Composition optimization of nanostructured polymeric scintillators for PSD applications

L.Pollice[a], X.Hu[b], D.Rigamonti[c], I.Villa[a], M.Mauri[a], M.Tardocchi[c], F.Meinardi[a], C.Weder[b], A.Monguzzi[a*]

[a]Department of Materials Science, University of Milano-Bicocca, 20125 Milano, Italy
[b]Adolphe Merkle Institute, University of Fribourg, CH-1700 Fribourg, Switzerland
[c]Institute for Plasma Science and Technology, National Research Council of Italy, Milan, Italy

Corresponding Author Email: Angelo.monguzzi@unimib.it

Scintillating materials can enable the discrimination of neutrons and charged particles from γ-rays by exploiting the pulse shape discrimination (PSD) technique. The ability to discriminate between high energy photons and ionizing particles is indeed useful in several fields, for example to estimate the power generated in nuclear reactors or to identify threat radioactive materials (Uranium-235 and Plutonium-230) from the reaction of other non-threat sources.
PSD techniques involve a time-gated analysis of the transient voltage pulse generated in the photodetector of the scintillation counter. This analysis allows to distinguish between fast and slow components of the scintillation signal, i.e., prompt and delayed emission, whose relative intensity and lifetime depend on the type of the incident radiation [1].
We demonstrated that sensitive and fast PSD detection can be achieved in nanostructured polymer scintillators. The material is made of a solid polymer matrix, which provides structural stability but is optically passive, liquid nanodomains containing an extremely high concentration of a triplet-triplet-annihilation (TTA) dye and optionally a triplet sensitizer, so that the delayed fluorescence occurs even at ultra-low energy densities [2].
In this work we investigated the PSD response of a series of nanostructured scintillators as a function of the composition, in order to point out the mechanism behind the sensitization of the delayed fluorescence generation in the presence of a triplet sensitizer. The obtained results provide the guidelines for the design and fabrication of high performance nanostructured multiphase scintillators that can surpass the state-of the art, commercially available, PSD plastic scintillators.

1. Bertrand, G. H. V. Pulse shape discrimination between (fast or thermal) neutrons and gamma rays with plastic scintillators: State of the art. *Nuclear Instruments and Methods in Physics Research, Section A: Accelerators, Spectrometers, Detectors and Associated Equipment.* **2015**, 776, 114–128.

2. Hu, X. Sensitized triplet-triplet annihilation in nanostructured polymeric scintillators allows for pulse shape discrimination. *In press,* DOI: 10.1002/adma.202400443