AN α-ACTIVITY IMAGING MONITOR SYSTEM FOR RAPIDLY DETECTING PU CONTAMINATION

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ABSTRACT

A new type of α-activity imaging monitor system was constructed for rapidly obtaining the position profile of Pu contamination on filter paper. The system consists of a detector head, an image intensifier, a low-lag vidicon and an image processor. When the integrated image is taken with 10 min., PuO_2 particles more than 0.03 Bq and $Pu(NO_3)_4$ particles more than 0.13 Bq can be rapidly detected by spot separation processing.

INTRODUCTION

When an air monitor gives extraordinary α counts in Pu facilities, it is necessary to distinguish rapidly between Pu contamination and Rn daughters[1]. If the α counts are judged to be caused by Pu particles, the size distribution is an important in evaluating the inhalation exposures.

The authors constructed an α-activity imaging monitor system which was developed from the charged-particle imaging video monitor system[2]. The present paper describes the methods for distinguishing between Pu particles and Rn daughters and estimating the size distribution of Pu particles.

IMAGING MONITOR SYSTEM

The schematic diagram of the imaging monitor system is shown in Fig. 1. The system consists of a detector head, an image intensifier, a low-lag vidicon and an image processor. The light image of α particles is integrated in the image processor. The system can display the distribution image of α particles becoming gradually clearer on a video display. The image memory consists of $512\times512\times16$ bit words (512 k bytes). The integrated image and the processed image are stored on a floppy disk.

IMAGE PROCESSING FOR RAPID DETECTION OF PU CONTAMINATION

When the integrated image of a filter paper is taken immediately after sampling, both α spots of Pu particles and Rn daughters are observed on the image. Large Pu particles result in clearer α spots, while small Pu particles produce only a cluster of a few small α spots. Smoothing process is effective

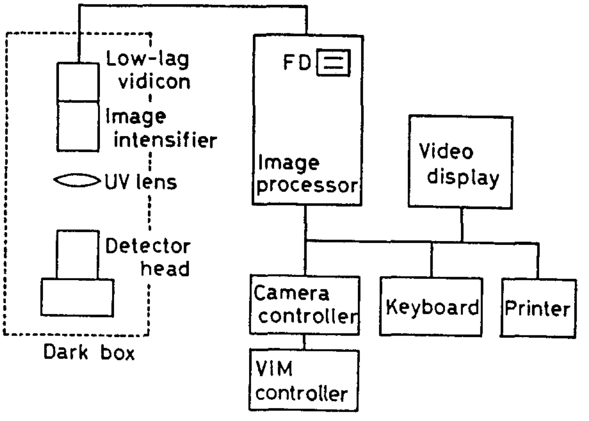


Fig. 1 Schematic diagram of the α-activity imaging monitor system.

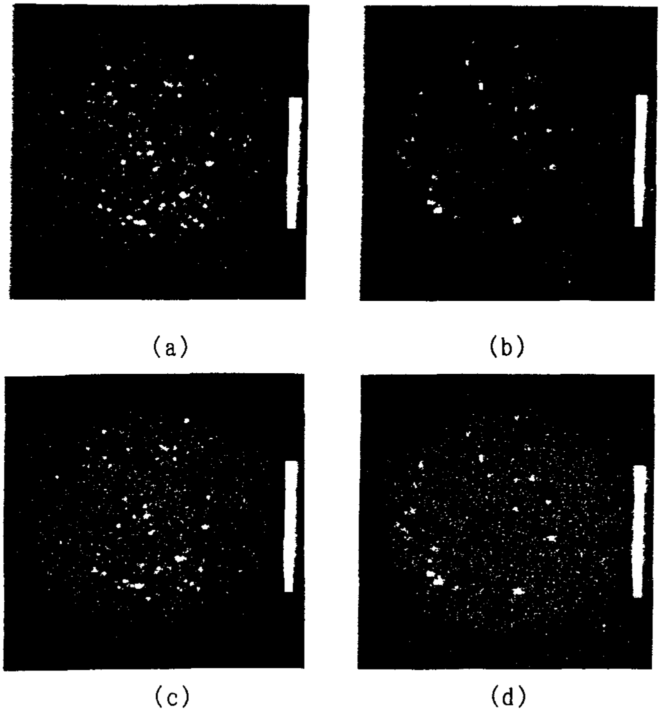


Fig. 2 Distribution images of (a) PuO_2 and (b) $Pu(NO_3)_4$ particles. Superimposed images of Rn daughters images of 1,771 counts and the images of (c) PuO_2 and (d) $Pu(NO_3)_4$ particles.

for collecting the scattering α spots into one spots.

The integrated image shows nonuniformity. To evaluate the image quantitatively, the uniformity correction process has been carried out by using a standadized α image.

The spots of Pu particles are separated from the small spots of Rn daugthers by using threshold level (TL) and separate level (SL) determined as a function of Rn daughters concentration on the filter. The values of TL and SL were decided as the probabilities that the counts of one pixel and one spot have more than TL and SL are less than 0.05, respectively.

