

Optical monitoring of OH radical using advanced Faraday rotation detection approach

T. Nguyen Ba, P. Kulinski, E. Fertein, W. Chen

*Laboratoire de Physico-Chimie de l'Atmosphère, Université du Littoral Côte d'Opale
189A Av. Maurice Schumann, 59140 Dunkerque, France*

The hydroxyl radical (OH) is one of the dominant oxidising species in the atmosphere. It is considered as a primary agent that is responsible to remove a majority of traces gas emitted into the atmosphere, including greenhouse gas (CH₄), volatile organic compounds (VOCs) and substances harmful to health (CO, SO₂) [1], [2]. It is also responsible to initiate the reactions leading to the formation of a wide range of secondary species such as ozone (O₃) and secondary organic aerosols (SOAs) [3]. Reliable and real-time assessment of the OH radicals concentration change and related chemical process in the atmosphere is therefore a key factor to exactly determinate the oxidation capacity of the atmosphere. Because of its very high reactivity, very short lifetime (≤ 1 s) associated with very low atmospheric concentration ($\sim 10^6$ OH radicals/cm³), the development of novel instrument allowing accurate, interference-free and ultra-high sensitivity in-situ direct measurement of absolute OH concentration presents a great challenge for atmospheric science and climate change research.

We report in this paper our recent development of an interband cascade laser (ICL) spectrometer operating at 2.8 μm for OH radical measurement using Faraday rotation spectroscopy (FRS) [4]. FRS can be considered as a sensitive, selective and background-free detection method for paramagnetic molecules and radicals such as O₂, NO, NO₂, OH [5]–[7]. This is mainly due to its insensitivity to non-paramagnetic molecules present in the atmosphere such as H₂O or CO₂. The first prototype instrument, using only an optical absorption path-length $L \sim 25$ cm, allowed us to achieve a 1σ (SNR=1) detection limit of 8.2×10^8 OH radicals/cm³ [8], [9]. As the Faraday effect on the rotation of the probing light polarization is proportional to the sample absorption path length, implementation of a long absorption path length could allow us to lower the detection limit of the instrument. FRS coupled to a multipass cell with an effective optical absorption path-length of ~ 1200 cm is under investigation.

References

- [1] L.K. Whalley, D. Stone, B. Bandy, R. Dunmore, J.F. Hamilton, J. Hopkins, J.D. Lee, A.C. Lewis, and D.E. Heard, *Atmos. Chem. Phys.* **16** (2016) 2109
- [2] D.E. Heard and M.J. Pilling, *Chem. Rev.* **103** (2003) 5163
- [3] D. Stone, L.K. Whalley, and D.E. Heard, *Chem. Soc. Rev.* **41** (2012) 6348
- [4] G. Litfin, C.R. Pollock, R.F. Curl, and F.K. Tittel, *J. Chem. Phys.* **72** (1980) 6602
- [5] B. Brumfield and G. Wysocki, *Opt. Express.* **20** (2012) 29727
- [6] P. Kluczynski, S. Lundqvist, J. Westberg, and O. Axner, *Appl. Phys. B-Lasers Opt.* **103** (2011) 451
- [7] C.A. Zaugg, R. Lewicki, T. Day, R.F. Curl, and F.K. Tittel, *Proc. SPIE - Int. Soc. Opt. Eng.* **7945** (2011) 74950-7
- [8] W. Zhao, G. Wysocki, W. Chen, E. Fertein, D. Le Coq, D. Petitprez, and W. Zhang, *Opt. Express.* **19** (2011) 2493
- [9] W. Zhao, G. Wysocki, W. Chen, and W. Zhang, *Appl. Phys. B-Lasers Opt.* **109** (2012) 511