PLAD – A Renewable, Ultra-Low-Cost Bio-Polymer Solid-State Gamma-Neutron Radiation Sensor & Dosimeter for Medical, Health Physics, and General Nuclear Industry Applications

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A novel solid-state neutron and gamma radiation monitor-dosimeter based on biopolymer polylactic acid (PLA) is presented. The resulting detector (PLAD) technology takes advantage of property changes of the renewable PLA resin when subject to ionizing nuclear radiation. A simple yet rapid and accurate (+/- 10%) low-cost (< $0.01/detector) Mass Loss upon Dissolution (MLD) technique was successfully developed; MLD is based on a simple mass balance for discerning neutron and/or gamma doses using small (40 mg, ~ 4mm diameter) ultra-low cost (<$0.01) resin beads via dissolution in acetone. Our GammaCell™ Co-60 irradiator and PUR-1 12 kW fission nuclear research reactor were utilized for irradiations, respectively. Irradiation absorbed doses ranged from 1-100 kGy. Acetone bath temperatures varied from ~40 to ~54˚C. Results revealed a strong dependence of MLD on acetone bath temperature between neutron and gamma photon dose components; this allowed for the unique ability of PLAD to potentially perform as both a neutron-cum gamma or as a gamma or neutron radiation dosimeter and intensity level detector. The potential was also studied for deployment (alternative to U-235-based fission chamber) as an in-core neutron and gamma monitor within extreme conditions in an operating 3 GWt light water reactor (LWR). Scoping tests were conducted using pre-irradiated (@ 20˚C) PLAD resin beads followed by heating to in-core LWR coolant (300˚C) conditions for ~ 30 seconds corresponding to the time to reach ~40 kGy total doses in a typical 3 GWt LWR. MLD results were unaffected, indicating the exciting and unique potential for in-situ (low-cost, accurate, and rapid) simultaneous mapping of neutron and gamma radiation fluxes, related dosimetry, and fission power level monitoring. Studies at Purdue have also successfully characterized PLAD with alternate metrics for gamma/e-beam dosimetry such as relative viscosity, hardness, embrittlement, and rheology property changes, which will be highlighted.