DISTINCTION BETWEEN PU PARTICLES AND RN DAUGHTERS

The applicability of the system for distinguishing Pu particles from Rn daughters was studied by using filters contaminated with PuO_2 particles, $Pu(NO_3)_4$ particles and Rn daughters. The whole activities of PuO_2 and $Pu(NO_3)_4$ particles are 2.37 Bq and 1.60 Bq. Figures 2 (a) and (b) show the images of PuO_2 and $Pu(NO_3)_4$ particles taken with 90 and 60 min. Figures 2 (c) and (d) shows the superimposed images of Rn daughters image of 1,771 counts and the images of PuO_2 and $Pu(NO_3)_4$ particles. The Rn daughters images of 5,475 and 10,857 counts were also superimposed on the images of PuO_2 and $Pu(NO_3)_4$ particles.

Figure 3 shows the detection limits of PuO_2 and $Pu(NO_3)_4$ particles when Rn daughters are present on the filter. The PuO_2 particle of 0.03 Bq (1.41μm : activity equivalent spherical diameter) and $Pu(NO_3)_4$ particle of 0.13 Bq (3.43μm) may be detected within 10 min, even if Rn daughters of 2 Bq are present on the filter. The activities of PuO_2 and $Pu(NO_3)_4$ particles of 0.03 Bq and 0.13 Bq in air per 1 m^3 are lower than DAC of ^{239}Pu particle (0.2 Bq·m^3) in air.

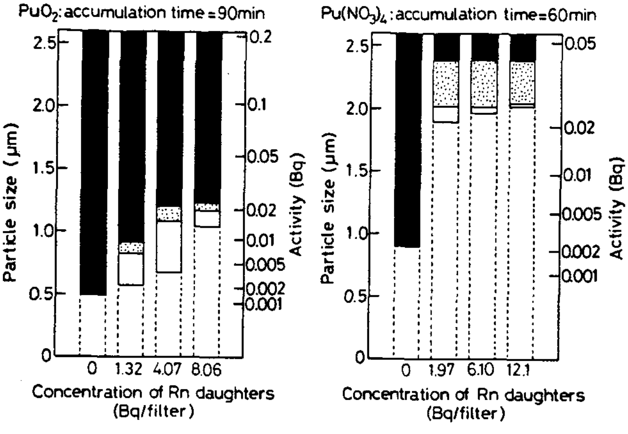


Fig. 3 Detection limits of PuO_2 particles and $Pu(NO_3)_4$ particles when Rn daughters are present on the filter.

ACTIVITY AND SIZE DISTRIBUTION OF PU PARTICLES

Radioactivity of PuO_2 particle is given by

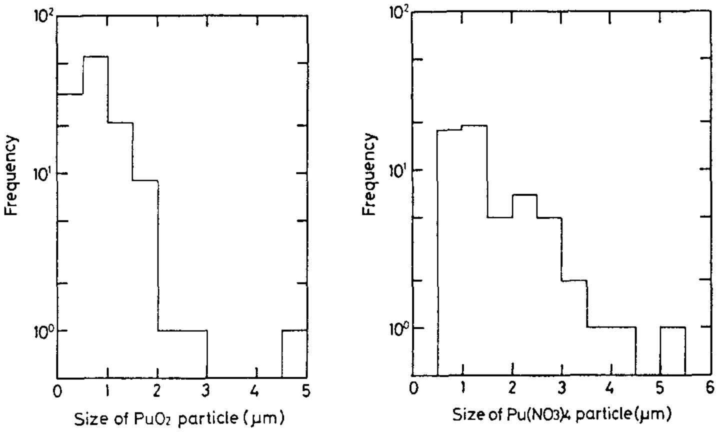
$$D = 4.01 \cdot C \qquad (1)$$

where D is PuO_2 activity (Bq) and C is the α count obtained on a uniformity-corrected image. The relation between the size and the activity of PuO_2 particle is given by

$$Y = (k \cdot D)^{1/3} \qquad (2)$$

where Y is particle diameter (μm) and k is constant of 83.4 for PuO_2 particles and 319 for $Pu(NO_3)_4$ particles[3].

The spot count of each Pu particle in Figs. 2 (c) and (d) is converted into size by eqs. (1) and (2). The results shown in Figs. 4(a) an (b). The size of almost Pu particles is less than 4 μm.



(a) (b)

Fig. 4 Size distribution of (a) PuO_2 and (b) $Pu(NO_3)_4$ particles.

CONCLUSIONS

The α-activity imaging monitor system has good spatial resolution. The integrated image can be evaluated quantitatively by the software programs. When the integrated image is taken with 10 min., PuO_2 and $Pu(NO_3)_4$ particles more than 0.03 Bq and 0.13Bq can be rapidly distinguished from Rn daughters by the spot separation processing. Moreover, the size distribution of Pu particles can also be determined from the integrated image.

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