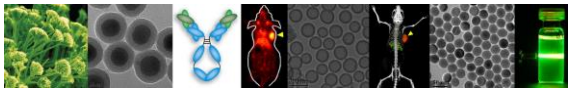

Intrinsically Radiolabeled Nanoparticles: An Emerging Paradigm

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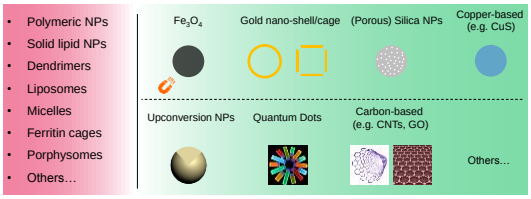
University of Wisconsin - Madison, USA

Email: wcai@uwhealth.org

2015 AAPM Annual Meeting, Anaheim, CA
July 15, 2015

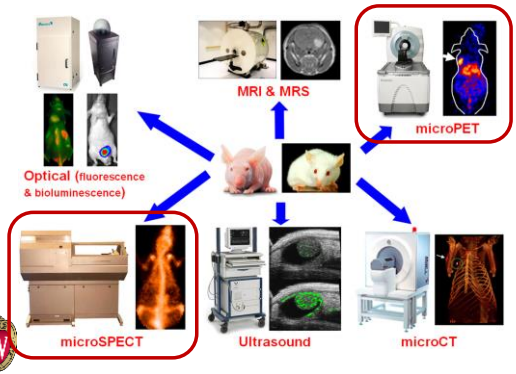
Nanoplatforms for Cancer Theranostics



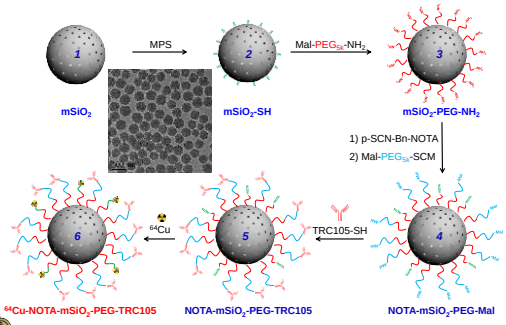
- Different nanoplatforms (organic and inorganic)
- Step-by-step surface modifications
- Potential to revolutionize diagnosis and treatment

Chen et al., J Nucl Med, 2014.

Small Animal Molecular Imaging



Functionalization of MSN for Theranostics

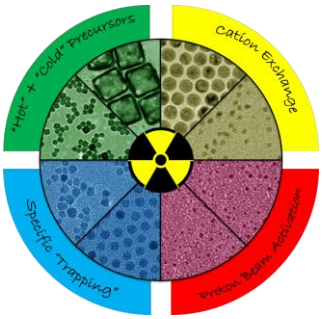


MSN: mesoporous silica ($mSiO_2$) nanoparticles

Chen, Hong, et al., ACS Nano, 2013.

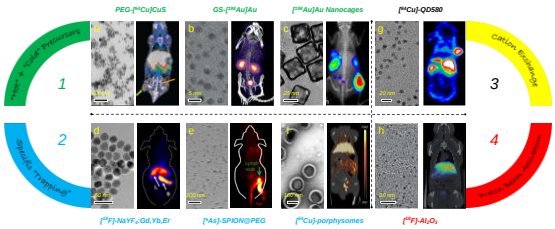
Intrinsically Radiolabeled Nanoparticles

Shreya Goel



Goel et al., Small, 2014.

Intrinsically Radiolabeled Nanoparticles



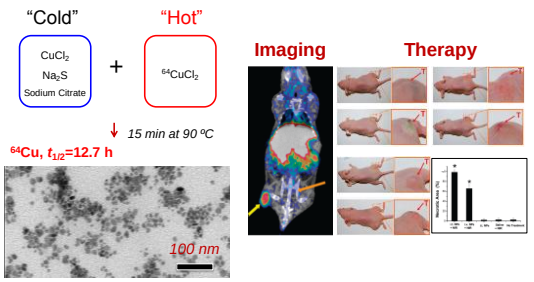
- Chelator-free (or no additional step) radiolabeling
- Takes advantages of the physical/chemical properties of rationally selected nanoparticles for radiolabeling
- Could offer an easier, faster and more specific radiolabeling possibility

Goel et al., Small, 2014.

Commonly Used Strategies

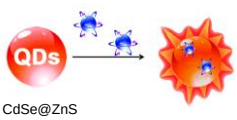
- Hot-plus-Cold Precursors
- Cation Exchange
- Proton Beam Activation
- Specific Trapping

Hot-plus-Cold Precursors: [^{64}Cu]CuS



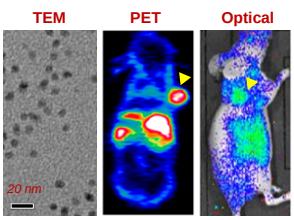
Zhou et al., J Am Chem Soc, 2010.

