Mixed nanoparticle matrix materials for mass spectrometry imaging of small molecules and lipids

Angela Hudock [1], Cameron Shedlock,[1] Mia Gianello,[1] Caitlin Tressler,[2] Kristine Glunde,[2,3] and Katherine A. Stumpo[1,2,4]

[1] Department of Chemistry, University of Scranton, Scranton, PA 18510, [2] The Johns Hopkins University School of Medicine, Russell H. Morgan Department of Radiology and Radiological Science, Division of Cancer Imaging Research, Baltimore, MD 21205, [3] The Sidney Kimmel Comprehensive Cancer Center, The Johns Hopkins School of Medicine, Baltimore, Maryland 21205, [4] Bruker Scientific, Billerica, MA 01821

Objectives

- Determine the level of ionization achieved with a combined Ag/Au nanoparticle matrix on various small molecules
- Use pneumatically sprayed AgNPs and AuNPs separately in order to determine the unique chemical signals they maximize.

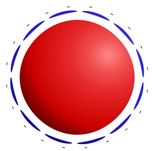


Figure 1. Cartoon of citrate-capped gold nanoparticles that facilitate ionization of small molecules in LDI-MS.

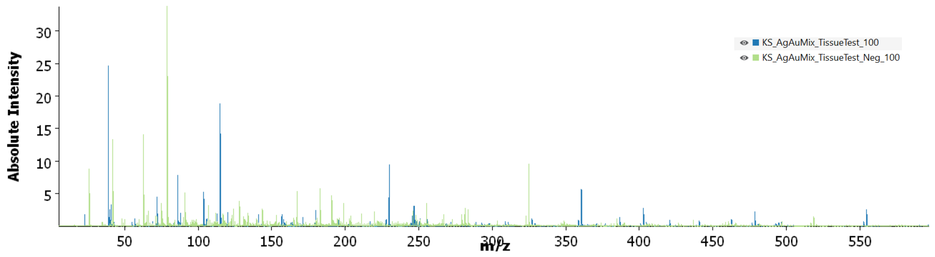
Background

A perpetual goal of mass spectrometry imaging (MSI) is to maximize ion signal and reduce matrix interferences. Traditional organic matrices suffer from high chemical noise in the low mass region and can make it difficult to distinguish analyte peaks from noise. Recent research using gold nanoparticles (AuNPs) has demonstrated their ability to ionize small molecules with limited matrix interference in the low mass region. Silver nanoparticles (AgNPs) are known to favorably ionize lipids. Combinations of matrix materials, including AuNPs, AgNPs, and organic matrices have been pneumatically sprayed on various mouse tissues (heart, pancreas, GI tract, kidney, brain) to demonstrate the broad applicability of these alternative materials to tissue imaging and the increase in molecular class accessible for one matrix preparation.

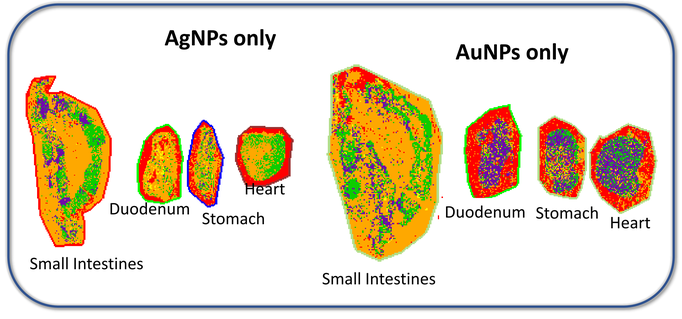
Experimental Methods

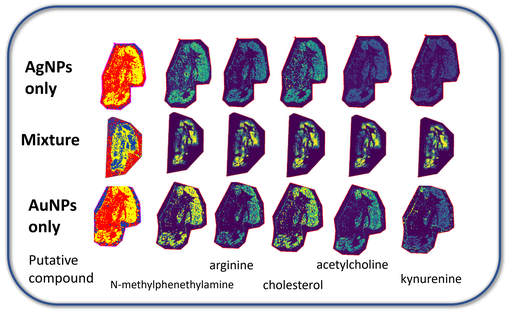
MSI experiments were performed on fresh frozen mouse organs. Tissue was sectioned at 10 um thickness and thaw mounted onto ITO slides at -16°C. AuNPs, AgNPs (Ted Pella, Redding, CA) and traditional matrices (e.g., DHB, CHCA, DAN) were sprayed onto tissue sections using an HTX M5 Imaging Sprayer. All imaging experiments were performed on Bruker Rapiflex MALDI TOF/TOF in reflectron positive mode at various pixel sizes ranging between 5 – 200 microns. Sample preparation consisted of AuNPs alone, AgNPs alone, and mixed Au/AgNPs. Data analysis was performed using SCiLS lab and MetaboScape (Bruker Scientific, Billerica, MA).

