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NDIR BASED SO_2F_2 DETECTOR FOR FUMIGATION MONITORING

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ABSTRACT

Sulfuryl Fluoride (SO_2F_2) is being considered as one of the preferred fumigants to replace Methyl Bromide (MBr) which, owing to its large Ozone depletion potential, is being partially phased out as a fumigant. Fumigation of commodities with SO_2F_2 in closed enclosures can last over 24 hours, during which period, fumigant concentration is to be continuously monitored as a measure of process control. SO_2F_2 concentration during such fumigation can range from a few hundred ppm to several thousand ppm. For the detection of SO_2F_2 in the said concentration range, instruments based on interferometry and thermal conductivity are available. However, both the above techniques have their own limitations. For example, thermal conductivity based detector fails to have specificity when other interfering gases (apart from normal constituents of air) are present along with SO_2F_2.

This paper presents a new instrument for the detection of SO_2F_2 in the concentration range of 500-30000 ppm. The instrument is based on NDIR (Non Dispersive Infrared) technique which is highly specific to the target gas. The instrument measures the absorbance of SO_2F_2 molecules in the IR region. The SO_2F_2 molecule has several absorption bands in the IR region, out of which, the absorption at 6.64 μm having no interference from possible other co-existing gases has been chosen as a fingerprint of the molecule. Using a specially designed NDIR absorption cell, the absorbance of SO_2F_2 at 6.64 μm is measured and related to its concentration.

The instrument is microprocessor based and has the capability of storing the measured concentration data. The details of operation, calibration and other features of the instrument are described in the paper.

Key words: Fumigation, Fumigant, Sulfuryl Fluoride, Infrared Absorption, NDIR.

INTRODUCTION

There is a constant search for substitutes in place of methyl bromide as a fumigant which is known to be an Ozone depletor and its use is banned for certain products and in certain countries. Ideally, a fumigant should pose no environmental hazard, penetrate quickly into porous materials, cause no undesirable changes or odors in the material treated, and dissipate rapidly during its removal by aeration. It should also be effective against a wide variety of insects and other pests. With these criteria in mind, the fumigation industry is narrowing down to sulfuryl fluoride (SO_2F_2) as a fumigant. It is non-corrosive, highly penetrating, is stable in air and practically insoluble in water. Unlike methyl bromide, SO_2F_2 does not deplete the atmospheric Ozone layer when released into the atmosphere. These desirable

properties, along with its marked toxicity to all types of insect pests, have made SO_2F_2 a recommended fumigant for a wide variety of closed structures, furnishings, food and other non-food products [1, 2].

NDIR (NON DISPERSIVE INFRARED) TECHNOLOGY

All diatomic and polyatomic molecules have one or several vibrational modes which can absorb radiation in the infrared region. Taking advantage of this absorption by molecules, instruments can be built for the detection of gas molecules. There are mainly two techniques available for the measurement of gas concentrations using IR technology. One is the dispersive technique and the other is the non-dispersive technique. In dispersive technique the light from a continuum source is dispersed in wavelength using prisms or diffraction gratings and the required wavelength is selected and its absorption is related to target gas concentration. Alternatively, in non-dispersive infrared approach, an optical filter can be used to select the transmission of only the absorption wavelength of the target gas molecule. It has been shown that non dispersive techniques using wavelength selective filters are typically 1000 to 100,000 times more sensitive than dispersive technique using gratings or prisms as no slits are used in the non-dispersive technique [3]. NDIR technique is also found to be cost effective, simple and rugged with no compromise on the performance.

NDIR BASED SO_2F_2 ANALYZER

Construction

The NDIR based SO_2F_2 analyzer described in this paper consists of an IR absorption cell and the signal conditioning electronics as shown in figures 1 & 2. The absorption cell is a 120 mm long cylindrical aluminium tube of 10 mm internal diameter with a highly polished inner wall (Fig.1). It has gas inlet and outlet ports. The cell is sealed with two CaF_2 windows on both open ends. On one end of the cell a ceramic IR radiation source is placed which emits IR radiation in the range of 2-16 μm and on the other end a detector module is placed. The module consists of two pyroelectric detectors fitted with two filters which serve as two channels, viz. reference and gas sensing channels. The sensing channel detector is fitted with a filter whose centre wavelength is 6.64 μm which coincides with the chosen IR absorption peak of SO_2F_2. The other detector is fitted with a filter whose centre wavelength lies at 3.9 μm which is not absorbed by SO_2F_2. This channel serves as the reference channel.

