The LONESTAR™ Portable Analyzer for Flavor Quality Control: Detecting Diacetyl, 2,3-pentanedione and Acetaldehyde

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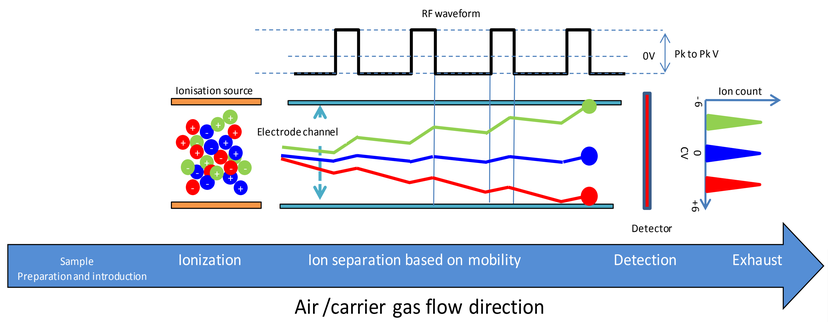
1. Introduction

The LONESTAR™ portable analyzer is an adaptable chemical monitor that uses Field Asymmetric Ion Mobility Spectrometry (FAIMS) technology. LONESTAR™ can be used in situ by non-specialists to rapidly detect and quantify the concentration of compounds that can negatively affect the flavor of brewed beverages, such as diacetyl, 2,3-pentanedione and acetaldehyde .

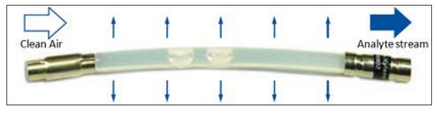
Figure 1 Schematic of FAIMS method



2. Methodology

Owlstone's dime-sized FAIMS chip uses an oscillating electric field to separate different gaseous analyte ions in a flow of gas based on their differential mobility (Figure 1). This technique produces separate spectra for positive and negative ions. The lower limit of detection (LOD) and the linearity of the FAIMS response to diacetyl and 2,3-pentanedione were investigated. Flows of carrier gas containing known concentrations of each compound were generated using Owlstone Vapor Generators (OVG-4) and calibrated gas permeation sources (Figure 2). The FAIMS response to ethanol (a likely interferent in samples from the brewing industry) was also tested in this way. Finally we show the LONESTAR™ response the headspace sampling of water samples containing acetaldehyde.

Figure 2 Permeation source and an OVG



LONESTAR™ Analyzer

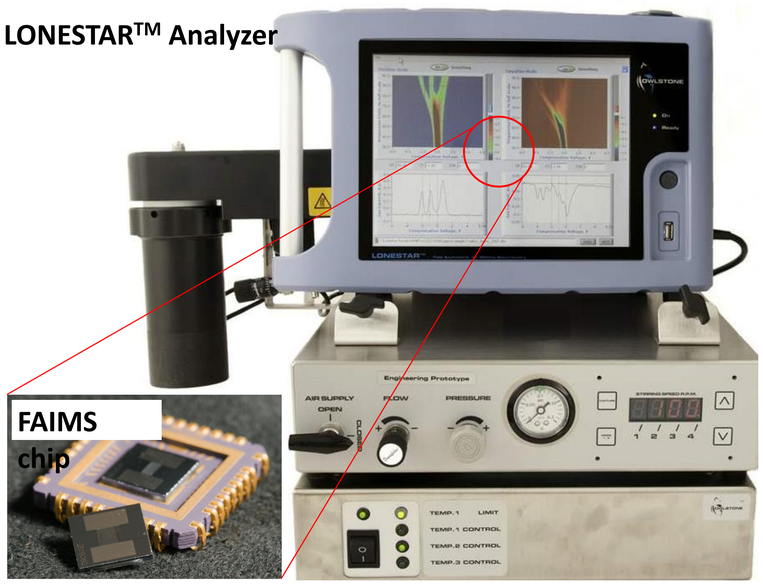
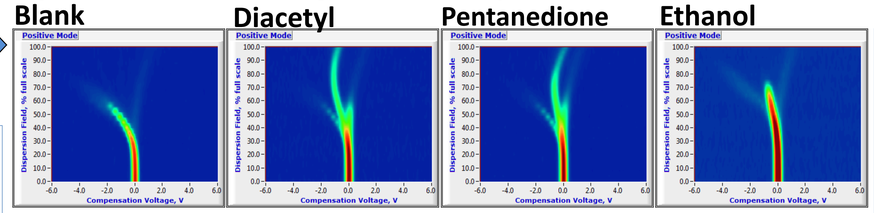


