OSL and PTOSL of dosimetric materials: observation of the luminescence after exposure to $^{90}Sr+^{90}Y$ source and LEDs in ultraviolet range

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Introduction

The study of luminescence phenomena by crystal-based radiation detectors is suitable for radiation dosimetry, once the light emitted by them enables the quantification of their deposited radiation energy. The light emission can be promoted when a material is illuminated with a certain wavelength and time interval, as in the optically stimulated luminescence (OSL) and phototransferred OSL (PTOSL) processes. The objective of this work is to evaluate the OSL and PTOSL responses of commercial dosimeters in order to study their luminescence and the possibility of use in radiation dosimetry with the PTOSL technique.

Methods

OSL and PTOSL responses of LiF:Mg,Ti, CaF_2:Dy, CaF_2:Mn and $CaSO_4$:Dy dosimeters, commercially sold as TLD-100, -200, -400 e -900, respectively, by Thermo Fischer Scientific, were studied. The samples were irradiated with the $^{90}Sr+^{90}Y$ source of the TL/OSL reader system Risø, and the measurements were taken using the same system and signal emission stimulus time of 100 s with blue LEDs. For PTOSL signal, the dosimeters were irradiated, thermally treated and illuminated with LEDs with wavelengths between 265 nm and 420 nm.

Results

The dosimeters were irradiated with 0.75 Gy (TLD-100 and -900), 20 Gy (TLD-200) and 50 Gy (TLD-900). The most intense OSL signal occurred for TLD-100 (initial decay point of 53.308 counts), while the TLD-200 presented the lowest OSL signal (value of 1.086 counts), for TLD-400 and -900, the values were 13.291 counts and 2.916 counts, respectively. In relation to the study of PTOSL response, after illumination the TLD-100 produced a signal of 56.600 counts, TLD-200 of 450 counts, TLD-400 of 650 counts and TLD-900 of 1.200 counts.

Conclusions

Comparing the OSL and PTOSL results, it is possible to observe clearly the phototransferred effect for TLD-100. For TLD-200 and -400, no effects were noted. In the case of TLD-900, it presented a PTOSL signal in a small-scale when analyzing the curve integral.

Enhancing Beta Spectrum Unfolding in mixed Beta/ Gamma Radiation Fields: Combining Iterative and Machine Learning Approaches

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Introduction

This study focuses on beta-ray dosimetry for mixed beta-gamma radiation fields. Beta unfolding algorithms have been developed to extract beta fluence rate spectra from raw pulse height spectra that were collected by a beta coincidence spectrometer consisting of a thin silicon detector and a plastic scintillator detector. The spectrometer rejects the gamma detection events by applying a coincidence method.

Methods

Stability tests were conducted to assess the reliability of the system using calibration sources. The energy-dependent response function was computed through Geant4 Monte Carlo simulations to establish its coincidence efficiency for different beta energies and beta-gamma ratios. A Gaussian Energy Loss function was determined as the system response by comparing measurements and corresponding simulations with a Sr/Y-90 calibration source and characterizing the response of the spectrometer with respect to the beta fluence rate spectrum at the detection window. Two unfolding algorithms, P.A. Jansson's iterative method and the Richardson-Lucy iterative deconvolution algorithm, were developed based on the system response. Additionally, a convolutional neural network (CNN) model was trained using artificially generated fluence rate spectra and the system response to serve as an unfolding algorithm. The performance of each method was evaluated using various beta spectra created by adding thin plastic moderators.

Results

The CNN unfolding method can produce a fluence rate spectrum, whose shape is more similar to that of the true spectrum. However, there is a potential risk of overfitting, which could be mitigated by expanding and diversifying the database used for training. The iterative unfolding algorithms' stability and interpretability offer advantages. A hybrid algorithm combines these unfolding methods is currently under development to improve the unfolding performance. These unfolding results will be investigated comprehensively further.

Conclusions

The combination of traditional iterative unfolding and machine learning-based unfolding methods shows promising results for the beta spectrum unfolding. By leveraging the strengths of both approaches, a reliable and effective unfolding result can be achieved.