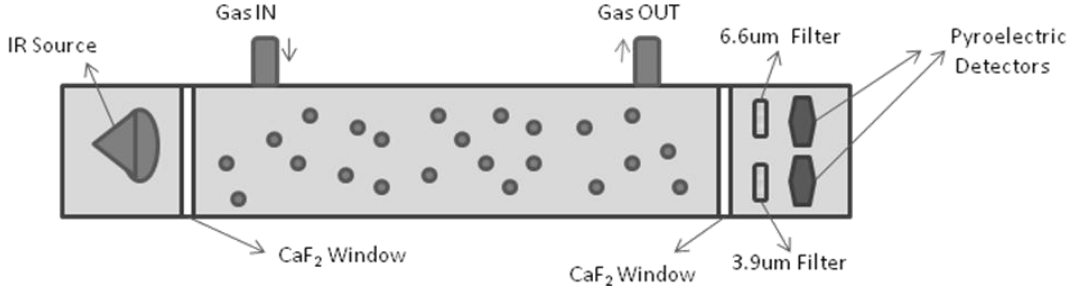

Fig. 1- SO_2F_2 IR absorption cell

The continuum radiation from the IR source passes through the gas cell and falls on the two detectors. However the filter on the sensing detector allows only 6.64 μm and the reference filter allows only 3.9 μm IR radiation to fall on detectors. If the cell is filled with SO_2F_2, the sensor signal decreases because of the absorption, and the reference signal is unaffected. This change in the signal with respect to the reference signal, caused due to the absorption by SO_2F_2 is calibrated with known standards to read the gas concentration. The reference signal serves to correct for any variation in source intensity and other parameters affecting absorption of SO_2F_2. The CaF_2 windows on the two sides not only transmits IR radiation but also serve to isolate the IR source and detectors coming in direct contact with SO_2F_2.

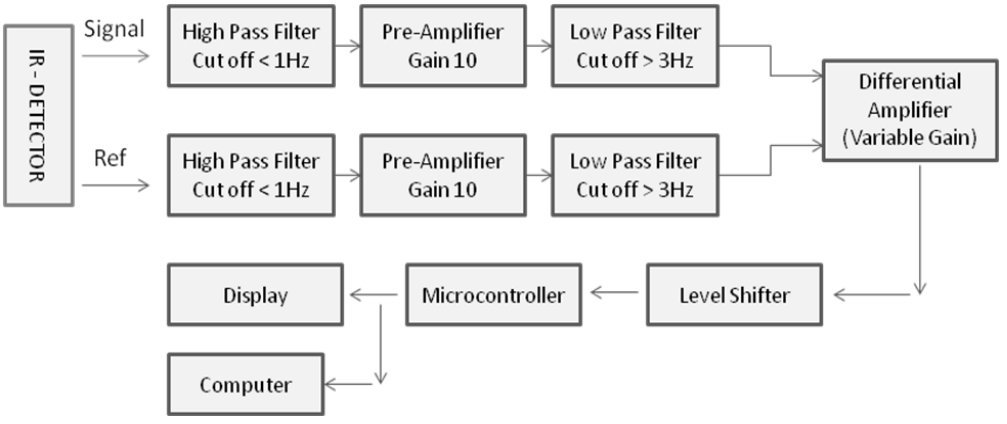

Fig. 2- Signal conditioning module

The instrument is specially designed for monitoring the gas concentration in the fumigated silo or container. The air sample is brought to the sensor by means of the built-in air-sampling pump of the instrument. A dust filter is placed in the inlet of the sampling line to prevent dust particles entering the absorption cell. The instrument works on built-in 14.8 V Li-Ion rechargeable batteries.

Performance & Calibration

The analog signals from both the channels of the detector are pre amplified and fed to the differential amplifier which gives a signal equal to the differences in the peak-to-peak amplitudes of the two signals. This differential signal is further amplified and fed to the microcontroller which gives the digital counts which are related to the gas concentration.

The instrument is calibrated in the range of 0-30,000 ppm using different SO_2F_2 gas concentrations. The instrument has two different ranges of measurement viz. 0-5000 ppm and 3000-30,000 ppm. The Concentration Vs Digital Counts is linear in the lower concentration range and is found to be exponential for higher concentrations of SO_2F_2 as shown in figures 3 & 4 respectively. For lower range the R-Square value was found to be 0.997 and for higher range, the R-Square value was found to be 0.999.

