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Extreme γ-ray radiation hardness and high scintillation yield in perovskite nanocrystals

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Radiation detection is of outmost importance in fundamental scientific research and applications including medical diagnostics, homeland security, environmental monitoring, and non-destructive inspection in industrial manufacturing. Lead halide perovskites (LHP) are rapidly emerging as high-Z materials for next generation of solution processable scintillators and photoconductors for ionizing radiation detection. To unlock their full potential as reliable and cost-effective alternatives to conventional scintillators, LHP urge to conjugate high scintillation yields with emission stability over prolonged exposure to high doses of ionizing radiation. To date, however, no definitive solution has been devised to suppress parasitic processes affecting the scintillation efficiency and resulting in undesiderable after-glows in LHP. Similarly, nothing is known of their radiation hardness for doses above a few kGy. Here, I demonstrate, for the first time, that CsPbBr3 nanocrystals (NCs) exhibit exceptional radiation hardness for 60Co gamma radiation doses as high as 1 MGy. Side-by-side spectroscopic and radiometric experiments further highlight that, despite their defect tolerance, scintillators based on standard CsPbBr3 NCs suffer from electron trapping in highly dense surface traps. This limitation is effectively overcome through a post synthesis surface fluorination treatment resulting in over 500% enhancement of the scintillation efficiency which becomes comparable to commercial scintillator crystals, while still retaining exceptional levels of radiation harness. These results have profound implications for the widespread of LHPs in radiation detection schemes for high-energy physics, nuclear monitoring, nuclear batteries and space-grade solar cells where high radiation hardness is critical for successful and long-running operation, as well as for ultra-stable scintillators in medicine, environmental/industrial monitoring and border control.

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