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Stability in Accumulated Pulsed Photostimulated Luminescence Signals of Minerals Extracted from Irradiated Korean Sesame and Perilla Seeds Stored under Room and Darkroom Conditions

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Introduction

Optically stimulated luminescence (OSL) was first suggested for radiation dosimetry by Antonov-Romanovsky et al. (1956) using infrared stimulated luminescence from doubly doped ZnS and SrS and the studies with similar samples were also carried out by Braunlich et al. (1967) and Sanborn and Beard (1967). The technique has gained importance after its application as a method of accumulated dose determination in dating of quartz extracted from sediments (Huntley et al. 1985). Hutt et al. (1988) demonstrated that transient luminescence could be stimulated in feldspars using infrared light in the wavelength of 530-1030 nm and measured a stimulation spectrum with a complex structure with several peaks. Following this study, a great numbers of studies have been carried out both on the technique and its applications relevant to dating. Sanderson and Clark were the first to investigate the potential of pulsed OSL from alkali feldspars relevant to dating and infrared stimulated pulsed PSL has been investigated in connection with the problem of detecting irradiated foods.

Pulsed photostimulated luminescence (PPSL), which uses light rather than heat to stimulate the release of trapped charge carriers, is radiation specific phenomena from energy storage by trapped charge carriers following irradiation. A detection method which is designed to allow direct measurements for rapid screening purposes without the need for sample preparation or re-irradiation such as the TL of irradiated foods (15-17). When exposed to ionizing radiation, most materials store energy by trapping charge carriers at structural, interstitial or impurity sites. Subsequent stimulation by electromagnetic radiation of the appropriate wavelength releases the trapped charge carriers, resulting in the emission of photostimulated luminescence (PSL). Therefore, the PPSL detection method has a possible application as a rapid screening purpose for many irradiated foods. Based on this background, The objective of this research was to examine differences in the PPSL signals according to storage conditions and periods on the accumulated PPSL signals of minerals separated from the irradiated perilla and sesame seeds, and thereby evaluating the possibility of PPSL on detection of irradiated perilla and sesame seeds.

Materials and Methods

Materials and irradiation

Perilla and sesame seeds harvested in Korea were purchased from a local market. Samples were packed in polyethylene bags and were irradiated using a Co-60 irradiator (AECL, IR-79, Ontario, Canada) with 1, 5, and 10 kGy, with a dose rate of 10 kGy/h at the Korea Atomic Energy Research Institute. To measure the exact total absorbed dose of gamma irradiation, the dose rates for cobalt-60 sources were determined using a ceric-cerous dosimeter.

Preparation of mineral extract

The 100 g samples were agitated with 2 L water for 5 min. The suspended samples were filtered through a 250-µm nylon cloth, and the constituents retained were discarded. The solution filtered was allowed to settle for about 5 min to separate the sediment minerals from supernatant. The sediment minerals were suspended in 5 ml sodium polytungstate[$Na_6O_{39}W_{12}.H_2O$] (Fluka 71913) solution which had been adjusted to a density of 2.0 g/ml by an addition of water for the separation of minerals and adhering organic materials. The minerals were pelleted through centrifugation for 2 min at 1000 rpm after a 5-min ultrasonic treatment. The low-density layer was decanted off. This procedure was repeated until all the organic materials were removed. After the polytungstate solution was removed, the minerals were washed twice in water and pelleted through centrifugation at 1000 rpm, followed by a 10-min treatment with 1 M HCl to remove carbonates. After neutralizing with 1 M NH_4OH for 10 min, the solution was discarded. The minerals were washed twice in deionized water and centrifuged at 1000 rpm for 2 min to separate a mineral fraction. After the supernatant was decanted, the remaining water was then rinsed off with 3 ml of acetone twice and dried in a laboratory oven at 50°C for 3 h. After irradiation, the samples of room condition were stored for 12 months in laboratory condition, which existed sunlight or a fluorescent light. The samples of darkroom condition were stored for the same period in a chamber oven (K.M.C-1203P3, Vision Scientific Co., LTD, Seoul, Korea) to block exposure by a light at room temperature.

Pulsed Photostimulated Luminescence (PPSL)

The PPSL system purchased from SURRC is composed of a control unit, sample chamber, and detector head assembly, and the control unit contains a stimulation source which is comprised of an array of infrared light (880 - 940 nm) emitting diodes which are pulsed symmetrically on and off for equal periods. PPSL is detected by a bialkali cathode photomultiplier tube operating in the photon counting mode. Optical filtering is used to define both the stimulation and detection wavebands. The separated minerals (1, 5, 10 mg) were introduced in 50 mm diameter disposable petri dishes (Bibby Sterilin types 122, Glasgow, UK). The samples were measured in the sample chamber for 120 s. The radiation-induced photon counts (PPSL signals) emitting per second from the samples were automatically accumulated in a personal computer and presented the photon counts accumulated up to 60 s and 120 s.

Results and Discussion

The accumulated PPSL signals of minerals separated from the irradiated and unirradiated Korean perilla and sesame seeds are shown in Table 2 and 3. The accumulated PPSL signals of the mineral measured exhibited an increase, showing decrease from 5 kGy to 10 kGy, with increasing irradiation dose and mineral content of 1, 5, and 10 mg. This trend was similar found in all storage conditions and periods. Threshold levels, meaning accumulated PPSL signals of minerals separated from unirradiated sesame and perilla seeds, were 80,113±3,198 and 58,827±21,417 photon counts at 10 mg, respectively. Difference in the signals between minerals separated from Korean and Chinese sesame seeds, and Sudanese perilla seed was also observed. The changes of decay rate calculated from accumulated PPSL signals of minerals separated from irradiated sesame and perilla seeds measured by PPSL with different sample amounts in the 60 and 120 s measurement times during storage periods of 12 months under room and darkroom conditions were studied. Decay rate of the accumulated PPSL signals decreased with increasing storage periods, and the sample stored in room condition showed higher reduction. The decay rates exhibited higher decrease in 5 and 10 kGy than in 1 kGy. Although, the accumulated PPSL signals of all sesame and perilla seeds decreased with increasing storage times, irradiated samples showed higher photon counts than those of unirradiated samples in room and darkroom conditions. In both conditions, detection of irradiation was still possible after 12 months. These results indicate that PPSL measurement methods using minerals separated can be used as a method for detecting the irradiation treatment of sesame and perilla seeds stored in different conditions during long-term storage. Difference in different measurement times (60 and 120 s) of accumulated PPSL signal of minerals separated from irradiated sesame and perilla seeds was observed under different storage conditions and periods during 12 months. The accumulated PPSL signal for 120 s were higher than those measured for 60 s. In the all samples, the photon counts of minerals seperated from all irradiated sesame and perilla seed samples were higher than those of the unirradiated ones regardless of measurement times of 60 and 120 s. Hence, the authors believe that the detection of irradiation is possible in both 60 s and 120 s measurement time.

Acknowledgements

The authors would like to thank the Ministry of Science and Technology (Research of the Long-and-Mid-term Nuclear R & D Program) for financial support during this study.

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