



Optical monitoring of dinitrogen pentoxide (N₂O₅) in an atmospheric simulation chamber using an external cavity quantum cascade laser

Hongming Yi (1), Tao Wu (2), Amélie Lauraguais (1), Vladimir Semenov (3), Cecile Coeur (1), Andy Cassez (1), Eric Fertein (1), Xiaoming Gao (4), and Weidong Chen (1)

(1) LPCA, Université du Littoral Côte d'Opale, Dunkerque, France, (2) Key Laboratory of Nondestructive Test, Nanchang Hangkong University, Nanchang, China, (3) AIRS, Moscow Institute of Physics and Technology, Moscow, Russia, (4) LAPC, Anhui Institute of Optics and Fine Mechanics, Chinese Academy of Sciences, Hefei, China

A spectroscopic instrument based on a mid-infrared external cavity quantum cascade laser (EC-QCL) was developed for high-accuracy measurements of dinitrogen pentoxide (N₂O₅) at the ppbv-level. A specific concentration retrieval algorithm was developed to remove, from the broadband absorption spectrum of N₂O₅, both etalon fringes resulting from the EC-QCL intrinsic structure and spectral interference lines of H₂O vapor absorption, which led to a significant improvement in measurement accuracy and detection sensitivity (by a factor of 10), compared to using a traditional algorithm for gas concentration retrieval [1].

The developed EC-QCL-based N₂O₅ sensing platform was evaluated by real-time tracking N₂O₅ concentration in its most important nocturnal tropospheric chemical reaction of NO₃ + NO₂ *leftrightharpoon* N₂O₅ in an atmospheric simulation chamber. Based on an optical absorption path-length of $L_{\text{eff}} = 70$ m, a minimum detection limit of 15 ppbv was achieved with a 25 s integration time and it was down to 3 ppbv in 400 s.

The equilibrium rate constant K_{eq} involved in the above chemical reaction was experimentally determined with direct concentration measurements using the developed EC-QCL sensing platform, which was in good agreement with the theoretical value deduced from a referenced empirical formula under well controlled experimental conditions. The present work demonstrates the potential and the unique advantage of using a modern external cavity quantum cascade laser for applications in direct quantitative measurement of broadband absorption of key molecular species involved in chemical kinetic and in climate-change related tropospheric chemistry.

Experimental details will be presented and discussed.

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Reference

[1] H. Yi, T. Wu, A. Lauraguais, V. Semenov, C. Coeur, A. Cassez, E. Fertein, X. Gao, W. Chen, High-accuracy and high-sensitivity spectroscopic measurement of dinitrogen pentoxide (N₂O₅) in atmospheric simulation chamber using quantum cascade laser, *Analyst* 142 (2017) 4638-4646