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Editorial: Perovskite and organic materials for radiation detectors

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Editorial on the Research Topic
Perovskite and organic materials for radiation detectors

The research of novel materials for the detection of ionizing radiation has grown rapidly in the last few years, driven by the increasing use of high-energy radiation in various domains of human society. This has stimulated the demand for radiation detectors with new capabilities and features. Perovskites and organic materials offer particular advantages over established technologies for such applications (mostly based on inorganic materials such as silicon, germanium, cadmium telluride, and cadmium zinc telluride), i.e., large area and potentially low-cost devices, lower operating power, materials grown using solution-based methods in place of traditional high-temperature melt crystal growth, high-Z materials for improved X- and gamma-ray detection efficiency, or materials which are specifically designed for efficient neutron detection. Further, they share the advantages of easy modification of their chemical, physical, and electronic properties through conventional wet chemical processes. This enables the fine-tuning and control of the detection performance of the detection device [1, 2].

Organics and perovskites can be employed in ionizing radiation detection through both direct and indirect detection approaches. For the indirect detection mode, the incoming ionizing radiation generates an electrical output signal in a two-step process: in the first step, a scintillator transforms the ionizing radiation into a visible photon and in the second step, a photodetector converts it to an electrical signal. For the direct detection mode, typically carried out by a semiconductor material, the incoming ionizing radiation is directly transduced into an electrical output signal [3]. Indeed, several significant works have demonstrated the successful use of organics and perovskites both as scintillators and/or UV/is photodetectors as indirect detectors and also as semiconducting active media in solid-state direct detectors [4–6].

The papers collected on this Research Topic well-represent the innovative approaches in the development of ionizing radiation detectors through the use of this novel class of materials.

He et al. provide an insightful review of the recent developments in band-engineering strategies to improve and control perovskite-based direct X-ray detectors. The authors present the most effective paths followed by researchers to reach high sensitivity and low detection limits, with a particular focus on material modification by cationic interstitial doping and device heterojunction design to ensure the suppression of dark current and the increase of sensitivity. Hybrid organic/perovskite devices have been developed, in which the introduction of polymers or small organic molecules, combined with perovskite

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nanocomposites as well as 2D/3D perovskite heterojunction design, results in improved detector performance thanks to an efficient blocking of ion migration and enhanced charge collection efficiency. At the same time, the nature of the metal-perovskite electric contact, either ohmic or Schottky, is essential for radiation detection. Therefore, it is important to study the charge transfer and the trapping processes at this interface to achieve a reliable and high-performance detector.

With their work, Bruzzi et al. introduced a novel application in direct radiation detection by perovskite-based devices, namely, the detection of proton beams, envisaging their utilization for real-time monitoring during proton therapy. The capability to detect charged particles has not been widely explored so far by the research community. Therefore, this work represents an important contribution to feeding this Research Topic. Flexible thin film-based perovskite detectors show a real-time response under a test beam with proton energy in the range of 100–228 MeV, exhibiting good linearity of the response with proton flux and current extraction.

Besides direct detection, the development and characterization of perovskite nanocomposites as scintillators in an indirect X-ray detection system are presented here by O'Neill et al. The authors produced scintillating disks by dispersing commercial $CsPbX_3$ (X = Cl or Br) nanoparticles in an insulating polymeric matrix such as PMMA and characterized their optical properties together with their radioluminescence when exposed to X-rays. Interestingly they found an increase in the Stokes shifts on the nanoparticle-loaded PMMA disk with respect to the dispersion, leading to a reduction of self-absorption of the scintillation light. They also demonstrated that the light yield increases with the increasing bromine ratio, while the presence of chlorine emerged as detrimental to light emission intensity and X-ray sensitivity. The high potential of perovskite scintillating nanocomposites and the cruciality of their composition are strengthened by this study, providing important hints to optimize detector performance.

In conclusion, the work of this Research Topic contributes to a timely overview of recent development trends in organic and perovskite materials for both direct and indirect detection of ionizing radiation, with a particular focus on the roles of chemical composition, arrangement of the active layer, and device structure design to achieve improved functionalities.

Author contributions

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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