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PLA Renewable Bio-Polymer Based Solid-State Gamma Radiation Detector-Dosimeter for Biomedical and Nuclear Industry Applications

Low-cost PLA beads serve as bio-based, solid-state gamma dosimeters across 0–120 kGy for food, medical, and nuclear radiation monitoring.

Summary:

Researchers at Purdue University have developed a method to determine the gamma irradiation (GI) dose through correlation of changes in the rheological properties of polylactic acid (PLA). Those properties include degree of deformation and increase in pore volume after the PLA is exposed to radiation and placed in a hot press. The experimental procedure was developed to determine GI in the low (0-11 kGy) and high (11-120 kGy) gamma dose ranges. Nominal gamma irradiation detectors can cost anywhere from millions of dollars (for radiation spectrometers) to 1-10 thousand dollars (for portable survey equipment), to $10 per detector for personal dosimeters (such as thermoluminescence dosimeters (TLDs)). A dosimeter composed of PLA beads could represent an advancement in radiation detector technology due to the large (100-1,000x) decrease in materials cost.

Technology Validation:

The parameters for measurement of GI dose through the relative viscosity of the PLA beads were determined by finding the optimal temperature, compressing force, and hold time for the ranges of 0-11 kGy and 11-100 kGy. The GI source has a known radiation output rate and was used to correlate the measurement outcome of the PLA-based dosimeters. It was found that the change in relative viscosity of the PLA was quadratically associated with the GI dose, with a high correlation coefficient ($R^2 > 0.95$) for both GI dose ranges.

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Using a similar procedure, an optimal set of measurement parameters was determined for the measurement of GI dose by an increase in porosity of the compressed PLA beads. The increase in porosity of the compressed PLA beads was measured systematically by marking a ~1 mm x 1mm grid on the compressed PLA and observing the pore area using image processing software.

Advantages:

- Nonpowered

- Solid-state

- Lightweight

- Inexpensive

- Bio-based renewable polymer

- General purpose radiation detector (alpha, beta, gamma, neutron)

- Capable of detecting GI dose from 0-120 kGy

Applications:

- Food Irradiation/Packaging Sterilization

- Medical Device Sterilization, Radiation Cancer Therapy

- Personal Dosimeters for Medical/Nuclear Reactor employees

- Nuclear Power Reactor Energy/Safety, Irradiators, Accelerator Systems

Related Publications:

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