Thermal Neutron Detection and Pulse Shape Discrimination using Polysiloxane Scintillators with B10-enriched Molecules

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Abstract:

Three boron-10 enriched aromatic molecules have been synthesized and incorporated into two different commercial polysiloxane resins, Shin Etsu KER-6000 and Wacker SilRes H62-C. Scintillating fluorophores, 9,9-dimethyl-2-phenylfluorene (PhF) and 2,5-diphenyloxazole (PPO), were tested in combination with each resin and boron-10 molecule for the simultaneous detection of gamma rays, fast neutrons, and thermal neutrons. Polysiloxanes can have the advantages of increased pulse shape discrimination at low dopant loadings and ease of fabrication. For example, 3 hours of thermal curing in air is sufficient while traditional PVT-based materials require up to 5 days of heating in vacuum, and polysiloxanes can achieve efficient PSD with 5 wt% dopant loading rather than the > 20 wt% necessary in PVT-based materials. The H62-C resin was able to solubilize a large amount of PhF, in excess of 20 wt%, however improvements in scintillation were limited after 10 wt% loading. Cure kinetics were controlled through the addition of divinylbenzene and phenyl tris(dimethylsiloxy)silane cross-linker solution to the H62-C resin, with rheology experiments demonstrating a threefold reduction in time to gelation when 20 wt% cross linker solution was added, from > 3 hours to 1 hour. PhF doped KER-6000 with ^{10}B enriched tolyl boronate pinacol ester exhibited the best overall performance with a light yield of 62% relative to EJ-200 and thermal neutron capture at energies up to 91 keVee. Over the course of 10 months, the KER-6000 samples showed precipitation of dopant molecules, which reduced their light yield by 15% on average, while H62-C proved to be much more stable with only a 6% reduction.