Cation Exchange: [^{64}Cu]QD580



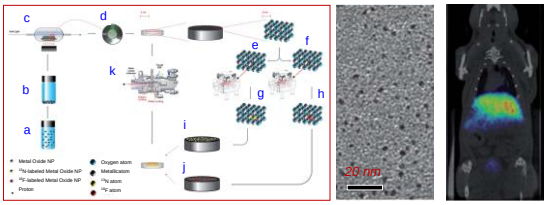
CdSe@ZnS

- ^{64}Cu replace Zn and Cd
- High stability in vivo
- Self-illuminating property
- PET/optical dual-modlity



Sun et al., J Am Chem Soc, 2014.

Proton Beam Activation: $[^{18}F]Al_2O_3$

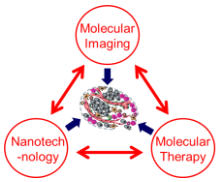


- Al_2O_3 was activated by protons to get $[^{18}F]$-Al_2O_3
- Nanostructure was found intact
- In vivo biodistribution study

Perez-Campana et al., Analyst, 2012.

Specific Trapping

Cai Research Group



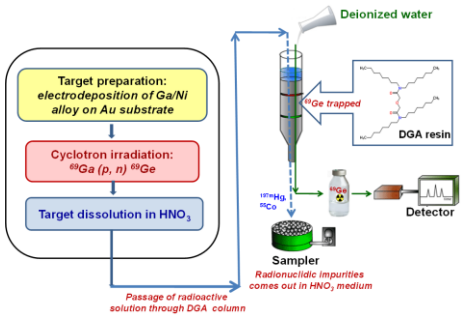
http://mi.wisc.edu

UW Cyclotron Group

- In > 40 years, UW - Madison cyclotron group produced >100 isotopes (mostly PET, led by Prof. R. Jerry Nickles)
- Current Director: Dr. Todd E. Barnhart

PET/MR Scanners

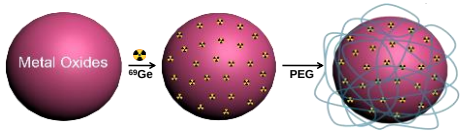
^{69}Ge ($t_{½}$ = 39.05 h)



Hard to label due to existence of ^{69}Ge as complex ions in aqueous medium

Chakravarty, Valdovinos, Chen et al., Adv Mater, 2014.

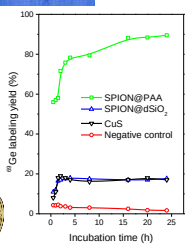
Labeling Inspired by ^{68}Ge/^{68}Ga Generators



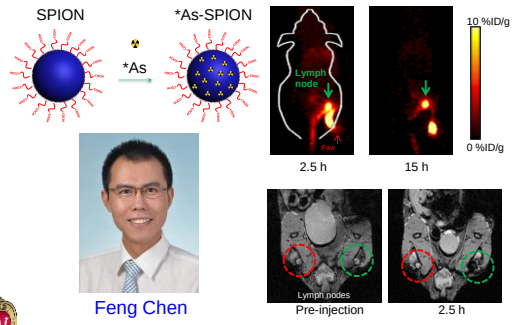
Chakravarty, Valdovinos, Chen et al., Adv Mater, 2014.

PET/MRI in Normal BALB/c Mice

Rubel Chakravarty



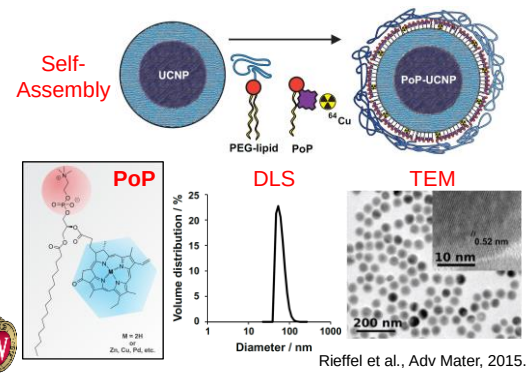
Chelator-Free Synthesis of PET/MRI Agent



Feng Chen

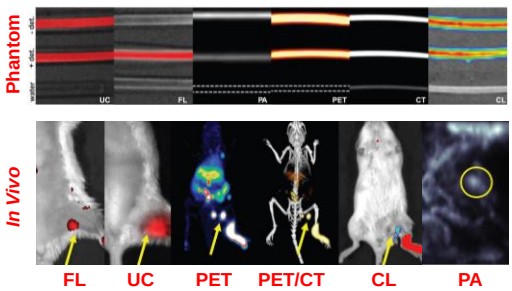
Chen, Ellison, et al., Angew Chem Int Ed Engl, 2013.

