Development of New Soft Ionization Mass Spectrometry Approaches for Spatial Imaging of Complex Chemical and Biological Systems

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Project 2.2; October 2010 – September 2013

Pacific Northwest NATIONAL LABORATORY

Proudly Operated by Battelle Since 1965

Purpose

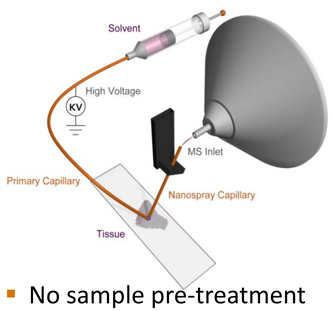
- Multimodal chemical characterization of microbial biofilms focused on understanding
  - Extracellular electron transport of interest to bioremediation
  - Metabolic exchange between bacterial colonies
- Develop novel mass spectrometry-based chemical imaging capabilities broadly applicable to multiple chemical and biological systems

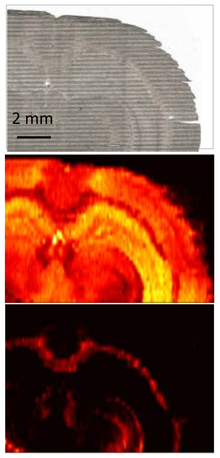
Key Successes

- Developed unique tools for imaging biological materials with high specificity and sensitivity using mass spectrometry
- 7 published papers, 4 submitted, 3 in preparation
- Our mass spectrometry imaging program is recognized by the scientific community

Research Accomplishments

Developed nanospray desorption electrospray ionization mass spectrometry (nano-DESI) as a robust tool for chemical imaging of biological materials

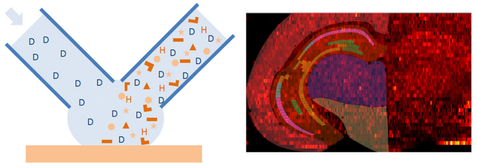




- No sample pre-treatment
- Sampling of living microbial colonies
- High sensitivity
- High spatial resolution (~10 μm)

Laskin J et al. 2012. *Analytical Chemistry* 84(1):141-148.
Lanekoff IT et al. 2013. *Analytical Chemistry* 85(2):882-889.
Lanekoff IT et al. 2012. *Analytical Chemistry* 84(19):8351-8356.

Developed unique approaches for in situ quantification of metabolites in nano-DESI imaging experiments.



Quantitative imaging of nicotine in rat brain tissue sections with subfemtomolar sensitivity achieved by by doping the working solvent with an isotopically labeled standard.

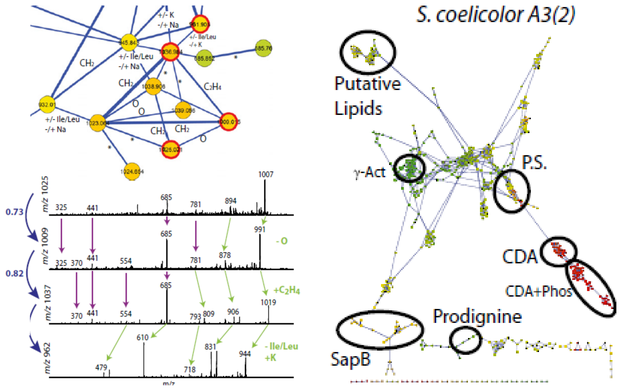
Lanekoff IT. 2013. *Analytical Chemistry* 85(2):882-889.

Demonstrated for the first time spatial profiling of chemical gradients of living bacterial colonies

- Detailed characterization of metabolites produced by *Synechococcus* sp. PCC 7002 colonies
- Salt-tolerant analysis
- Only two molecules, sucrose and glucosylglycerol, are secreted onto agar
- Their chemical gradients depend on the age of the colony

Lanekoff IT. 2013. *Analyst* 138(7):1971-1978.

Developed molecular networks—a unique approach for facile classification and identification of hundreds of metabolites in living bacterial colonies



Watrous JD et al. 2012. *Proceedings of the National Academy of Sciences USA* 109(26):E1743-E1752.

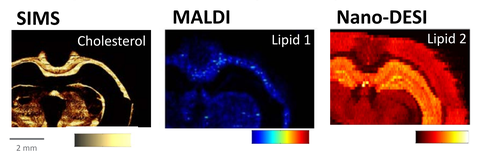
High spatial and mass resolution C_{60} secondary ion mass spectrometry (SIMS) – a unique tool for chemical imaging of biological materials

Designed and built world's first **C_{60} SIMS FT-ICR MS**. Unique capabilities for imaging biological samples:

- High mass accuracy (<1 ppm)
- High mass resolving power ($m/\Delta m_{50\%}$ >3,000,000)
- Tandem MS capabilities

Smith DF. 2011. *Analytical Chemistry* 83(24):9552-9556.
Smith DF et al. 2013. *Analytical Bioanalytical Chemistry,* In press.

Conducted first multimodal imaging of biological materials using nano-DESI, SIMS, and matrix-assisted laser desorption/ionization (MALDI)



Complementary characterization of lipids and metabolites using different imaging modalities

Next Steps

Four proposals submitted to National Institutes of Health (NIH) are under review, one is in preparation. Overall, we participated in 7 proposals submitted to NIH.

Three proposals for Exploratory Collaborations between EMSL and the Joint Genome Institute are under review

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