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Scintillation Materials based on Metal Organic Frameworks

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Existing scintillation detectors are limited by material properties, such as nonproportional response and low luminosity. For example, conventional organic scintillators (liquid or plastic) used for fast neutron detection suffer from low, and highly nonlinear light yield for recoil protons below 10 MeV, resulting in low signals for neutrons relative to electrons, and an effective threshold for gamma rejection well above the fission spectrum peak. These limitations could be addressed by designing new materials with low dE/dx and high scintillation efficiency.

Metal organic framework (MOF) materials are a new class of nanoporous coordination polymers that can be designed with unique structure and properties with potential for improved scintillation materials. The distinguishing features of MOFs are coordinating metal polyhedra causing organic "linker" molecules to self-organize into highly porous networks capable of accommodating a variety of adsorbates or molecular "guest" molecules. The linkers enable rational control over pore geometry and chemistry, affording new degrees of freedom to design materials for specific radiation detection applications, including: independent control of mass density and fluorescence properties; tailorable composition through linker moieties; metal clusters and guest species; ultra-low density materials to minimize dE/dx quenching; ultra-high surface areas (up to 6,000 m2/g) for high-density storage of particle conversion gases (e.g., H_2, boron compounds, or Xe).

We have synthesized and tested new highly fluorescent MOFs based on stilbene dicarboxylic acid as a linker. The crystal structure and porosity of the product are dependent on synthetic conditions and choice of solvent and a low-density cubic form has been identified by x-ray diffraction. In this work we report experiments demonstrating scintillation properties of these crystals. Bright proton-induced luminescence with large shifts relative to the fluorescence excitation spectra were recorded, peaking near 475 nm. Tolerance to fast proton radiation was evaluated by monitoring this radio-luminescence to absorbed doses of several hundred MRAD. Scintillation and pulse-mode detection were demonstrated in Am-241 alpha particle counting experiments, and the luminosity was compared to anthracene samples tested under identical conditions.

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