Luminescent materials: from inorganic to hybrid nanoscintillators for medical diagnostic and therapy

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The great advantage of nanomaterials is the tunability of their physico-chemical properties and of their emission features through the control of their structure, morphology, and doping. In biomedical applications exploiting ionizing radiations, such as in radiotherapy (RT) as well as in total body medical imaging techniques, the scintillation performance (intensity and fast timing features), should be optimized towards the improvement of the therapeutic and diagnostic results. The nanoscintillators (NS) are mostly inorganic nanomaterials featuring high atomic number and density that enable the efficient interaction with the ionizing radiation. Recently, a new class of hybrid NS has been coming into the spotlight. Hybrid NS are composed of an inorganic dense scintillating nanoparticle coupled to an organic fast emitter or a cancer killing agent (photosensitizers). Hybrid NS can also be embedded in a polymeric host for the creation of scintillating composite.[1] The exploitation of hybrid NS as co-adjuvant in the established RT protocols would allow to reduce side effects and cancer recurrence. The use of NS, coupled with highly emissive and fast dyes, would result in the upgrading of the final image resolution in medical diagnostic (down to the millimetric range) for early-stage cancer diagnosis. We present the investigation on Hf oxide nanoscintillators (HfO_2) doped with Europium ions (Eu) for biological applications. In the in vitro imaging field, we demonstrate that Eu:HfO_2 can be used as non-toxic, highly stable probes for cell optical imaging and, potentially, as radiosensitive materials for clinical treatments.[2] We present a successful case of biocompatible chrysotile NS functionalized by photosensitizers for RT. The optimized design of the NS surface, of the composition, as well as of the spatial arrangement of dyes allow to boost the performance of NS.[3] Lastly, we propose the preliminary results obtained on HfO_2-based hybrid composite NS for fast timing medical techniques. The high density of Hf enhances the interactions of the X-rays. The investigation on the luminescence/scintillation performance is performed in relation to the surface functionalization and optimization of the polymeric matrix loading to maximize the energy sharing mechanism and boost the luminescence and timing qualities of this hybrid composite.

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