

Quantum Cascade Laser Based Sensor for Carbonyl Sulfide

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Recent research has identified carbonyl sulfide (OCS) in expired human breath as a possible marker for liver disease and acute allograft rejection in lung transplant recipients [1,2]. This is an exciting possibility in that exhaled breath analysis may offer a non-invasive alternative to such procedures as transbronchial biopsies for diagnosing acute rejection [2]. However, there is a need to develop sensors capable of real-time, robust, and routine measurement of OCS at low- to mid- parts-per-billion (ppb) levels. Mid-infrared tunable laser absorption spectroscopy (TLAS) is a candidate technology on account of its molecular selectivity, rapid response times, and strong absorption intensities of OCS near $4.86\ \mu\text{m}$ ($>1 \times 10^{-18}\ \text{cm}^{-1}/\text{molecule} \times \text{cm}^{-2}$). We report on the use of a near-room temperature pulsed quantum cascade (QC) laser based sensor to perform OCS measurements with ppb sensitivities. Isotopic selectivity was also demonstrated for $^{16}\text{O}^{12}\text{C}^{32}\text{S}$ and $^{16}\text{O}^{12}\text{C}^{34}\text{S}$.

An important aspect of exhaled breath analysis is potential interference from water vapor and exhaled carbon dioxide (eCO_2), both of which have high concentrations in exhaled breath. Figure 1 shows the results for measuring 506 ppb calibrated OCS gas mixed with either exhaled breath (upper plot) or pure N_2 (lower plot). There was no change in the OCS absorption profile at $2054.078\ \text{cm}^{-1}$ due to the presence of molecular breath constituents making this absorption feature suitable for breath analysis. Measurement of exhaled carbon dioxide (eCO_2), which is overlapped with OCS near $2053.63\ \text{cm}^{-1}$, provides a method to verify for proper breath donations [3].

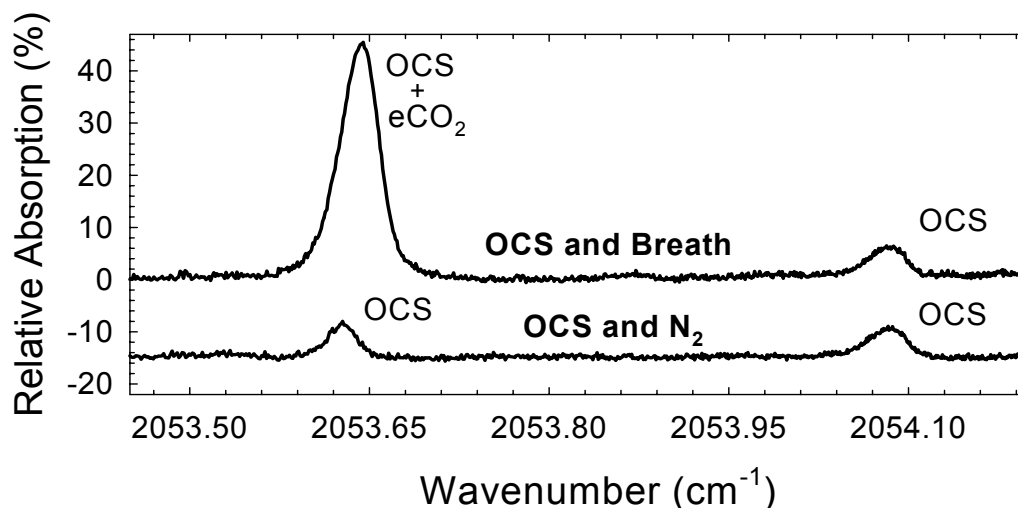


Figure 1. Measured absorption spectra of 506-ppb OCS calibrated gas mixed with exhaled breath (upper plot) and purified N_2 (lower plot). Molecular constituents in breath did not significantly affect the OCS absorption feature at $2054.078\ \text{cm}^{-1}$. [eCO_2 – exhaled carbon dioxide]

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