Dual polarity mass spectrometric imaging from single tissue sections with Desorption Electrospray Ionization (DESI) mass spectrometry

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Over the years Desorption Electrospray Ionization (DESI), an ambient ionization technique, has been applied to Mass Spectrometry Imaging (MSI) to allow for the direct analysis of surfaces at atmospheric pressure. DESI can be utilized as an imaging technique by rastering a surface under the spray using a high precision XY stage. As the electrospray droplets impacts upon the surface, chemical constituents are desorbed and carried towards the atmospheric inlet of the mass spectrometer. Ionization of the desorbed molecules occurs via the charge imparted onto the droplets. By utilizing optimized gas and solvent flow rates as well as voltages, the DESI technique does not destruct the tissue surface and therefore provide the opportunity to re-analyze multiple times the same tissue with the same or different experimental conditions or techniques. Here, we demonstrate that with sufficiently low gas and solvent flow rates, the desorption was not destructive and the same tissue section could be repeatedly analyzed without modification or exhaustion of the surface molecules. This allowed dual polarity analysis on the same tissue section to access to a wealth of molecular information from a single tissue section without the need to alter the MS Imaging conditions.

Initially imaging experiment on porcine liver were performed using DESI with the MS operating in negative mode, followed by another DESI imaging experiment on the same tissue section with the MS operating in positive mode. In both modes of ionization, plentiful lipids and endogenous metabolites were detected, giving intense peaks.

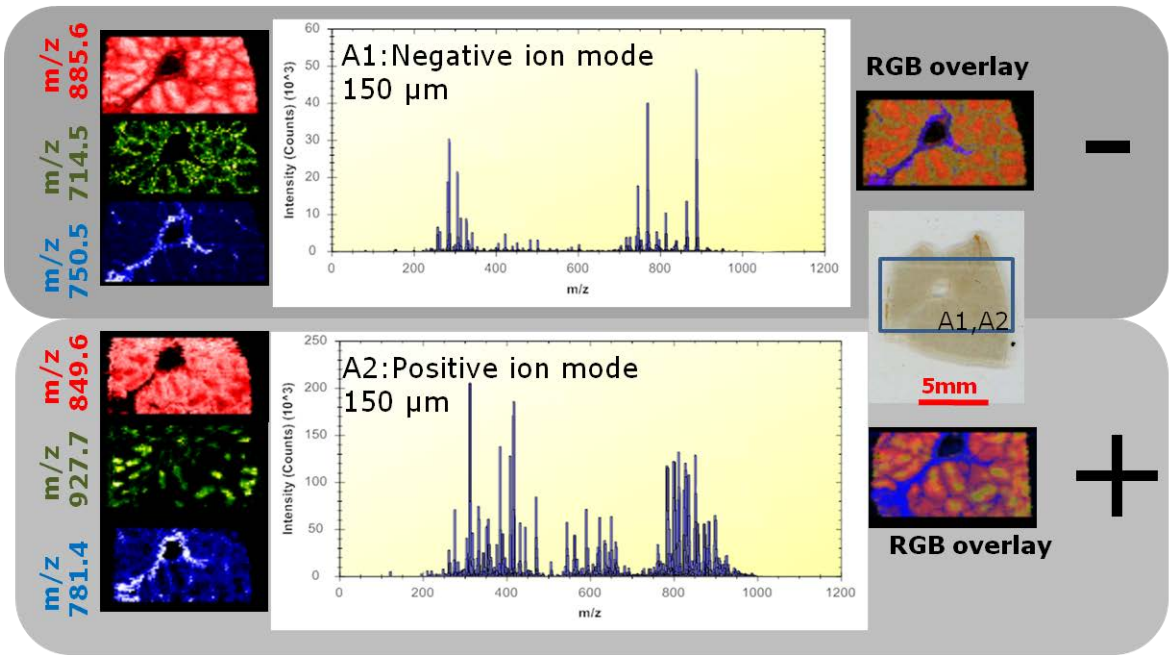

Figure 1: Two successive DESI imaging analyses of the same region of a tissue section from porcine liver. A1) First analysis, 150µm spatial resolution negative ion mode, three color overlay and average spectrum. A2) Second analysis, same raster conditions- 150µm spatial resolution positive ion mode, three color overlay and average spectrum.

