Title: DEVELOPMENT OF ALL-SOLID-STATE SENSORS FOR MEASUREMENT OF NITRIC OXIDE AND AMMONIA CONCENTRATIONS BY OPTICAL ABSORPTION IN PARTICLE-LADEN COMBUSTION EXHAUST STREAMS

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Abstract

An all-solid-state continuous-wave (cw) laser system for ultraviolet absorption measurements of the nitric oxide (NO) molecule has been developed and demonstrated. For the NO sensor, 250 nW of tunable cw ultraviolet radiation is produced by sum-frequency-mixing of 532-nm radiation from a diode-pumped Nd:YAG laser and tunable 395-nm radiation from an external cavity diode laser (ECDL). The sum-frequency-mixing process occurs in a beta-barium borate (BBO) crystal. The nitric oxide absorption measurements are performed by tuning the ECDL and scanning the sum-frequency-mixed radiation over strong nitric oxide absorption lines near 226 nm. The demonstrated detection limit for the system is less than 1 ppm of NO for a 1-meter absorption path length in clean flows.

During the past year the original 395-nm ECDL from from Toptica has been replaced with a new 395-nm ECDL from Sacher Lasers. The new ECDL has a mode-hop-free tuning range of 90

GHz, as compared to 25 GHz for the old system, and can be scanned over this tuning range at rates up to 1 kHz, as compared to 10 Hz for the old system. The new ECDL system will allow us to increase the data rate for our system by over an order of magnitude and will increase the precision and accuracy of the NO measurements because the spectral baseline will be better characterized.

A series of NO absorption measurements are planned for late May 2005 using the new 395-nm ECDL system. These measurements will be performed in the exhaust of a co-fired combustion facility. The conventional co-fired boiler burner facility is a 30 kW (100,000 Btu/hr) downward-fired furnace with a steel shell encasing ceramic insulation. The combustion facility was modified so that optical absorption measurements can be performed in the exhaust stream. The exhaust is routed from the coal combustor laboratory to an adjoining laboratory where the sensor systems are located. The exhaust tube is fitted with a window assembly for the NO measurements. This sampling assembly has also been substantially improved over our previous apparatus.

We are also in the process of developing a near-infrared diode-laser-based sensor for the measurement of ammonia concentrations. We plan to use a near-infrared telecommunications laser near 1532 nm. Out initial proposed mid-infrared measurements did not appear promising from theoretical spectral calculations due to interference form water vapor absorption. We will also modify our data analysis code by incorporating a computer model of the near-infrared NH_3 absorption. This model will be developed using data from the HITRAN computer code and will be tested using calibrated mixtures of ammonia and buffer gases.

Papers and Presentations

1. R. P. Lucht, T. N. Anderson, S. Priyadarsan, S. Arumugam, R. Barron-Jimenez, J. A. Caton, and Kalyan Annamalai, "Diode-Laser-Based Sensor Measurements of Nitric Oxide in Particulate-Laden Combustion Exhaust Streams," Proceedings of the Twentieth Annual International Pittsburgh Coal Conference, Pittsburgh, Pennsylvania, September 15-19, 2003; paper in preparation for submission to *Energy and Fuels*.