Nanoscale Hafnium for Radiation Therapy and 'Color' CT Imaging

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High-Z based nanomaterials can act as effective radiosensitizers in radiation therapy (RT) and as contrast agents for computed tomography (CT) imaging. It has been a long-standing challenge to counter the effects of radiation in RT and CT with the added disadvantage of poor soft tissue contrast and lack of material discrimination by CT to effectively utilize metal-based contrast agents. Recent emergence of photon counting CT (PCCT) allows material decomposition, artifact correction and brings a universal, quantitative set of "colors" to CT scans. Combined with imaging probes based on metals with appropriately placed K-edge energy within the X-ray bandwidth of CT, molecularly targeted 'multicolor' agents offer spatially specific and quantifiable information facilitating better diagnosis and therapeutic management of diseases. Hafnium-based nanoparticles provide unique advantages by reducing overall patient radiation burden in RT and their well-positioned k-edge absorption energy (65.3 keV) provides strong attenuation and minimal overlap across the clinically relevant CT tube potential (20-120 kVp).

In this poster, we demonstrate the utility of novel hafnium-based nanoparticles as radiosensitizing agents in RT for colon cancer treatment as well as their potential as targeted contrast agents for quantitative detection of osteoarthritis progression (OA) using color PCCT imaging. In the former, the nanoscale materials elevate the magnitude of radiation-induced cellular damage due to the comparatively greater energy attenuation of hafnium versus other elements common in biological systems. In the latter, PCCT imaging combined with targeted hafnium-oxide nanomaterial enabled clear 3D visualization of the bone and cartilage degradation at varying stages of OA progression by quantifying the biomarker expression levels based on individual bound nanoparticle concentration. These newly developed hafnium-based nanomaterials are expected to pave the way towards unique theranostic applications that can transform disease diagnosis and management without increasing the complexity of clinical workflows.