Open-Path Detection of Organic Vapors via Quantum Infrared Spectroscopy

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In recent years, the detection of volatile organic compounds (VOCs) has arisen as a cornerstone for various sectors including security, health, and environmental management. In principle, the ability to measure low VOC concentrations could enable non-invasive medical diagnoses, remote explosive detection, and precise tracking of industrial pollution. Laser technology, particularly Fourier transform infrared (FTIR) spectroscopy, has facilitated the detection of such gasses, but conventional spectrometers are limited in the mid-infrared (MIR) region due to important shortcomings of current classical sources and detectors. Quantum Fourier transform infrared (QFTIR) spectroscopy has recently emerged as an alternative to conventional absorption spectroscopy in the MIR region, raising hopes for more sensitive broadband spectrometers. By harnessing induced coherence [1] and spectral correlations of photon pairs in a nonlinear Michelson interferometer [2], this technique offers promising potential for the practical detection of organic gasses. However, little research was conducted to bring QFTIR spectrometers closer to domestic or in-field usage.

We hereby present the first use of a QFTIR spectrometer for open-path detection of multiple interfering organic gasses in ambient air. We built a nonlinear Michelson interferometer with 1.7m-long arms to increase the absorption length, coupled with analysis techniques from classical differential absorption spectroscopy used for gas-traces detection [3]. We thus characterized our spectrometer's sensitivity to acetone, methanol and ethanol vapors, and demonstrate the accurate identification of mixtures of these gasses released in ambient air. We showed this characteristic is preserved over time, by performing a measurement overnight and tracking the evolution of different gasses' average concentrations. These results constitute the first use-case of a QFTIR spectrometer as a detector of organic gasses, and thus represent an important milestone towards the development of such detectors in practical situations.

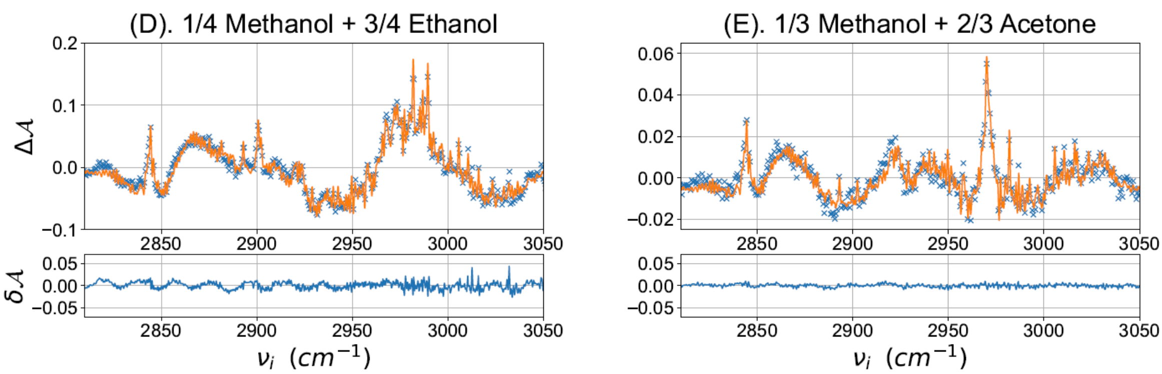

Fig. 1: Differential absorbance ΔA recorded by our QFTIR spectrometer, probing vapors emitted from liquid mixtures made of (D) 1/4 methanol and 3/4 ethanol, (E) 2/3 acetone and 1/3 methanol. The fitting method accurately returns the composition of the mixtures.

References

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