AN FT-IR BASED SYSTEM FOR FIRE DETECTION

Michael A. Serio[†], Anthony S. Bonanno[†], Kim S. Knight[†], and Jeffrey S. Newman*

[†]Advanced Fuel Research, Inc.
87 Church Street
East Hartford, CT 06108

* Factory-Mutual Research Corp.
1151 Boston-Providence Turnpike
Norwood, MA 02062

ABSTRACT

A major advance in fire safety technology during the past two decades is the availability of low cost smoke detectors based on either ionization or photoelectric detectors. However, these detectors have some drawbacks because of the high frequency of false alarms and maintenance problems. Other types of detector technologies have been developed for specific gases, such as CO_2, CO, or O_2, based on metal oxide semiconductors, electrochemical sensors, or optical sensors. However, all single parameter methods are hindered by the lack of generality for several types of fires and a lack of "intelligence," i.e., not always being able to discriminate against false signals (1-3). It has long been recognized that multi-parameter detectors which can measure, for example, heat, smoke and CO gas are more reliable indicators of a real fire. In the case of buildings with high value contents, such as telephone central exchanges, clean rooms, banks, military installations, etc., the reliability and sensitivity of the fire detection technology are the most important criteria in selecting a detection system.

There are three recent events which together provide an opportunity to develop a new generation of fire detection systems, 1) the availability of low cost, high speed computation in the form of personal computers; 2) the availability of software packages involving data analysis techniques such as neural networks or fuzzy logic; 3) the availability of advanced sensor technology which can dramatically increase, at relatively low cost, the amount of information upon which an alarm condition can be established. One of the most significant recent advances in sensor technology is the development of portable, low cost FT-IR spectrometers which are operated by personal computers.

These are three basic approaches to implementation of an FT-IR based fire detection system. The first is to make short path measurements in a ventilation duct that removes air from a room or a combination of rooms, as shown in Fig. 1a. This is one of the simplest and least expensive solutions to implement. The major drawbacks are lower sensitivity due to the short path and dilution of the combustion products. This technique does not indicate the exact location of a fire in a room, although this may not be important if the room is relatively small.

The second approach is to make long path measurements across a room at the ceiling level, as shown in Fig. 1b. While this technique is inherently more sensitive, it also requires transport of the combustion products to the beam path. The path must also be arranged so that there are no obstructions between the source and detector and multiple beam paths may be required to properly cover a room. This can be accomplished with specially designed optics or multiple spectrometers.

A third approach is to integrate an FT-IR spectrometer equipped with a multi-pass gas cell into an extractive system, thus replacing the more conventional smoke detector. Such an implementation is shown schematically in Fig. 1c. Since the costs of installing the tubing network is estimated at $\$1/ft^2$, the cost of the detector technology becomes incidental for a large facility ($>200{,}000\ ft^2$). An example of the type of data that would be obtained by this method is shown in Fig. 2. A piece of PVC insulation was heated in air at 10°C/min in a

TGA/FT-IR system. The combustion products in this instrument automatically flow into a multi-pass cell. The spectra include both pyrolysis and combustion products.

The paper will discuss the infrared spectral signatures observed during fire events, data analysis strategies for discriminating fire events from non-fire conditions, and the practicality of implementing an FT-IR based fire detection system for various applications. The combustion of a standard set of flammable materials, such as heptane, polystyrene, PMMA, and PVC is being studied. A comparison will be made to existing multi-parameter methods for fire detection developed by Newman and coworkers (4-6).

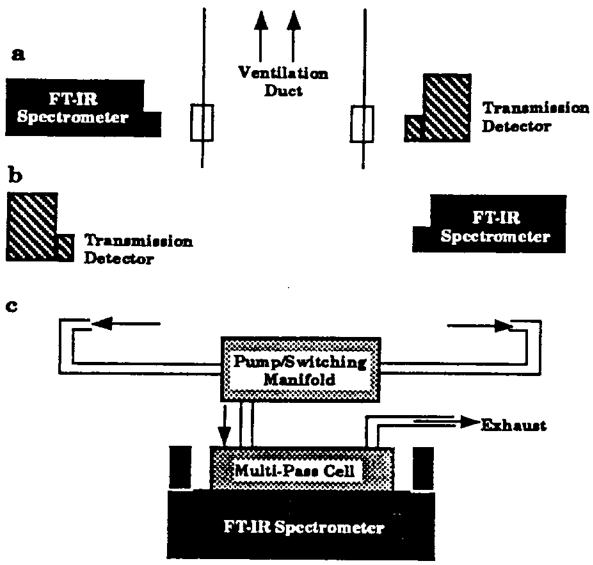

Figure 1. Possible Fire Detection Systems Involving FT-IR Spectroscopy. a) Short-Path Duct Measurements; b) Long-Path Room Measurements; c) Extractive Measurements in Multi-Pass Cell.

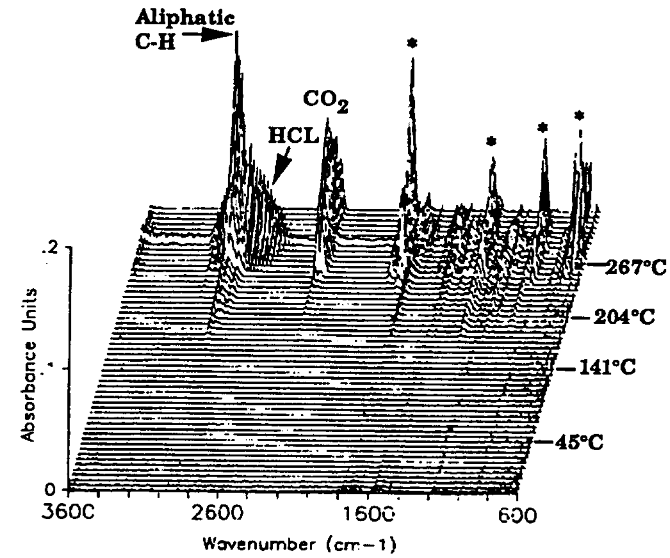

Figure 2. FT-IR Analysis of Combustion Products from PVC Insulation. Asterisks Indicate Spectra from Volatile Organics.

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