A second experiment was designed to evaluate whether the first passage of the DESI spray alters the chemical information that is obtained from the same tissue. Figure 2 compares the spectrum that was generated from a single DESI imaging experiment in positive mode (top), and the spectrum (bottom) that was generated from a consecutive tissue section also in positive mode after a first experiment was carried out in negative mode. Identical peaks were observed in both spectra with very similar relative intensities.

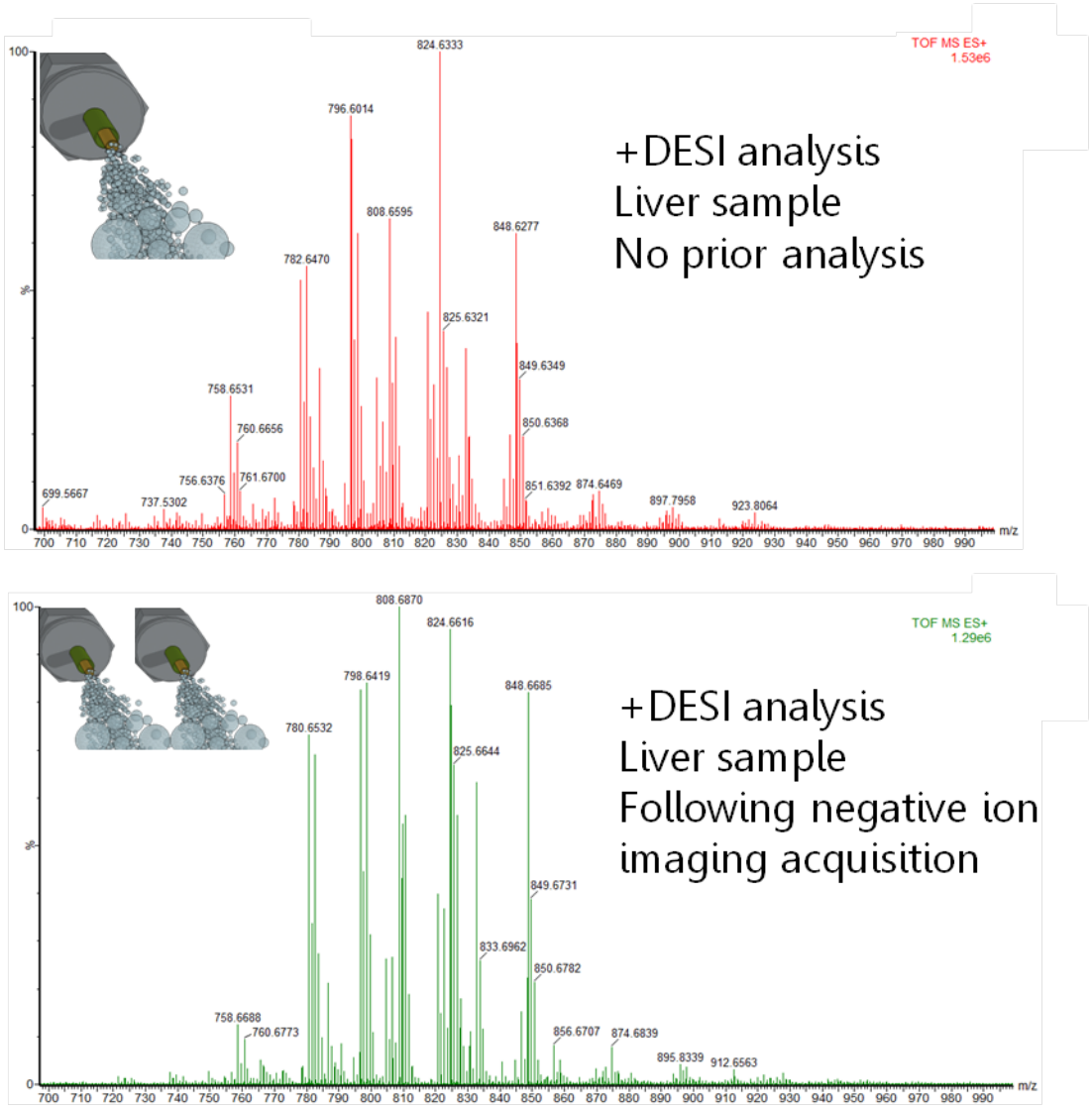

Figure 2: Combined positive mode mass spectra from similar regions of serial porcine liver sections: A) on a pristine surface B) on an altered surface where a full negative ion DESI imaging experiment was carried out prior.

