§13. Disk Shaped Radiation Sources for Education Purposes made of Chemical Fertilizer

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In a previous study, a method of fabricating a radiation source from materials containing natural radioisotopes was developed using potassium chloride chemicals. This fabrication method involves compression and formation, which maintains the amount and concentration of radioactivity in the original material while reducing its volume. In this compression and formation method, a certain amount of powdered material is placed in a stainless steel formwork and compressed to form a solid disk. Using this method, educational radiation sources were fabricated using a commercially available chemical fertilizer.

The chemical fertilizer contains potassium, which is composed of a small amount of naturally occurring potassium-40. The potassium-40 radionuclide emits beta and gamma radiation. The chemical fertilizer was used to fabricate disk-shaped radiation source and the fabricated radiation source is called a chemical fertilizer radiation source. The radiation source was examined for applicability to an educational radiation course. In the examination, tests to determine dependence of count rate on distance, shielding thickness, and shielding materials were conducted using the chemical fertilizer radiation source.

For the distance dependence test, count rates were measured with a GM survey meter for eight distances ranging from 0 to 20 cm. Results are shown in Fig. 1. Count rates dramatically decrease initially and then decreased moderately with an increase in distance. This proportion

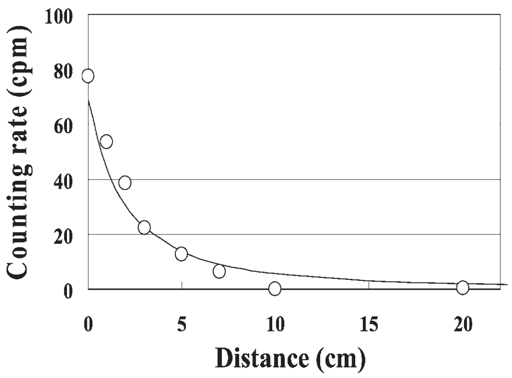

Fig. 1 Dependence of radiation counting rate on distance

appears to follow the inverse-square law. Figure 1 also shows the inverse-square law $Y = A/(a+X)^2$, where X and Y are distance and count rate, respectively, and A and a are constants with values of 1400 and 4, respectively. The count rates are distributed around the curve as a function of distance. The experimental results obtained with the chemical fertilizers can be semi-quantitatively explained by the inverse-square law, which is an important principle of radiation protection; radiation strength decreases with increasing distance from the radiation source.

For the test of dependence on shielding thickness, at a fixed distance of 15 mm, shielding materials of varying thickness were inserted between the GM probe and the source, and the count rate was measured using a GM survey meter. By dividing the shielded count rates by unshielded count rates, transmission rates were obtained. In the experiment, commercially available "Paper (Kent paper)", "Plastic (card case made of vinyl chloride resin)" and "Aluminum" were used as different shielding materials. Paper, Plastic, and Aluminum were plates with a thickness of 0.25, 0.4, and 0.5 mm, and mass density of 0.93, 1.35, and 2.7 g/cm^3, respectively. These shielding materials were cut into 50 mm square plates and stacked to produce shielding materials of various thicknesses. Results are shown in Figure 2, in which circles, squares, and triangles indicate Paper,

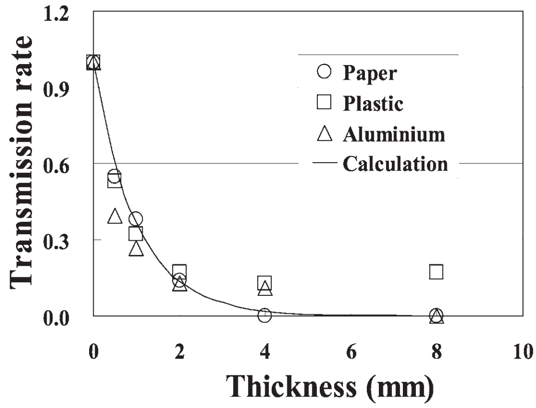

Fig. 2 Dependence of transmission rate on shielding thickness.

Plastic, and Aluminum, respectively. As shown in Fig. 2, a small transmission rate corresponded to greater shielding effectiveness. This semi-quantitative experimental result explains the relation between material thickness and effectiveness of shielding against radiation, in which transmission rates decease as the thickness of the shielding material increases. A curve representing the exponential function $Y = e^{-X}$ also is shown, where X and Y are shielding thickness and transmission rate, respectively, The transmission rates obtained experimentally lie around the exponential curve as a function of material thickness. This relation is similar to the inverse-square law, being difficult to distinctively distinguish the curve drawn in Fig. 1 from that in Fig. 2.

All of the results indicated that the educational radiation sources fabricated from chemical fertilizer was suitable for demonstrating the characteristics of radiation relating to distance and shielding thickness. The chemical fertilizers treated in the present study are common materials that are widely available. The radiation sources fabricated from the chemical fertilizers can be safely and easily handled in educational radiation courses and are not governed by radiation related laws.

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