Broadband trace sensing using supercontinuum light sources

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Supercontinuum light sources are attractive for spectroscopic applications in physics, chemistry and biology, owing to their unique combination of high spectral brightness and broadband wavelength coverage. We have developed a broadband multiple species trace gas detection scheme based on cavity enhanced absorption spectroscopy (CEAS) and a supercontinuum (SC) light source [1]. The method allows observation of spectra covering 100 nm or more all at once. We have applied this technique for quantitative measurement of NO_2 and NO_3, species of importance in atmospheric chemistry. In the case of NO_3, a sensitivity of three parts per trillion by volume was achieved for a measurement lasting less than 2s.

In order to calculate absolute absorber concentrations from CEAS data, the reflectivity of the cavity mirrors was experimentally determined. This is particularly important in broadband studies where the mirror reflectivity can change considerably over the covered spectral range. In previous broadband CEAS experiments, methods adopted for this purpose have included the direct reflectivity determination by cavity ring-down spectroscopy using a broadband dye laser [2]. An alternative approach uses a species present within the cavity at a well defined concentration. Here we report a calibration scheme based on an acousto-optical tuneable filter and phase shift cavity ring-down spectroscopy. In this approach the supercontinuum source is used for both the CEAS measurement and reflectivity calibration.

Exciting potential lies with application of the technique to liquid phase measurements. We have demonstrated an evanescent wave variant of broadband CEAS by detecting electro-generated species in the liquid phase at the silica-water interface of an intra-cavity prism [3].

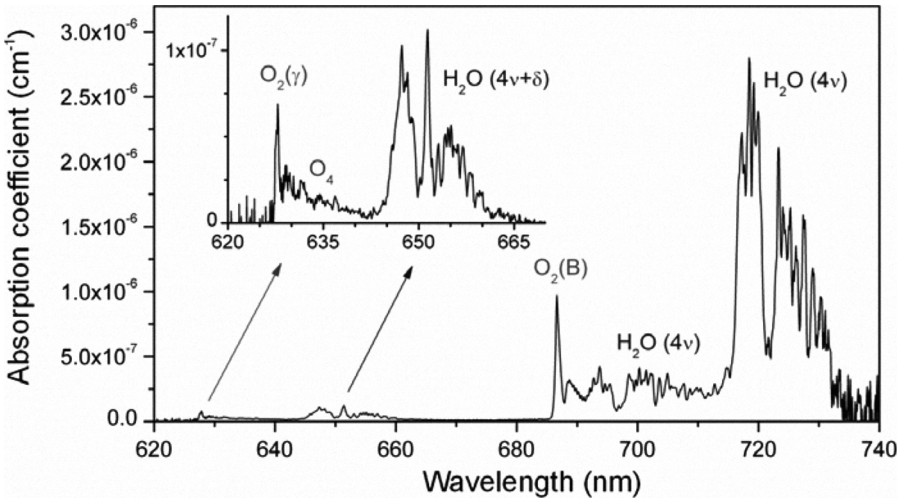

Fig. 1 Broadband SC-CEAS spectrum of synthetic air humidified to 77% RH. The spectrum covers 100 nm at a resolution of 0.3 nm FWHM. The spectrum was acquired in a single measurement in 2 s. using a grating spectrometer and a CCD camera.

The performance of the broadband technique, together with its conceptual simplicity and robust nature, make it well suited to a range of spectroscopic applications from trace gas sensing to liquid phase analytics in electrochemistry and in the life sciences.

References

[1] J. M. Langridge, T. Laurila, R. S. Watt, R. L. Jones, C. F. Kaminski, and J. Hult, "Cavity enhanced absorption spectroscopy of multiple trace gas species using a supercontinuum radiation source," Opt. Express **16**, 10178 (2008).

[2] S. M. Ball, J. M. Langridge, R. L. Jones, "Broadband cavity enhanced absorption spectroscopy using light emitting diodes," Chem. Phys. Lett. **398**, 68 (2004).

[3] M. Schnippering, P.R. Unwin, J. Hult, T. Laurila, C.F. Kaminski, J.M. Langridge, R.L. Jones, M. Mazurenka, S.R. Mackenzie, "Evanescent wave broadband cavity enhanced absorption spectroscopy using supercontinuum radiation: a new probe of electrochemical processes," Electrochem. Commun. **10**, 1827 (2008).

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