Additive Manufacturing of Photopolymerizable Organic Scintillators for Triple Radiation Discrimination

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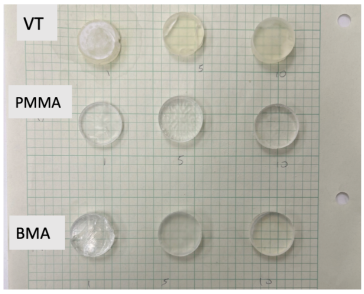
Additive manufacturing provides a promising route for producing complex geometries of organic scintillators that can be deployed into adverse environments in a variety of nuclear non-proliferation applications, but the development of photopolymerizable resins suitable for plastic scintillators with a capacity for triple radiation discrimination remains limited. In this work, we investigate a series resin formulations designed for stereolithography-based additive manufacturing of organic plastic scintillators using an off-the-shelf Formlabs printer.

The resins consist of matrix bases composed of vinyl toluene (VT), methyl methacrylate (MMA), or benzyl methacrylate (BMA), combined with a bisacylphosphine oxide (BAPO) photo initiator and a novel hybrid crosslinker system incorporating divinylbenzene (DVB) and pentaerythritol tetraacrylate (PETA). Scintillation performance is enabled through the incorporation of 2,5-diphenyloxazole (PPO) as the primary fluor and 1,4-bis(5-phenyloxazol-2-yl)benzene (POPOP) as the wavelength shifter. An additive of Lithium-6 is used to detect thermal neutrons, enabling discrimination among gamma rays, fast neutrons, and thermal neutrons within a single detector.



3D stereolithography printed scintillators with variable bases, mixtures of DVB and PETA crosslinker, BAPO, PPO, and POPOP

We explore the balance between aromatic monomers, which have high scintillation performance, and methacrylate components, which improve printability and hardness. The resulting printed scintillators are evaluated with respect to radiation detection performance, polymerization time, and mechanical properties.

This study establishes key relationships between monomer composition, additive optimization, and light yield and pulse-shape-discrimination capability. These findings provide further insight into the development of 3D-printable triple discriminating organic scintillators.