

Multiplexed Sensor for Synthesis Gas Composition and Temperature

Steven G. Buckley (PI) and Mohammadreza Gharavi
University of California, San Diego

Address: 9500 Gilman Drive MS 0411; La Jolla, CA 92093-0411
Telephone Number: 858-534-5681
Fax Number: 858-534-5354
E-mail address: buckley@ucsd.edu
Grant Number: #DE-FG26-04NT42172.

Performance Period: September 2004 to October 2006, no-cost extension through September 2007

OBJECTIVES

The overall goal of this project is to develop a highly sensitive, multiplexed TDL-based sensor for CO₂, CO, H₂O (and temperature), CH₄, H₂S, and NH₃. Such a sensor will be designed with so-called “plug-and-play” characteristics to accommodate additional sensors, and will provide *in situ* path-integrated measurements indicative of average concentrations at speeds suitable for direct gasifier control. The project will develop the sensor and culminate in a real-world test of the sensor.

The products of this research are expected to have a direct impact on gasifier technology and the production of high-quality syngas, with substantial broader application to coal and other energy systems.

ACCOMPLISHMENTS TO DATE

This project has met milestones #1-#6 of the 7 planned milestones towards development of an instrument for real-time measurement of coal synthesis gas. The initial year of the project involved spectroscopic parameter selection, system design, and construction of the sensor system. These tasks were completed (milestones 1-3) in Year 1, as scheduled. In Year 2 of the project, Labview™ analysis software was written to control the lasers, collect and analyze the data. In addition, measurement of temperature- and pressure-dependent spectroscopic parameters and testing of the sensor at pressure and temperature conditions closely matched to expected gasifier conditions was completed. The spectroscopic parameters of CH₄, CO, CO₂, H₂O, and toxic species NH₃ have been measured closely, and parameters pertaining to H₂S have been measured closely enough that good qualitative measurements can be obtained. These represent planned milestones #4-#6.

We have proven that the sensor under development in this project will be able to make the high speed measurements needed to resolve the dynamics in an operating gasifier, and to potentially implement feedback control, which is the envisioned use of the sensor. This project is also making important contributions in developing the near-infrared spectroscopy of the molecules under scrutiny. The measurements that have been completed in Milestones #4 and #5 will contribute to our knowledge of spectroscopic parameters that are fundamentally useful for measurements, or for physical chemists studying the spectroscopy and energy states of these simple molecules.

FUTURE WORK

A field test of the sensor under close-to-real-world conditions is planned.

LIST OF PAPERS PUBLISHED

M. Gharavi and S.G. Buckley, "Pressure broadening parameters of H₂O absorption transitions of 2ν₁ and 2ν₂+ν₃ bands at elevated temperatures," *submitted, Journal of Quantitative Spectroscopy & Radiative Transfer*.

M. Gharavi and S.G. Buckley, "Calibration-free wavelength modulation spectroscopy for temperature and H₂O concentration measurement using a single diode laser," *submitted, Applied Optics*

U.S. PATENT/PATENT APPLICATION(S),

A provisional patent application has been filed on methods development, partially funded through this grant.

CONFERENCE PRESENTATIONS

M. Gharavi and S.G. Buckley, "Wavelength Modulation Spectroscopy for Simultaneous Temperature and H₂O Concentration Measurement in a Flame," Federation of Analytical Chemistry and Spectroscopy Societies (FACSS) Meeting, Portland, OR, October 2, 2004.

M. Gharavi and S.G. Buckley, "A Multiplexed Diode Laser Sensor Based on Wavelength Modulation Spectroscopy for Simultaneous Measurement of Temperature and Concentration of H₂O and CH₄," 4th Joint Meeting of the U.S. Sections of the Combustion Institute, Philadelphia, PA, March 20-23, 2005.

M. Gharavi and S.G. Buckley, "Near-Infrared Optical sensor for Monitoring NH₃ using Wavelength Modulation Spectroscopy," Federation of Analytical Chemistry and Spectroscopy Societies Meeting, Lake Buena Vista, FL, September 24 – 28, 2006.

M. Gharavi, Z.M. Ibrahim, F.A. Williams, S.G. Buckley, and L. Arellano, "Tunable Diode Laser Measurements of Equivalence-Ratio Fluctuations for Premixed Gas-Turbine Applications" U.S. National Combustion Meeting, San Diego, CA March 25-28, 2007.

STUDENTS SUPPORTED UNDER THIS GRANT

Dr. Mohammadreza Gharavi (post-doctoral researcher)

Geoff Rapoport

Christine Lao

Ariel Schuger