Hexamodal Imaging with Nanoparticles



Rieffel et al., Adv Mater, 2015.

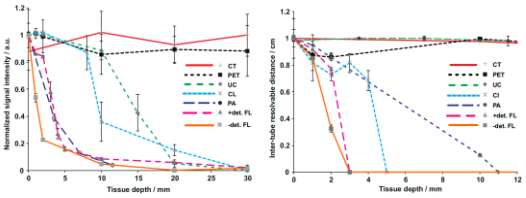
Hexamodal Imaging with Nanoparticles



FL: fluorescence UC: upconversion CT: computed tomography
PET: positron emission tomography CL: Cerenkov luminescence
PA: photoacoustic

Rieffel et al., Adv Mater, 2015.

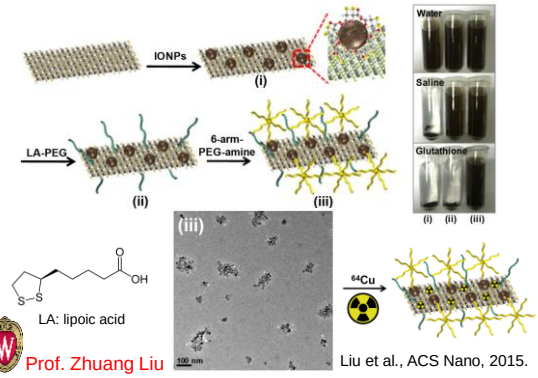
Direct Comparison of Imaging Techniques



- Self-assembly of 2 active imaging components (PoP & UCNPs)
- FL (and PA) provided unique information on the self-assembly status
- PET and CT provided the deepest imaging capabilities
- CL and UC imaging was effective for imaging at intermediate depths, significantly better than FL
- Such simple yet higher-order multimodal imaging agents can facilitate the development of integrated imaging systems

Rieffel et al., Adv Mater, 2015.

Iron Oxide Decorated MoS_2 Nanosheets

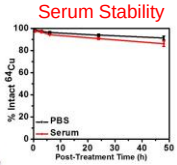


Prof. Zhuang Liu

Liu et al., ACS Nano, 2015.

Non-Invasive Quantitative PET Imaging

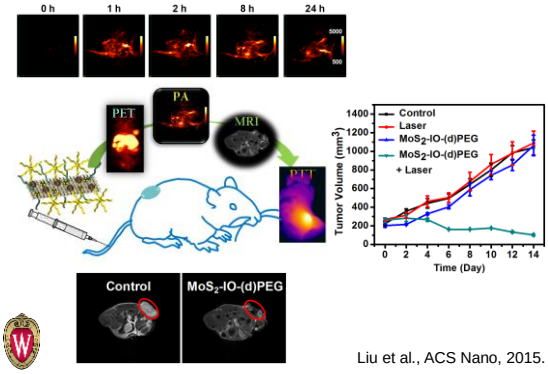
Serum Stability



Sixiang Shi

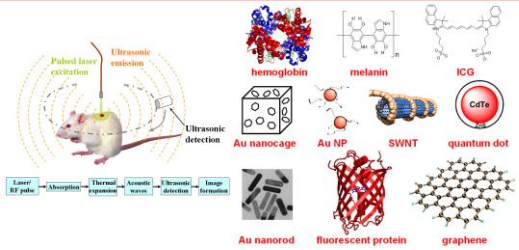
Liu et al., ACS Nano, 2015.

Multimodal Image-Guided PTT



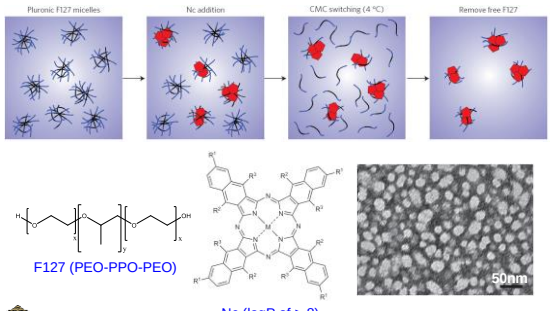
Liu et al., ACS Nano, 2015.

