Nanocomposite Scintillator Films with Improved Gamma-Ray Interaction

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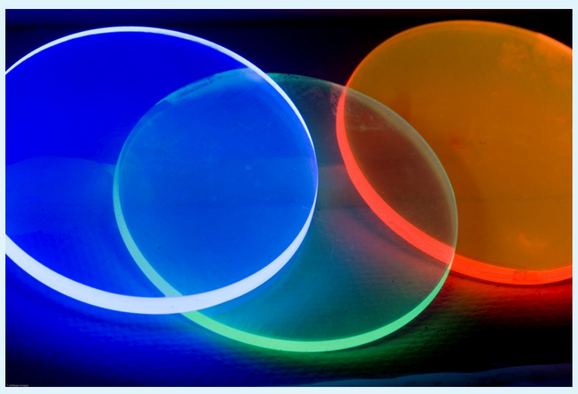
Context

Plastic scintillator features

- Low cost
- Large-scale manufacture
- Impact and environmental resistance
- Fast decay times
- Broad tunability



- Low Z_{eff} number
- Low density

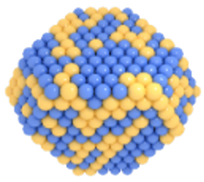
→ Poor gamma identification

- Lower light yield in comparison to inorganic scintillators

→ Reduced photons creation

Inorganic nanoparticle loading

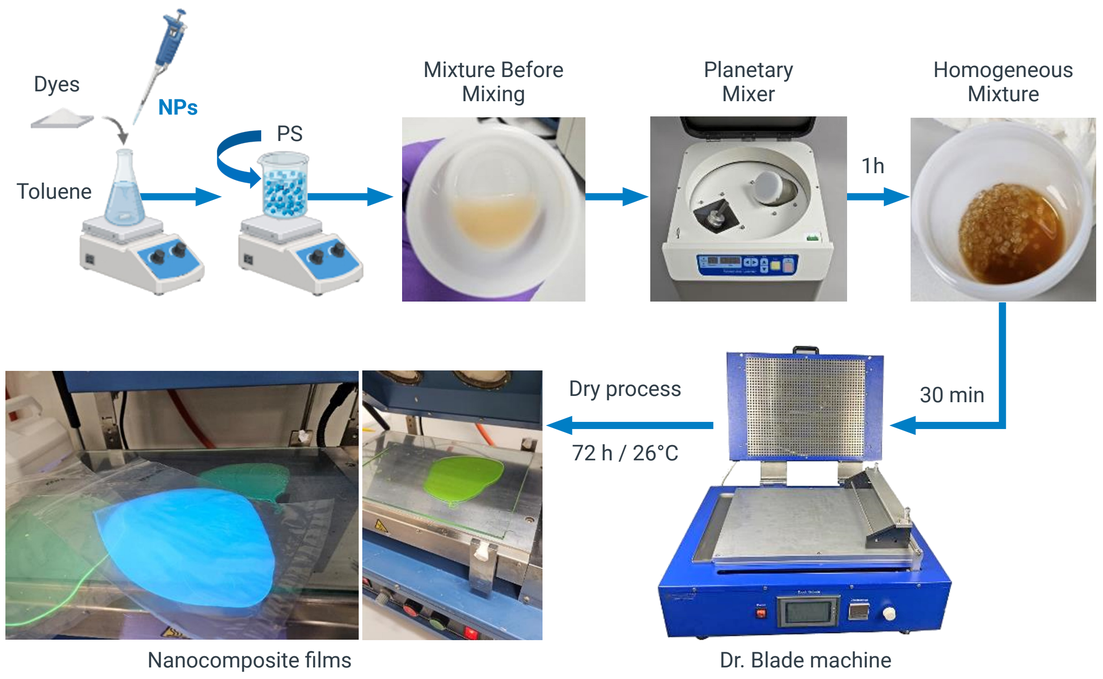
High Z number
High density



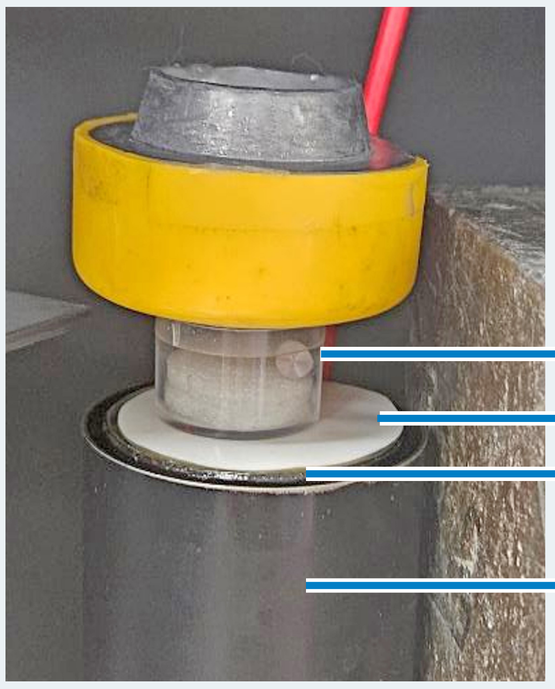
→ **High photoelectric effect: improvement of γ/matter interaction**