Results: Average spectra



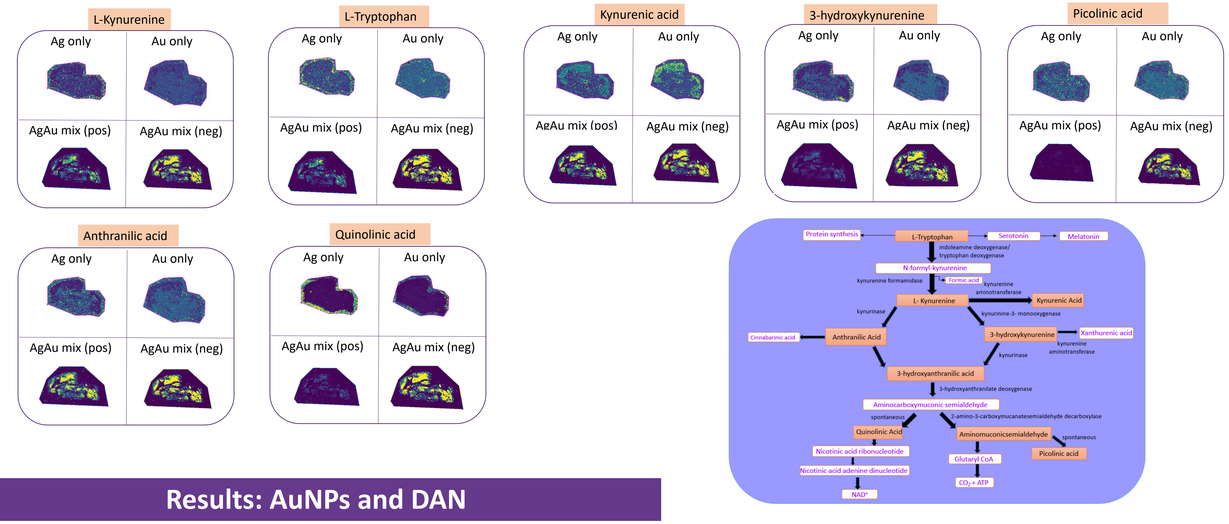
Results: Comparison of NPs



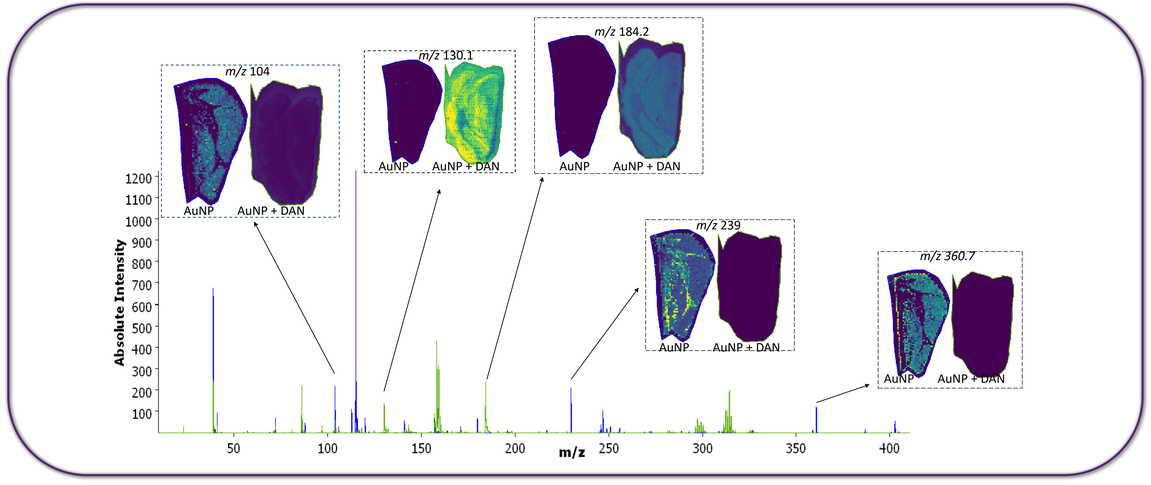


- Mouse organ tissue sections with comparative analysis for silver nanoparticles, gold nanoparticles, and mixed nanoparticles

Results: Application to a Pathway



Results: AuNPs and DAN



- Mouse brain sprayed with 1 pass of AuNPs (left of each pairing) or 1 pass of AuNPs then 2 passes of DAN (right of each pairing)
- Enhancement of lighter organic acid spray when layered with AuNPs
- Different ionization profiles for each preparation

Conclusion And Future Directions

- AuNPs can benefit from additional preparations including with AgNPs and layered with organic matrices.
- Compounds from a typically difficult to access pathway are observed in multiple organ systems with new matrix combinations.

References

Stumpo, Katherine A and McLaughlin, Nolan, *Method of Comprehensive Neurotransmitter Detection using Citrate-Capped AuNPs for Imaging Mass Spectrometry,* U.S. Patent Pending #62/935,882, **Nov 15, 2019.**

McLaughlin, Nolan; Bielinski, Tyler; Tressler, Caitlin; Barton, Eric; Glunde, Kristine; Stumpo, Katherine A. "Pneumatically Sprayed Gold Nanoparticles for Mass Spectrometry Imaging of Neurotransmitters" *JASMS*, **2020**, 31, 2452-2461.

Acknowledgements

This work was supported by the Chemistry Department and the MAGIS Honors Program in STEM at the University of Scranton. The AIMS Core Facility (Drs. Cay Tressler and Kristine Glunde) at Johns Hopkins University is acknowledged for instrument usage.