

Molecule Specific Imaging and Analysis in Biology: What are the Challenges and The Important Applications

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It is becoming clear that mass spectrometry is a powerful tool for the analysis and imaging of complex organic and biological systems. The discussion session "Meeting the Challenge of Molecule Specific Analysis and Imaging in Organic and Bio-Systems" will attempt to illustrate the challenges to be met in mass spectral imaging and analysis of biological samples. Some of these challenges will be discussed here including the issues of sensitivity needed to obtain high resolution images at the cellular and subcellular level, information that can be obtained with alternative techniques and where will they be better vs. when SIMS will be better suited to the need, and finally the need for depth profiling and mechanisms to achieve this goal for cellular samples.

There are a myriad of biological applications that mass spectrometric imaging can be used for in biology. Nowhere is this more important than in small samples of tissue, single cells, and sub-cellular organelles. Cell membranes are among the most poorly understood structures of cells as the phospholipids, steroids, glycans, glycolipids, and glycoproteins that make up much of the membrane structure are difficult to detect by most techniques. In addition, the chemical diversity of the lipids alone is enormous with hundreds of permutations of the aliphatic tail groups possible and, when the high variability of glycosylation is added, this becomes a problem of extreme complexity. Mass spectrometry provides potentially great mass resolution and high detectability, but this technique has been limited traditionally in its spatial resolution. Advances in mass spectral imaging techniques developed as well as techniques on the horizon show promise in this area - especially in analysis of inorganic ions, phospholipids, and vitamin A. Inorganic ions have been imaged in cells with high success, phospholipids have been imaged with success in specific applications and these techniques are under constant development, but small molecules have not been explored heavily to date, Biologists of many ilk would welcome methods to spatially resolve and determine concentration of molecules like cyclic AMP, inositol, glucose, ATP, thioesters, and small drugs molecules (i.e. cancer drugs) to name a few. It would also be extremely interesting to have the ability to image small transmitters in vesicles and the molecular machinery inside the nucleus, mitochondria, golgi and endoplasmic reticulum. These are lofty goals, but mass spectrometry provides a promise of selectivity, sensitivity, and spatial resolution to obtain many of the answers to key questions in cell biology. Increased sensitivity and the resulting increase in spatial resolution, depth profiling, development of simultaneous complementary techniques, and depth profiling will all make this a break-through area in the decade to come. A weakness of mass spectral schemes is that samples must be examined in vacuum and, hence, a final challenge is to develop schemes to capture temporal snapshots of events taking place in a cell.