Experimental set-up

Nanocomposite films preparation



Scintillation set-up

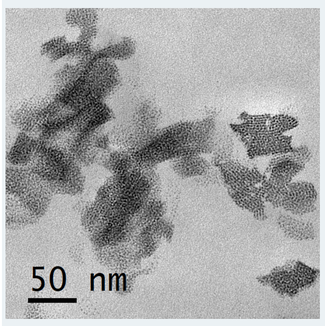


^{241}Am source – 1.69 MBq
Tension: 1600V
Time acquisition: 3600 s

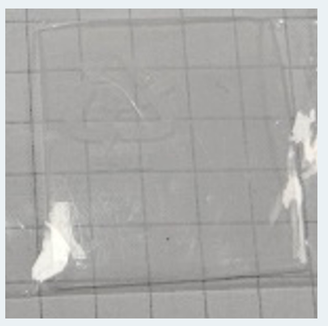
Results

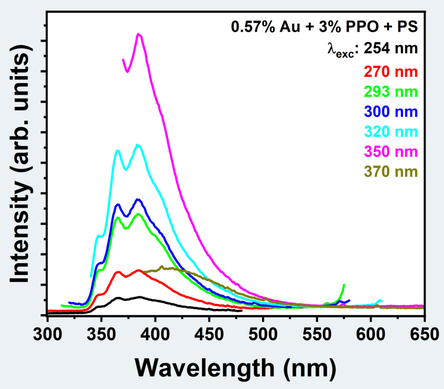
Au loaded nanocomposite

TEM image of Au NPs



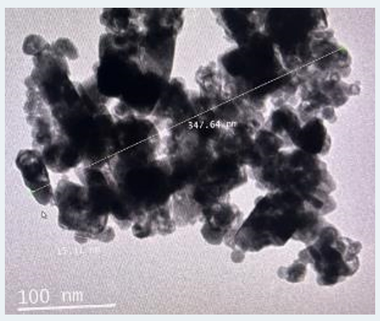
0.57 % Au NP + PPO + PS





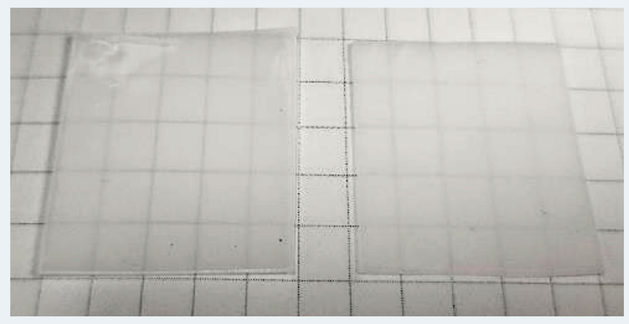
Bi loaded nanocomposites

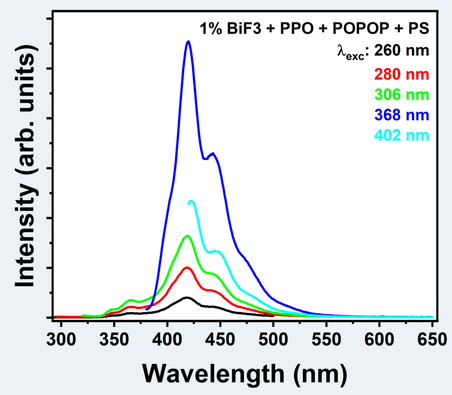
TEM image of BiF3 NPs



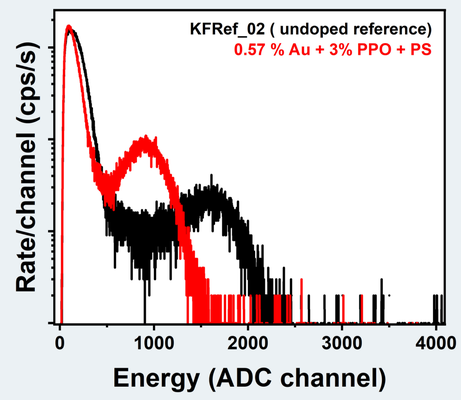
1% BiF3 NP + PPO + POPOP + PS

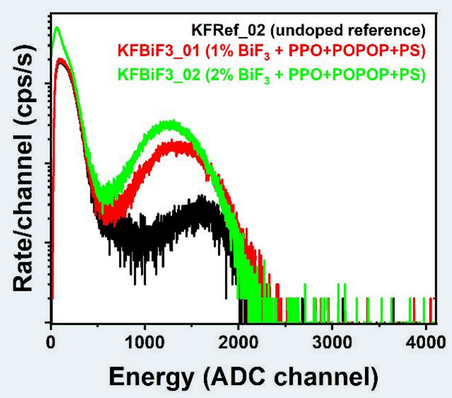
2% BiF3 NP + PPO + POPOP + PS





^{241}Am Pulse Height spectra





	KFRef_02 (3%PPO + 0.03% POPOP + PS)	0.57% Au NPs + 3% PPO+PS	1%BiF_3 NPs +3% PPO + 0.03%POPOP + PS	2%BiF_3 NPs +3% PPO + 0.03%POPOP + PS
PE Position	1610	126	17657	46059
Counting rate/µm/s	0.0035	0.014	0.0269	0.0443
LY (%)	100%	57%	83%	79%

Conclusions & Perspectives

Transparent plastic scintillator nanocomposites (500 µm thickness) incorporating Au and BiF_3 nanoparticles were successfully developed. All samples preserved the characteristic emission of PPO/POPOP dyes. A reduction in light yield (LY) was observed upon nanoparticle incorporation, likely due to quenching effects, where excitons generated on the nanoparticles can be rapidly deactivated. In contrast, a significant enhancement in γ-ray interaction was achieved, with counting-rate increases of 3.6× for 0.57 wt% Au and up to 13× for 2 wt% BiF_3 compared to undoped EJ-200-type reference films. These results highlight the strong potential of such nanocomposites for gamma detection. Further optimization of nanoparticle loading in the polystyrene (PS) matrix could improve overall performance by balancing interaction efficiency and light yield.

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References

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2. Yu Hal, et al. “Fast Spectroscopic Gamma Scintillation Using Hafnium Oxide Nanoparticles–Plastic Nanocomposites”, Chem. Mater., 36, 1, 533-540 (2024).
3. H. Tsukahara and M. Koshimizu, “Development of LiGaO2 nanoparticle-loaded plastic scintillators for thermal neutron detection”, J Mater Sci: Mater Electron, 36, 1223 (2025).