Imaging Mass Spectrometry: Advancing systems approaches for biological sciences

Ravi Ramesh Pathak, Ph.D.
Managing Editor, Journal of Postdoctoral Research
Email: ravi.pathak@postdocjournal.com

The impact of technology in modern science is unequivocal. As scientific thought and design moves from traditional reductionism towards holism, advances in technology have altered the landscape of modern science. The modern systems biology approach models the dynamics and structure of biological systems. Implementing systems biology models in conjunction with imaging provides a way to refine understanding of biological systems

Modern imaging technologies allow visualization of multi-dimensional and multi-parameter data to measure physical parameters and acquire temporal insight on biological function. One such exciting imaging technology is mass spectrometry (MS). From the early Calutron mass spectrometers used to separate uranium isotopes during the Manhattan project, to present day instrumentation that enables imaging modalities, MS technology has come a long way. This evolution was a culmination of decades of scientific research and discoveries[1]. For instance, the invention of Cathode-ray equipment drove the discovery of X-ray, which in turn led to development of computerized tomography (CT) scans. Concepts like Zeeman splitting (effect of splitting a spectral line into several components in the presence of a static magnetic field) were applied towards the development of 2D magnetic resonance (NMR), and then to magnetic resonance (MR) imaging. To put this into perspective, the developmental stages of MS technology have progressed from applications based on physics to chemistry, and now derive from biological/clinical applications.

The most recent advancement in imaging is the matrix-assisted laser desorption/ionization imaging mass spectrometry (MALDI IMS). In this method images are reconstructed from the mass spectrum charts using thousands of spots from biological tissues to show the distribution of various molecules. It has rapidly emerged as a versatile tool for multiple applications including pharmacokinetic monitoring, pharmacotoxicology, and performing metabolome-mapping to monitor metabolic behavior of thousands of molecules. The ability to use minute amounts of clinical biopsies to obtain and perform accurate metabolomics analysis is a major advantage of this method and it is hardly surprising the mass microscope is beginning to assume its place next to CT, positron emission tomography (PET), and magnetic resonance imaging (MRI) in many health care institutions.

Dr. Boone Prentice, the recipient of the March Postdoc of the Month Award, has worked extensively on MALDI IMS, and provides edifying insight on the biological and clinical relevance of this technology in his featured article entitled, "The Need for Speed in Matrix-Assisted Laser Desorption/Ionization Imaging Mass Spectrometry[2]. Outlining the basic methods of sample preparation, Dr. Boone goes on to describe an experimental setup to image rat brain and details the current applications and limitations of the technique. It is critical for an investigator to acknowledge that any technology is only as good as the biological/clinical question posed. Dr. Boone rightly acknowledges this in his article, and encourages users to focus on the biological questions to provide clinically relevant time scales to advance the technology.

IMS has emerged as a frontier technology for medical and clinical applications thanks to the tireless and persistent efforts of scientists such as Dr. Boone. Like its predecessors it is by no means in its final form. The next series of innovations in the area will deal with challenges to improve resolution and allow 3-D spectral imaging. The next decade promises to be an exciting one in terms of the development of these and other innovations that will revolutionize biological and medical sciences.

Reference:

1. Maher, Simon, Fred PM Jjunju, and Stephen Taylor. "Colloquium: 100 years of mass spectrometry: Perspectives and future

trends." *Reviews of Modern Physics* 87.1 (2015): 113.

2. Prentice M, Boone and Caprioli M, Richard The Need for Speed in Matrix-Assisted Laser Desorption/Ionization Imaging Mass Spectrometry. Journal of Postdoctoral Research, Vol. 4, No. 3, 2016, 3-13. http://doi.org/bdh4