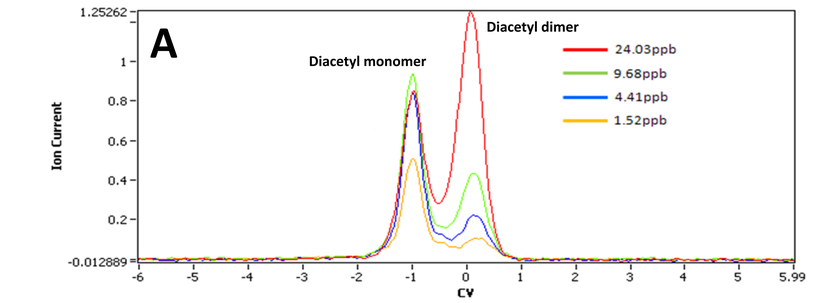
Figure 3 Positive and negative FAIMS spectra from LONESTAR™

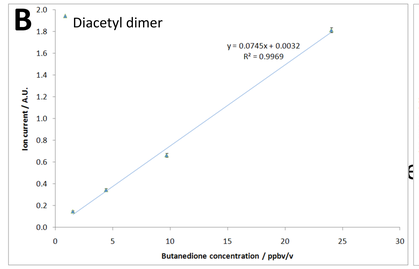


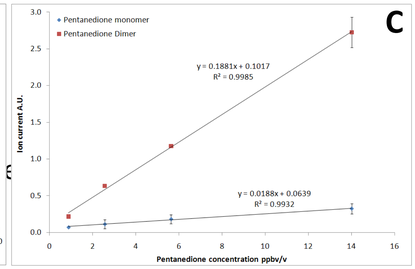
3. Results: diacetyl & 2,3-pentanedione

The 2D FAIMS spectra in Figure 3 show the variation in ion trajectories (in terms of a compensation voltage) with increasing dispersion field (DF) strength for a background blank run (just water and air ions), diacetyl, 2,3-pentanedione and ethanol. The tested compounds are all easily distinguishable from the background at above 60% DF. It is also clear that the FAIMS response for ethanol does not interfere with the other compounds, which is due to the instability of the ethanol ions at higher DF. The LODs for diacetyl and 2,3-pentanedione in the vapor phase from positive FAIMS spectra using a LONESTAR™ with a Ni-63 ionisation source were found to be 762 $ppt_{v/v}$ and 324 $ppt_{v/v}$ respectively. The response to higher concentrations of diacetyl at a single DF value is shown in Figure 4A. Calibration of LONESTAR™ was performed using a series of increasing concentrations of both compounds, the resulting linear plots are shown in Figure 4B and C.

Figure 4 A) FAIMS response to diacetyl B) Lonestar calibration plots for diacetyl and 2,3-pentanedione



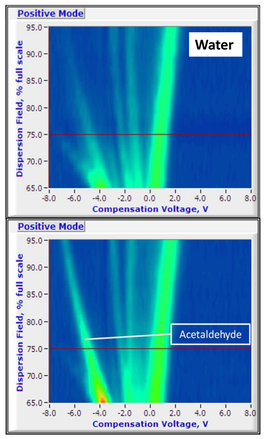




4. Results: acetaldehyde

LONESTAR™ is primarily used to sample the headspace gas of liquid samples. Figure 5 compares a pure water blank (top panel) with water spiked with 0.1 µg L^{-1} acetaldehyde (bottom panel). Their is a noticeable change in the LONESTAR™ response, indicating the efficacy of the FAIMS technique for detecting compounds from the headspace of aqueous samples, such as beer.

Figure 5



5. Conclusions

The FAIMS technique was able to detect diacetyl, 2,3-pentanedione at ppt (part per trillion) concentrations at DFs that exclude the likelihood of interference from ethanol. Acetaldehyde was detectable from the headspace of water samples containing 0.1 µg L^{-1}. These results show that LONESTAR™ is an ideal choice for simple, rapid and precision monitoring of brewed products in situ for compounds that have a negative flavor impact.