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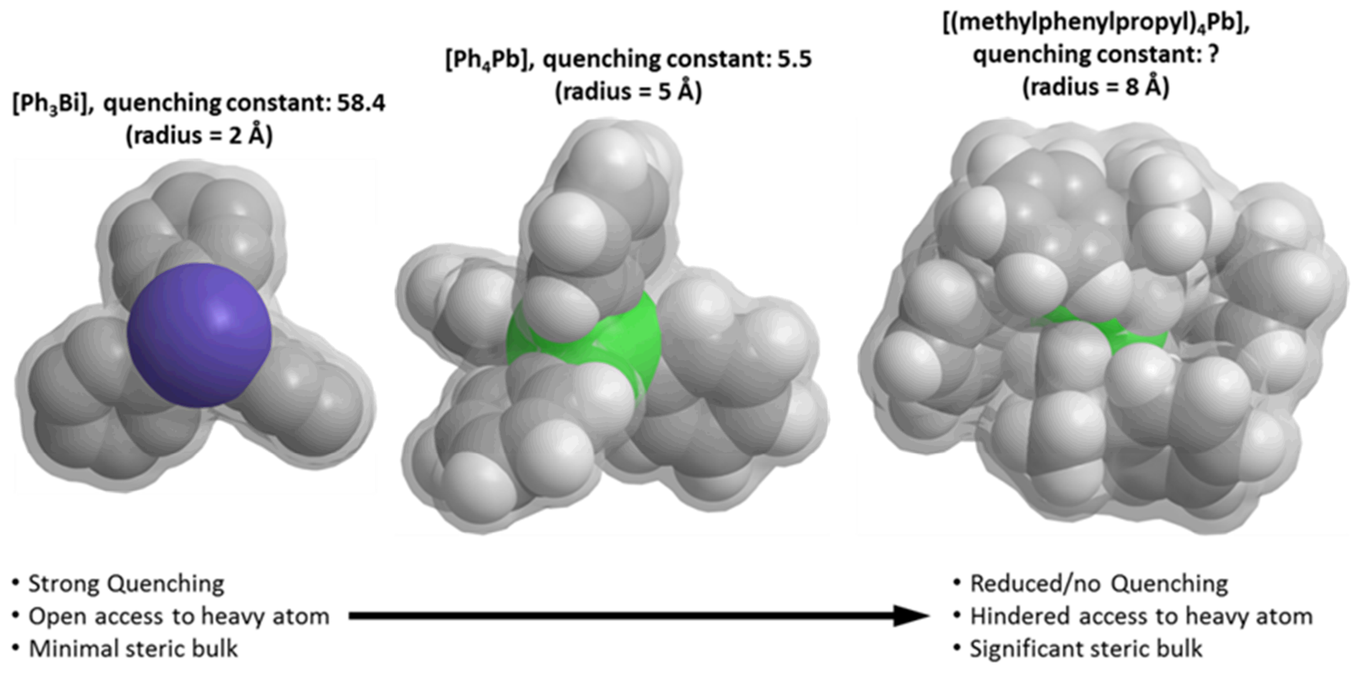

