Shashank N, Naik RC, Shroff RD (2016) Non-dispersive infrared based SO_2F_2 analyzers for fumigation monitoring and personal protection. Pp. 387–389. In: Navarro S, Jayas DS, Alagusundaram K, (Eds.) Proceedings of the 10th International Conference on Controlled Atmosphere and Fumigation in Stored Products (CAF2016), CAF Permanent Committee Secretariat, Winnipeg, Canada.

Non-dispersive infrared based SO_2F_2 analyzers for fumigation monitoring and personal protection

N SHASHANK*, R C NAIK, R D SHROFF

Uniphos Envirotronic Pvt. Ltd., A Group Company of UPL Ltd., India

ABSTRACT

Sulfuryl fluoride (SO_2F_2) as an alternative fumigant is becoming popular because it is non-corrosive, highly penetrating, stable in air and practically insoluble in water. Fumigation with SO_2F_2 involves exposing the commodities to SO_2F_2 concentration in the range 5000 ppm to 25000 ppm in closed enclosures for over 24 h, during which period, fumigant concentration is to be continuously monitored as a measure of process control. The fumigation process also involves checking leaks, if any during fumigation, and aerating the fumigated area post fumigation to remove any residual gases–to ensure that the fumigated area is safe to enter. This requires suitable low range instruments which can detect fumigant concentration below the threshold limit value (TLV). Measurement of SO_2F_2 can be done using various techniques, viz. thermal conductivity measurement, interferometry, non-dispersive infrared (NDIR) sepctroscopy etc. amongst which, NDIR technique is found to be cost effective, simple and rugged with no compromise on the performance. Based on NDIR technique, Uniphos Envirotronic Pvt. Ltd. (UEPL) has developed two instruments (Fumispec-Hi and Fumispec-Lo) for fumigation monitoring and leak detection applications.The developed Fumispec-Hi is a three port fully automatic system specially designed for monitoring the gas concentrations in a fumigation enclosure in the range 5–150 g/m^3 (0.1 to 4%). The instrument is programmed to take samples from three different locations for analysis. Another developed instrument is Fumispec-Lo, a battery operated portable instrument for leak detection and personal safety. It has a specially designed long path gas cell meant for the detection of low concentration of SO_2F_2 in the range of 0–100 ppm.

Key words: Fumigation, NDIR detector, Sulfuryl fluoride detector

Fumigation of food and other commodities are carried out for infestation control during storage. There are several popular fumigants like phosphine (PH_3), sulfuryl fluoride (SO_2F_2), methyl bromide (MBr), carbon dioxide (CO_2) etc. which are used depending on the commodities and the available time for fumigation. The SO_2F_2 is becoming popular because it is non-corrosive, highly penetrating, stable in air, practically insoluble in water with many other favourable properties (Mühle et al., 2009). These desirable properties, along with its marked toxicity to all types of insect pests, have made SO_2F_2 a popular fumigant for a wide variety of closed structures, furnishings, food and other non-food products. Fumigation with SO_2F_2 involves exposing the commodities to SO_2F_2 concentration in the range 5000 ppm to 25000 ppm in enclosed environments for over 24 h (Derrick et al., 1990). As a process control measure, and also to conform to regulatory norms, it is necessary to monitor the fumigation process by measuring the SO_2F_2 concentration during the entire period of fumigation. For this purpose, suitable monitoring instruments able to detect fumigant concentrations in the high range (5000–25000 ppm) are required. On the other hand, leak detection during fumigation and safe environment conditions after fumigation are also important tasks to be carried out for concerns regarding operator safety and protection, which requires monitoring instruments able to measure gases in threshold limit value (TLV) range (TLV for SO_2F_2 is 5 ppm). The paper describes the two instruments developed by

*Corresponding author e-mail: *nagarajs@uniphos-envirotronic.com*

Uniphos Envirotronic Pvt. Ltd. (UEPL) for fumigation monitoring and leak detection for SO_2F_2 fumigant.

