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# Spoilage of Salmon fillets as observed by THz waves

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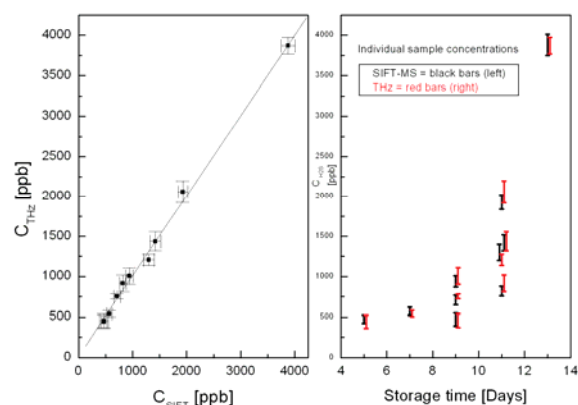
**Abstract**—The minimization of food wastage is an important challenge for today's society. Microbial activity during the storage of foodstuffs packed under a protective atmosphere, will lead to the generation of a complex mixture of trace gases that may be used as food spoilage indicators. THz waves have been used to monitor the generation of hydrogen sulfide in the headspace of a sealed plastic tray containing a salmon fillet portion.

## I. INTRODUCTION

OUR capacity to determine degree of spoilage of a given product is critical to assure its quality and economical viability [1]. Spoilage is typically due to microbial activity, and leads to the production of numerous volatile compounds. Trace quantities of these molecules accumulate in the package headspace resulting in unpleasant off-odors that eventually cause consumer rejection. THz spectroscopy has great potential for the analysis of complex gas mixtures [2]. We have demonstrated THz spectroscopy for the monitoring of food spoilage by measuring H<sub>2</sub>S levels in the headspace of Atlantic salmon (*Salmo salar*) packaged under 100 % N<sub>2</sub>. The approach was validated by comparison with selective-ion flow-tube mass spectrometry (SIFT-MS).

## II. RESULTS

Thirty samples of salmon fillets were prepared and packed in plastic trays under a pure nitrogen environment before being sealed by a top film. The samples were stored at 4.0°C for a duration of 1, 3, 5, 7, 9, 11 or 13 days before being analyzed simultaneously by SIFT-MS and THz spectroscopy. A high-resolution THz spectrometer constructed using such an amplified frequency multiplication chain [3] was developed to probe the H<sub>2</sub>S line at 611.441 GHz with a line strength of  $4.18 \times 10^{-21}$  (cm<sup>-1</sup>/(molecule.cm<sup>-2</sup>)). The use of a calibrated gas sample and a model for the Voigt regime measured in FM mode allowed quantitative data to be extracted. Figure 1 shows the good agreement between the THz and SIFT-MS measurements. The concentration as a function of time for both techniques indicates for a given time the sample-to-sample variation is larger than the measurement uncertainties. The uncertainty of the THz measurement was established at 100 ppb [4].



**Fig. 1.** Left pane: concentration of H<sub>2</sub>S measured by THz spectroscopy as a function of concentration measured by SIFT-MS for each sample. Right pane: measured concentration values as a function of storage time for each sample. Red bars THz, black bars SIFT-MS. Length of bars (red THz, black SIFT-MS) indicate the measurement uncertainty.

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