004.
[3] C. D. Wickens, S. E. Gorden, Y. Liu, An Introduction to Human Factors Engineering, Addison Wesley, pp.81~109, 1997.