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Book of Abstracts
November 2-5, 1998

Kellie Ann Beall, Editor

Building and Fire Research Laboratory
Gaithersburg, Maryland 20899

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U.S. Department of Commerce
William M. Daley, *Secretary*
Technology Administration
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Comparison of Near and Mid-Infrared Tunable Diode Laser Absorption Spectroscopy for the Analysis of Combustion Gases

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The need for reliable, rapid, and accurate measurements of species concentrations in flames has been the motivation for the development of laser diagnostics for more than 20 years. A wide variety of techniques has been proposed including those which feature molecular absorption, fluorescence, and scattering. None of these techniques is universally applicable to all combustion species and all combustion environments. For instance, Raman scattering is relatively insensitive and is subject to interference by fluorescence by polynuclear aromatic hydrocarbons, which are found in many hydrocarbon flames. Laser-induced fluorescence is limited to molecules with accessible electronic transitions and is also subject to interference from other emitters. Therefore, the practical application of laser diagnostics requires compromises and a heavy dose of skepticism on the part of the researcher.

In our laboratory, we have had extensive experience in the development and application of mid-infrared (defined here as ≈3.5 to 16 μm) diode lasers in combustion systems. We have used these lasers to characterize the concentration of carbon monoxide and local flame temperature in methane/air and ethylene/air diffusion flames supported on laboratory scale burners (Miller et al. 1993, Skaggs and Miller, 1995). TDLAS has also been used for the detection of methane, carbon dioxide, and acetylene in a laboratory burner designed to model upset conditions in a hazardous waste incinerator (Skaggs et al., 1996, Tolocka and Miller, 1994).

A limitation of the mid infrared diode laser technology is the requirement for cryoscopic temperatures for the laser's operation and the high cost of both the devices and the detectors required at these wavelengths. In contrast, visible and near infrared lasers (and detectors) are relatively cheap. Further, low-loss and inexpensive optical fibers do not exist for the longer wavelength devices and application of the technology to systems with limited optical accessibility is hampered. For that reason, far more literature has appeared in the last several years exploring near infrared laser applications rather than mid infrared devices (Allen et al., 1995; Cassidy and Bonnell, 1988; Sonnenfroh and Allen, 1996). The former have found application in combustion systems for the detection of molecular oxygen, carbon dioxide, ammonia, methane, water, and carbon monoxide.

The Building and Fire Research Laboratory of NIST has followed these developments and has recently purchased a near infrared system for the analysis of combustion gases. In our laboratory, we have initiated a research program that will complement the NIST effort in two ways:

- We have continued the development of spectral simulation and fitting software which can be used in both the mid and near infrared.

- We have also acquired a near infrared system similar to that acquired by BFRL/NIST so that a side-by-side comparison of near and mid infrared technologies for the *in situ* analysis of combustion gases may be performed.

In this presentation, a progress report will be made on our efforts in the near infrared and implications for the detection of fire signatures will be discussed.

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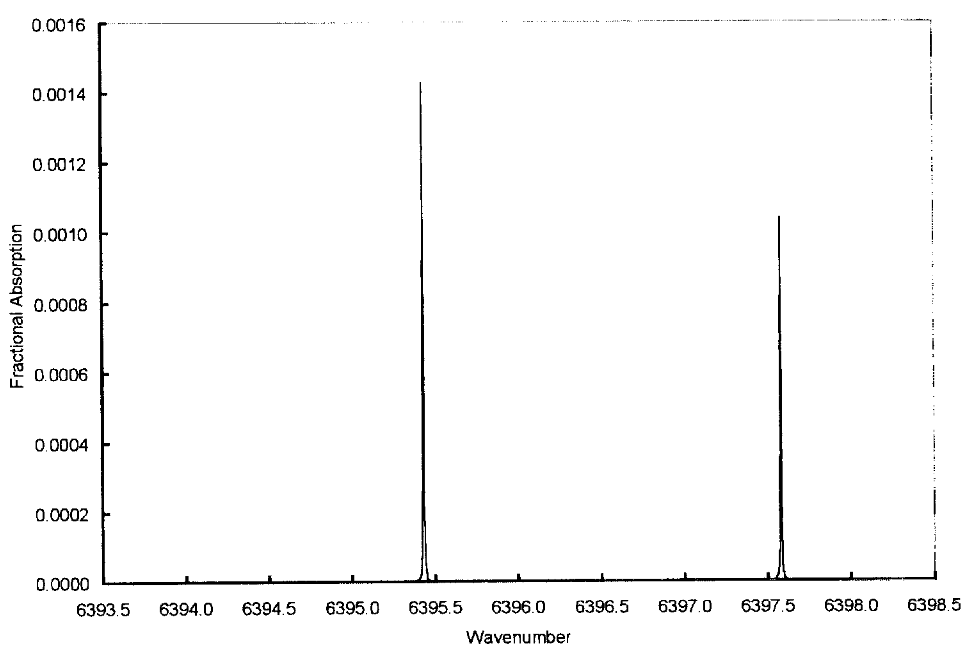

Figure 1: Simulation of expected spectrum in vicinity of 6395 cm^{-1} as observed on fuel rich side of flame front in Wolfhard-Parker slot burner supporting a methane/air diffusion flame. Both observable lines are attributable to carbon monoxide. Carbon dioxide and water, which both absorb in this spectral region, are much weaker in intensity.