LASER ABLATION AND ANALYSIS OF A SINGLE CELL

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Mid-IR laser radiation at 2.94 μm is readily absorbed by biological cells and tissues due to their high water content. The rapid local heating of free standing aqueous phases gives rise to surface evaporation and, at elevated fluences, to phase explosion [1]. In case of cellular structures, the irradiated small liquid volumes are confined by cell walls or cell membranes of varying tensile strength. Nevertheless, laser ablation of suspended, sessile or embedded single cells produces a plume from the cytoplasm in the form of vapor and small droplets.

To obtain information on the chemical composition of the cell, the plume can be ionized by intercepting it with an electrospray. The highly charged droplets in the electrospray coalesce with the laser plume constituents. This is followed by ion production from these seeded droplets and mass spectrometric analysis. This novel analytical technique is termed laser ablation electrospray ionization (LAESI) [2]. Selection and targeting of the cells is based on focusing the laser light through the etched tip of an optical fiber made of a GeO_2-based glass. Ablation sampling can be less than ~30 μm in diameter enabling the mass spectrometric analysis of large single cells.

Epidermal cells of *Allium cepa* and *Narcissus pseudonarcissus* bulbs were ablated to compare the chemical composition of single cells and cell populations in the intact tissues (see Figure 1). About two dozen metabolites were detected in the LAESI mass spectra of a single epidermal cell of *A. cepa* (see Figure 2) Metabolite profiling of two neighboring cells with different colors showed the presence of flavonoids, such as quercetin and cyanidin, in the red cells and their absence in colorless cells. Both *A. cepa* cells also contained polysaccharide ions, possibly fructans, while the spectra of the *N. pseudonarcissus* epidermal cells were dominated by alkaloids. These results show the feasibility of analyzing biological tissues cell-by-cell, with the ultimate goal of molecular imaging based on cells as the natural voxels.

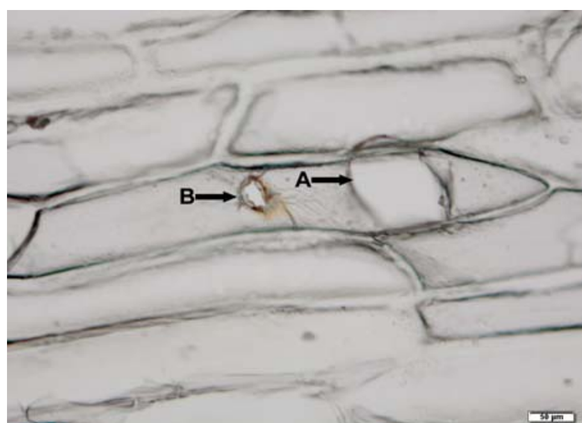

Figure 1. Initial ablation, marked (A), on a turgid *A. Cepa* epidermal cell resulted in the loss of the cytoplasm. Phase explosion of the water inside the cell led to the bursting of the cell wall and ejection of the enclosed material. After the second ablation, marked (B), on the same cell, when it was already flaccid due to the loss of the cytoplasm, only a slight degradation of the cell wall was visible.

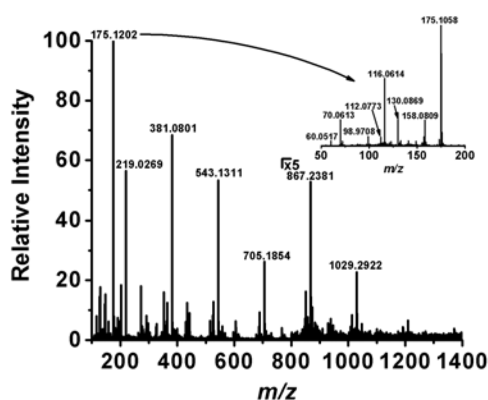

Figure 2. Background subtracted LAESI mass spectrum obtained from the ablation marked (A) of a single epidermal cell of *A. Cepa* in Figure 1 was dominated by metabolites. The eight fragments from the collision activated dissociation of the *m/z* 175 ion in the inset showed similarity to standard arginine tandem mass spectra. No spectrum was produced by ablation (B) in Figure 1.

[1] Z. Chen and A. Vertes, Phys. Rev. E, **77**, 036316 (2008).
[2] P. Nemes and A. Vertes, Analytical Chemistry, **79**, 21 (2007).