Laser Absorption Spectroscopy of Atmospheric Formaldehyde

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For the real time detection of atmospheric CH_2O with ultra high sensitivity and excellent selectivity, a cw tunable mid-IR spectroscopic source based on difference frequency generation (DFG) has been developed. The motivation for such a laser source is the acquisition of high quality CH_2O concentration measurements. Formaldehyde is an important intermediate present in all regions of the atmosphere and in testing the current understanding of hydrocarbon photochemistry. CH_2O plays also a critically important role in the chemistry of the urban atmosphere because of health effects associated with CH_2O, as well as its role in ground-level ozone formation.

The mid-infrared DFG source is based on low-power diode laser sources at 1 and 1.5 μm, which seed 1.5W Yb and 0.6W Er/Yb fiber amplifiers, respectively [1] . One seed source is a 1083 nm DFB diode laser, and 12 mW of its output was coupled into a single mode fiber to seed the Yb amplifier. A 2 mW fiber pigtailed 1.56 μm DFB telecommunications diode laser amplified to 30 mW with an Er fiber amplifier was used to saturate the gain of the Er/Yb fiber amplifier. A fiber beam coupler combines the two pump beams and delivers them to a lens for imaging the available pump power into a 19 mm long periodically poled lithium niobate (PPLN) crystal to produce up to 250 μW of cw DFG radiation in the PPLN crystal with grating periods ranging from 29.7 to 30.5 μm. The mid-infrared radiation is then collimated and directed into a 100 m long multipass absorption cell for CH_2O detection at reduced pressures. Various detection schemes were evaluated that included balanced detection with two MCT detectors, 2f-modulation spectroscopy, and CH_2O free zero air rapid background subtraction. The DFG wavelength is rapidly scanned using a sawtooth waveform (~0.17 cm^{-1}) across CH_2O absorption lines at 50 Hz.

This instrument was used both at NCAR in Boulder and at a rooftop location at Rice University in Houston, TX to acquire high quality CH_2O concentration measurement at the 1-20 ppbv level. At pressures of 40 torr, a temperature of 286 K and a pathlength of 100 m a minimum detectable absorbance of 10^{-5} was achieved with a measurement precision in the 0.2 to 0.3 ppbv range.

Reference:

[1] D.G. Lancaster, D. Richter, R.F. Curl, F.K. Tittel, L. Goldberg, J. Koplow, Opt. Lett. **24**, 1744 (1999)