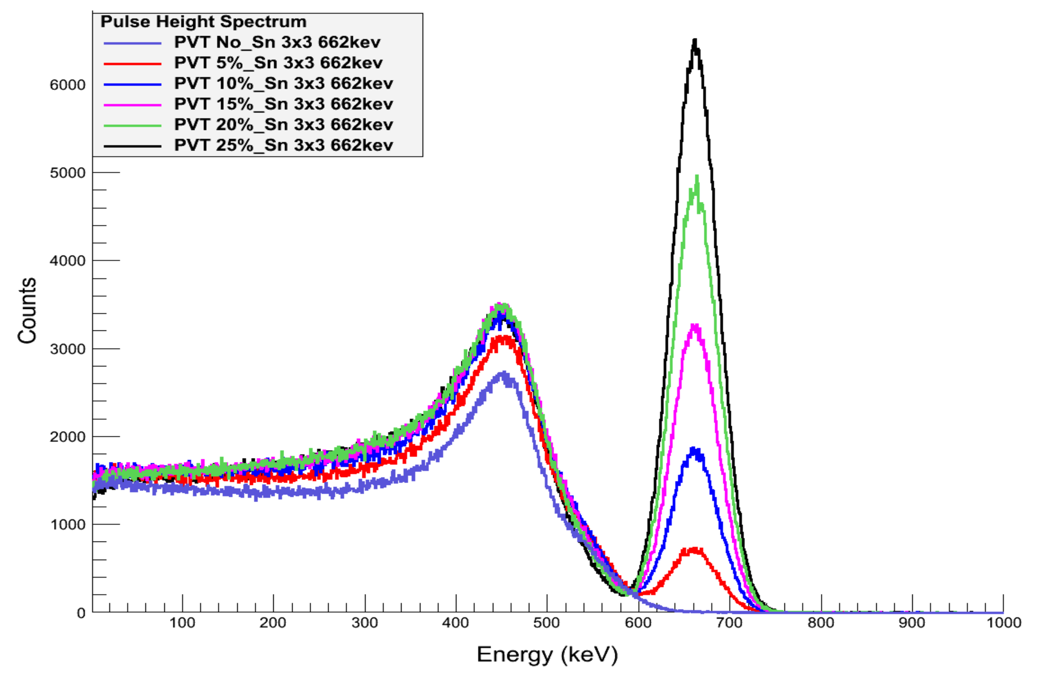

Synthesis of Sn-Loaded Plastic Scintillators

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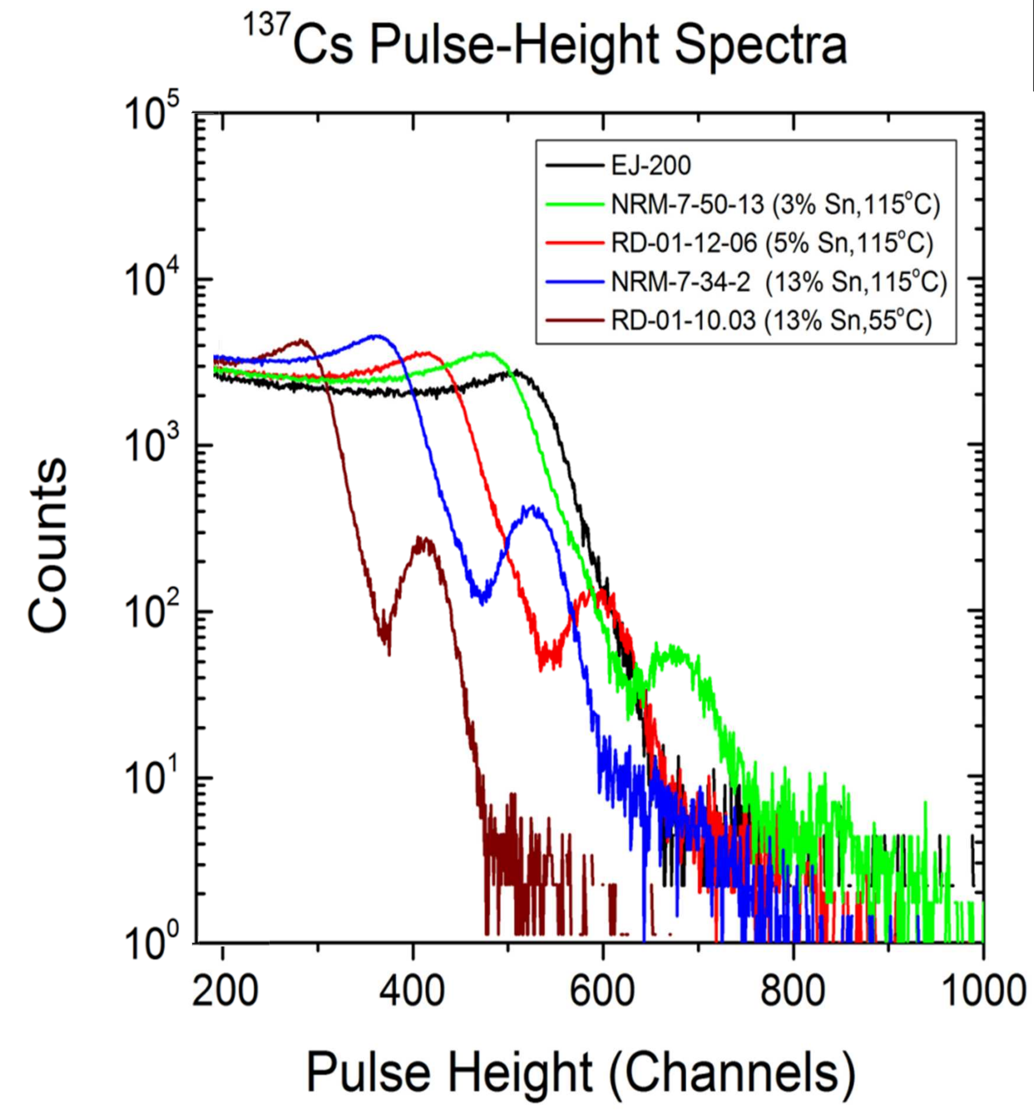
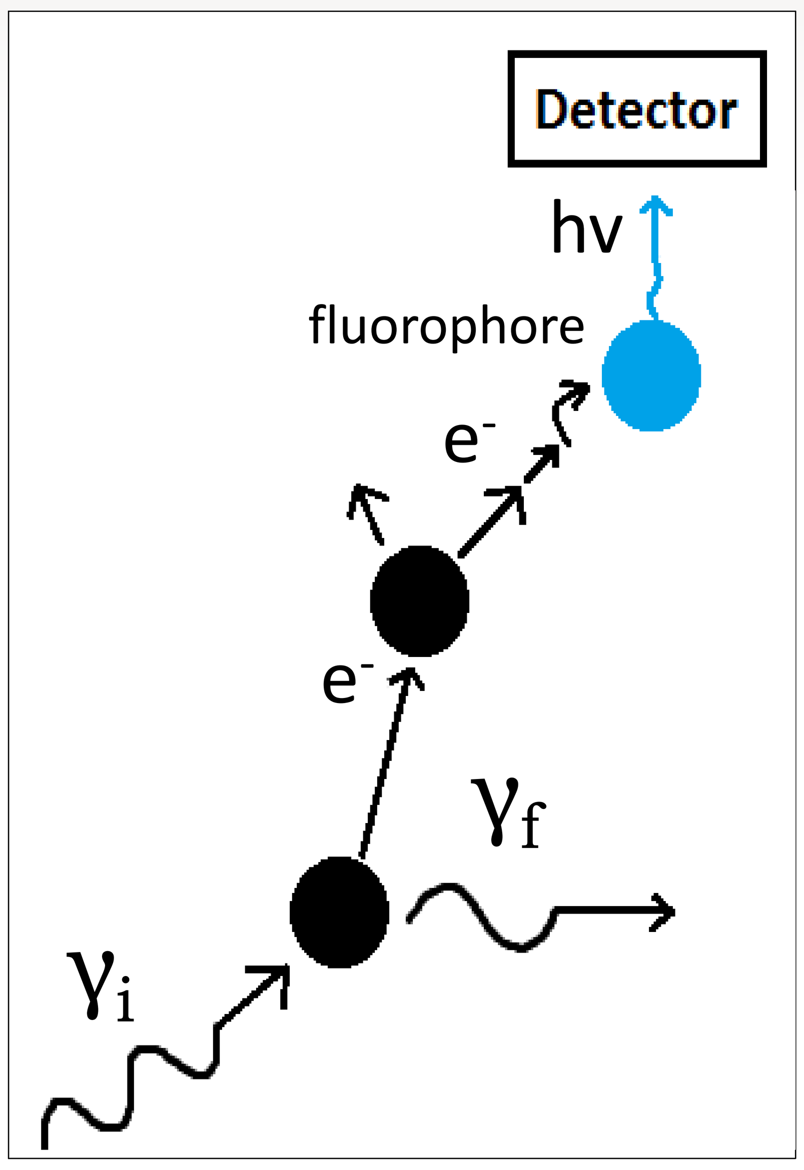
Abstract

Due to the threat of nuclear terrorism, the development of spectroscopic radiation detectors is critical to national security. To this end, we have developed a suite of organo-tin additives for plastic scintillators which enhance their spectroscopic capabilities. By increasing the plastic's effective atomic number, the scintillator's ability to fully stop incident radiation, and thus to reliably resolve its energy, is dramatically improved. Current efforts focus on finding compounds containing multiple tin atoms which allow for desired tin-loading while maintaining scintillator transparency and light yield.