Photoacoustic Tomography (PAT)



- Deeper signal penetration than other optical methods
- Inherently real-time imaging, suitable for imaging dynamic processes without sacrificing spatial resolution
- In the USA alone, digestive diseases are implicated in upwards of 100 million ambulatory care visits annually

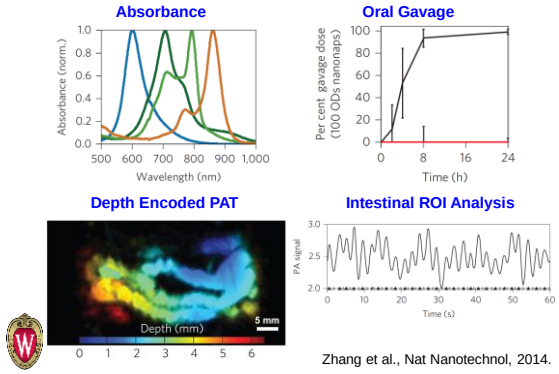
Kinetically Frozen Micellar Naphthalocyanines



Prof. Jonathan F. Lovell
University at Buffalo

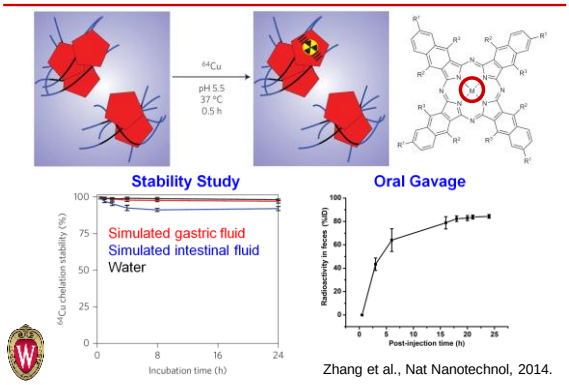
Zhang et al., Nat Nanotechnol, 2014.

Multispectral Nanonaps & PAT Imaging



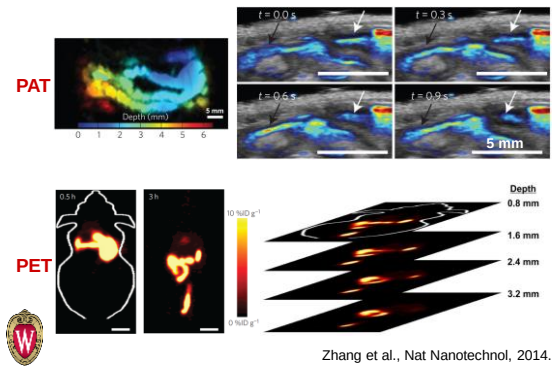
Zhang et al., Nat Nanotechnol, 2014.

Seamless ^{64}Cu-Labeling



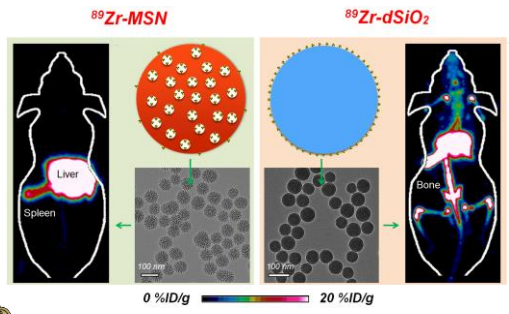
Zhang et al., Nat Nanotechnol, 2014.

Dual-Modality In Vivo PAT/PET Imaging



Zhang et al., Nat Nanotechnol, 2014.

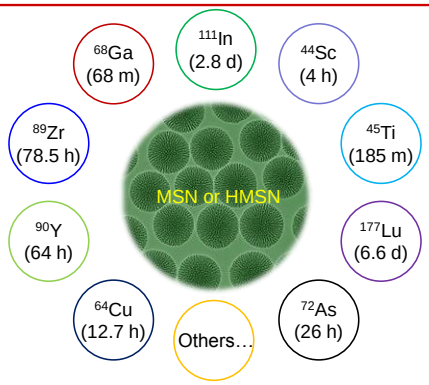
Chelator-Free ^{89}Zr-Labeling of MSN



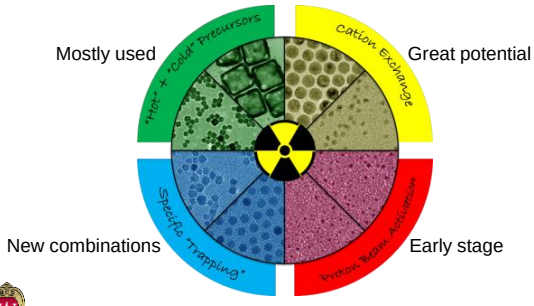
MSN: mesoporous silica ($mSiO_2$) nanoparticles

Chen, Goel, et al., ACS Nano, Revision.

MSN: A Versatile Radiolabeling Platform



Intrinsically Radiolabeled Nanoparticles



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