Operation

Once the instrument is turned ON the instrument goes through a series of prompts such as model number, monitor name, operating ranges, etc.. After the initialization, the instrument is automatically driven into purging mode for 3 minutes and the internal air sampling pump gets activated to draw in fresh air in order to purge the absorption cell. After purging, the instrument enters into measurement mode upon selection of suitable range for measurement. As soon as the instrument enters the measurement mode the internal air sampling pump will be activated & will draw the air/gas sample from the fumigation chamber/silo. By default the pump will be on for 3 minutes. Once the pump stops, the unit goes into the data processing mode for about 10 seconds. After completion of the data processing it gives the reading of the SO_2F_2 gas concentration on the LCD panel. Being a microprocessor based unit it has data logging facility and it can store data such as gas concentration, silo/container number etc. with date and time. There is also provision to download the stored data on a computer or a serial printer.

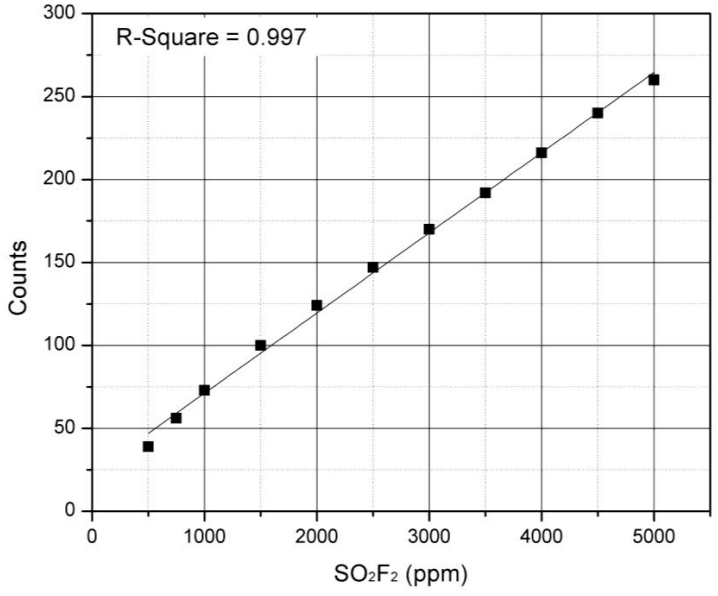

Fig. 3- Low range (0-5000 ppm)

CONCLUSION

SO_2F_2 is becoming popular as a fumigant of choice for closed structure fumigation, furnishings, etc. NDIR based instruments provide a cost effective, accurate and reliable measurement system for monitoring of SO_2F_2 concentration during fumigations. It is endowed with high specificity and sensitivity with no interference from other coexisting gases.

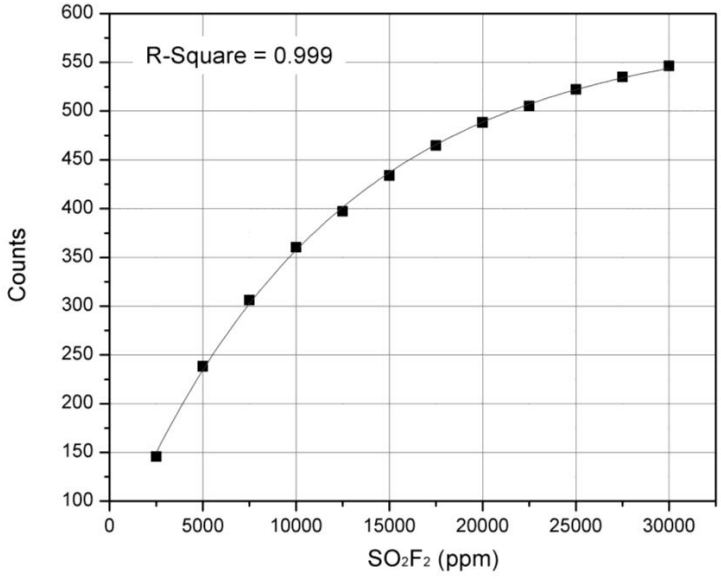

Fig. 4- High range (3000-30000 ppm)

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