Introduction

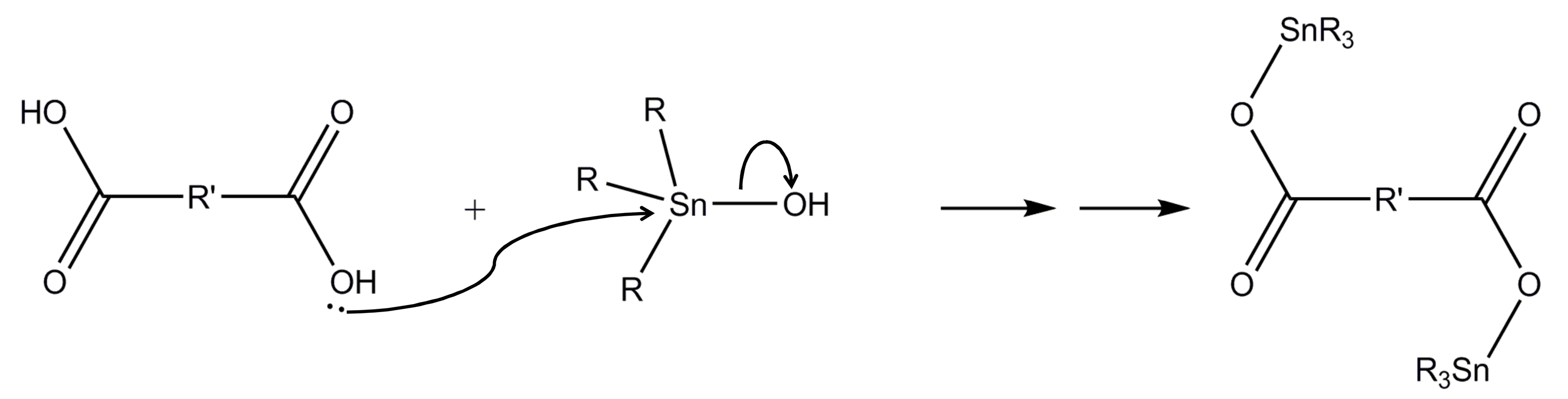
Modern scintillators used for border security applications are composed primarily of polystyrene or polyvinyltoluene. While quite sensitive, these plastics have too small of a gamma-ray absorption crossection to fully absorb incident radiation, leading to the dominance of Compton-scattering as the primary detection mode. Larger atoms such as tin, however, have much greater absorption crossections, so adding them increases the probability of full photon absorption. This full absorption allows for much more consistent energy resolution and thus spectroscopic ability. In order to increase attainable tin-loading percentages, additives containing multiple tin atoms are being explored. Our objective is to synthesize an organo-tin compound with sufficient solubility in the plastic matrix to achieve greater than 10% w/w tin loading while maintaining optical clarity.





Methods

Organo-tin compounds are synthesized via a simple one-step condensation reaction between a multi-carboxylic acid and trialkylstannyl hydroxide/bis-oxide. The additives are then mixed with styrene prior to polymerization. Resulting loaded-plastics are analyzed via photoluminescence, quantum yield, and pulse height spectrometry.



R=Me, Bu R'=Naphthalene, Benzene, Biphenyl, Stilbene, none

Results and Current Direction

Previous work on this project has led to promising results. Scintillators with tetramethyl tin, for example, exhibit full absorption with photopeak:Compton ratios matching radiation transport modeling (pictured above). However, lack of steric bulk leads to lower than desired light yield through heavy-atom quenching. Our current approach of synthesizing molecules containing multiple Sn atoms has one key advantage; it provides greater synthetic flexibility because bulkier base compounds can be used without "diluting" the tin beyond the usable limit. This flexibility is advantageous because it should allow for the tuning of an additive's solubility in the plastic matrix, thus allowing for maximal loading. Other properties of the additive can also be explored, such as photoluminescence. We hope that using this approach will allow us to achieve 10% w/w Sn in a plastic sample.

U.S. DEPARTMENT OF ENERGY NNSA National Nuclear Security Administration

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