Laser Ablation Electrospray Ionization (LAESI) Mass Spectrometry for Direct Analysis and Imaging of Cells and Tissues

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Abstract: Direct mass spectrometric analysis of diverse biological samples has been demonstrated using a novel ionization technique called laser ablation electrospray ionization (LAESI). LAESI is based on mid-IR ablation of water rich samples followed by electrospray ionization of molecules from the ejected plume. In this talk, applications of LAESI are presented for various tissue samples and individual plant and animal cells. For example, in mouse and rat brain tissue analysis ~200 different ions are found in the LAESI mass spectra. Using accurate mass measurements, tandem mass spectrometry and isotope distribution patterns small metabolites and lipids are assigned to these ions. Structural elucidation of lipids is facilitated by reactive LAESI based on introducing reactant ions through the electrospray. Simultaneous imaging of the ion distributions reveals the localization of these species in various anatomical regions. Pearson cross-correlation analysis and colocalization maps are used to find synchronous variations in the ion intensities. To explore metabolic variations in small cell populations, another variant of LAESI mass spectrometry is introduced. Using a sharpened optical fiber for the delivery of the laser pulse enables the direct analysis of individual cells. In the metabolic analysis of single cells and small cell populations of Allium cepa and Narcissus pseudonarcissus bulb epidermis 332 peaks are detected of which 35 are assigned to metabolites. The metabolic profiles from single cells of the two species include a large variety of oligosaccharides including fructans in A. cepa, and alkaloids, e.g., lycorine in N. pseudonarcissus. Analysis of adjacent individual cells with a difference in pigmentation show that, in addition to essential metabolites found in both variants, the pigmented cells contain anthocyanidins, other flavonoids and their glucosides. Analysis of single epidermal cells from different scale leaves in an A. cepa bulb show metabolic differences corresponding to their age. Our results indicate the feasibility of using LAESI-MS for the in situ analysis of metabolites in single cells with potential applications in studying cell differentiation, changes due to disease states and response to xenobiotics.

Novelty of this Contribution: Direct analysis of tissues and cells by LAESI mass spectrometry