The ability to revisit the same section to increase the amount of information could be of great importance when samples are precious, such as with clinical human samples. Figure 3 shows one such example where the same section[1] was analyzed by DESI MS imaging in both polarities. Lipid species specific to tumor and healthy tissue in positive and negative ion mode were identified. By not altering the tissue with the DESI technique, subsequent additional surface analysis or staining techniques (i.e. H&E staining) could be performed on the same tissue section for further more comprehensive and accurate characterization of the tissue regions by a pathologist.

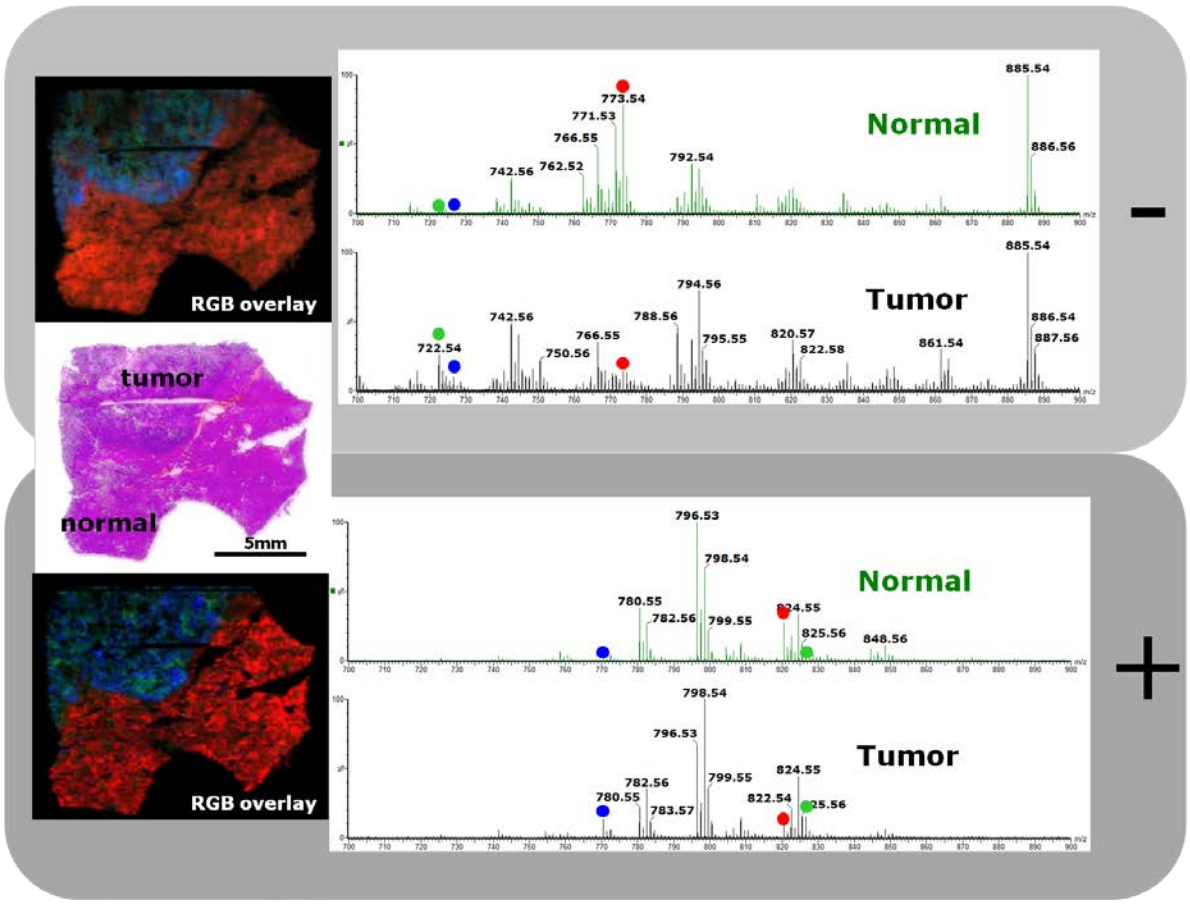

Figure 3: Clinical human sample (single tissue section from a block of liver[1] containing both normal tissue and a secondary tumor) was analyzed in negative, then in positive ion mode where many lipid species in both polarities were more abundant in one tissue type than the other, thus creating a signature chemical fingerprint defining the tissue morphology and type.

ACKNOLEDGEMENTS

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