Emerging Trends in Photon Counting CT Imaging and Synergistically Developed Ligand Directed Nanoprobes

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Nanoscale structures offer unprecedented potential in pre-emptive medicine covering early detection, diagnosis and therapy of diseases.[1-16] Pan Lab@Illinois (and now @UMaryland) advances translatable technologies for human health by uniquely merging 'molecule making' and 'device making' through innovations in molecular imaging,[1-3,10, 12, 14-16] drug delivery,[4,5,7] point-of-care biosensing[8,9,11] and machine learning tools. [9-13]

Computed tomography (CT) is one of the most commonly used radiology technologies in the clinics today.[16] Numerous improvements have been proposed to make this technique more powerful with enhanced signal sensitivity, rapid image acquisition and faster reconstruction. K-edge imaging is the newest progression in this area, which boosts traditional CT images with the capability to image and quantify certain elements based on their characteristic K-edge energies within the bandwidth of CT. If combined with sensitive probes, this technique is anticipated to overcome the relatively low inherent contrast within soft tissue and distinguish the high attenuation of contrast-enhanced targets.

Effective probes designed for K-edge imaging must incorporate very high concentration of elements. Useable elements found within the X-ray energy bandwidth are typically heavy metals with possible toxicities in their free form, therefore whole-body bioelimination is a prerequisite consideration in the design of these agents. This talk will discuss distinct approaches developed in our laboratories for imaging biological targets, e.g. atherosclerosis, bone disease and cancer.[6, 14-16] Seminal results obtained with MARS and Philips spectral photonn counting CT indicate that molecular K-edge imaging with these probes, which was developed to complement the newest advancement in CT imaging technology, clearly enhances traditional CT images with the capability to image and quantify certain elements based on distinctive K-edge energies. We anticipate that the synergistic development of the probes and 'color' CT will revolutionize radiographic imaging field soon.

References

1. Adv. Funct. Mater. 2019, 1902466.
2. ACS Nano. 2019, 13(7):7690-7704.
3. Adv. Funct. Mater. 2019 (Early View) https://doi.org/10.1002/adfm.201904936
4. Proc Natl Acad Sci U S A. 2018; 115(32): 8087-8092.
5. J Med Chem. 2018; 61(23):10739-10752.

6. Biomaterials. 2018; 181:252-267.
7. Mol Cancer Ther. 2018; 17(1):119-129.
8. Biosens Bioelectron. 2018; 120:77-84.
9. Biosens Bioelectron. 2018; 110:132-140.
10. J Am Chem Soc. 2017; 139(5):1746-1749.
11. Anal Chem. 2017; 89(3):2107-2115.
12. Adv. Funct. Mater. 2016; 26: 8031-8041.
13. Sci Rep. 2015; 5:16011.
14. ACS Nano. 2012;6(4):3364-70.
15. Angew Chem Int Ed Engl. 2010;49(50):9635-9.
16. J Am Chem Soc. 2009;131(42):15522-7.