DETECTION TECHNIQUE AND INSTRUMENTATION

The SO_2F_2 can be detected by instruments based on interferometry, thermal conductivity measurements or non-dispersive infrared (NDIR) spectroscopy.

The interferometric technique makes use of the differing refractive index of normal air and air containing SO_2F_2. The change in the interferometric pattern resulting between normal air and air containing the fumigant gas is related to gas concentration. This is a very expensive technique and highly sensitive to dust, moisture and temperature, among others factors. It also lacks specificity as it is affected by the presence of other impurities.

Thermal conductivity detector (TCD) makes use of the property of differing thermal conductivity of SO_2F_2 compared to normal air. The TCD sensor consists of a sensor cell and a reference cell used in the bridge circuit. The thermal conductivity difference between normal air and sample air containing fumigant gas results in an out of balance voltage which is proportional to the fumigant gas concentration. As compared to interferometric method this is much less sensitive to environmental factors and much less expensive. But this method also lacks specificity and works very well when only one extraneous gas is present in the matrix air.

The other technique is based on NDIR spectroscopy. All polyatomic molecules including diatomic molecules have strong adsorption bands in the infrared. They can be used as fingerprints of the molecules for their detection and determination. There are many dispersive and non-dispersive infrared analyzers, which make use of this absorption property of the gas molecules. Industrial applications in the field mostly use NDIR analyzers. A typical NDIR setup is shown in Fig.1.

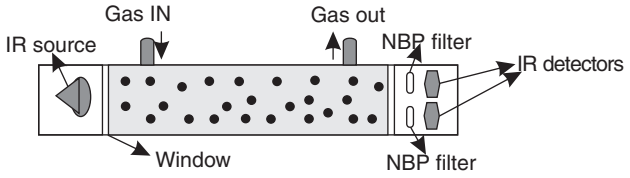

Fig. 1. Schematic of non-dispersive infrared sensor

The basic block diagram of NDIR based SO_2F_2 monitor is shown in Fig. 2.

Based on this technology, the UEPL has developed two instruments for the detection of SO_2F_2 for

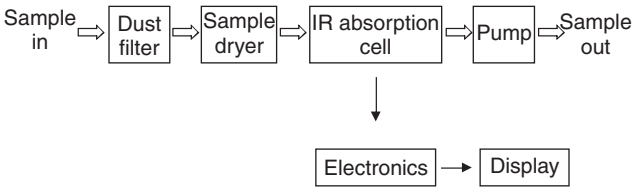

Fig. 2. Block diagram of non-dispersive infrared based SO_2F_2 monitor

fumigation applications, viz. Fumispec –Lo, for leak detection and personal safety and Fumispec –Hi, for fumigation monitoring. An IR absorption band of SO_2F_2 at 6.6 micron is used as its fingerprint.

Fumispec-Lo

It is a battery operated portable instrument (Fig. 3) which can measure SO_2F_2 in the range 0–100 ppm. It has a specially designed long path gas cell meant for the detection of low concentration of SO_2F_2 in the range of 0-100 ppm. The sample for measurement is drawn by the inbuilt sample draw pump. The instrument is suitable for applications related to personal protection and safety (since it can measure SO_2F_2 concentrations in the range of the TLV of 5 ppm) and also for leak detection when used with a sampling probe.

Fig. 3. Fumispec-Lo

Fumispec-Hi

It is a fully automatic system specially designed for monitoring the gas concentrations in a fumigation enclosure or silo and can measure SO_2F_2 in the range 1000–40,000 ppm (~ 4-160 g/m^3). The basic components of the instrument are the NDIR cell, a dust filter, dehumidifier, a sample draw pump, a set of solenoid valves and microprocessor based signal conditioning electronics. The block diagram of a 3 port SO_2F_2 fumigation monitor is shown in Fig. 4.

The instrument is calibrated in the range of 1,000–40,000 ppm using different SO_2F_2 gas concentrations.

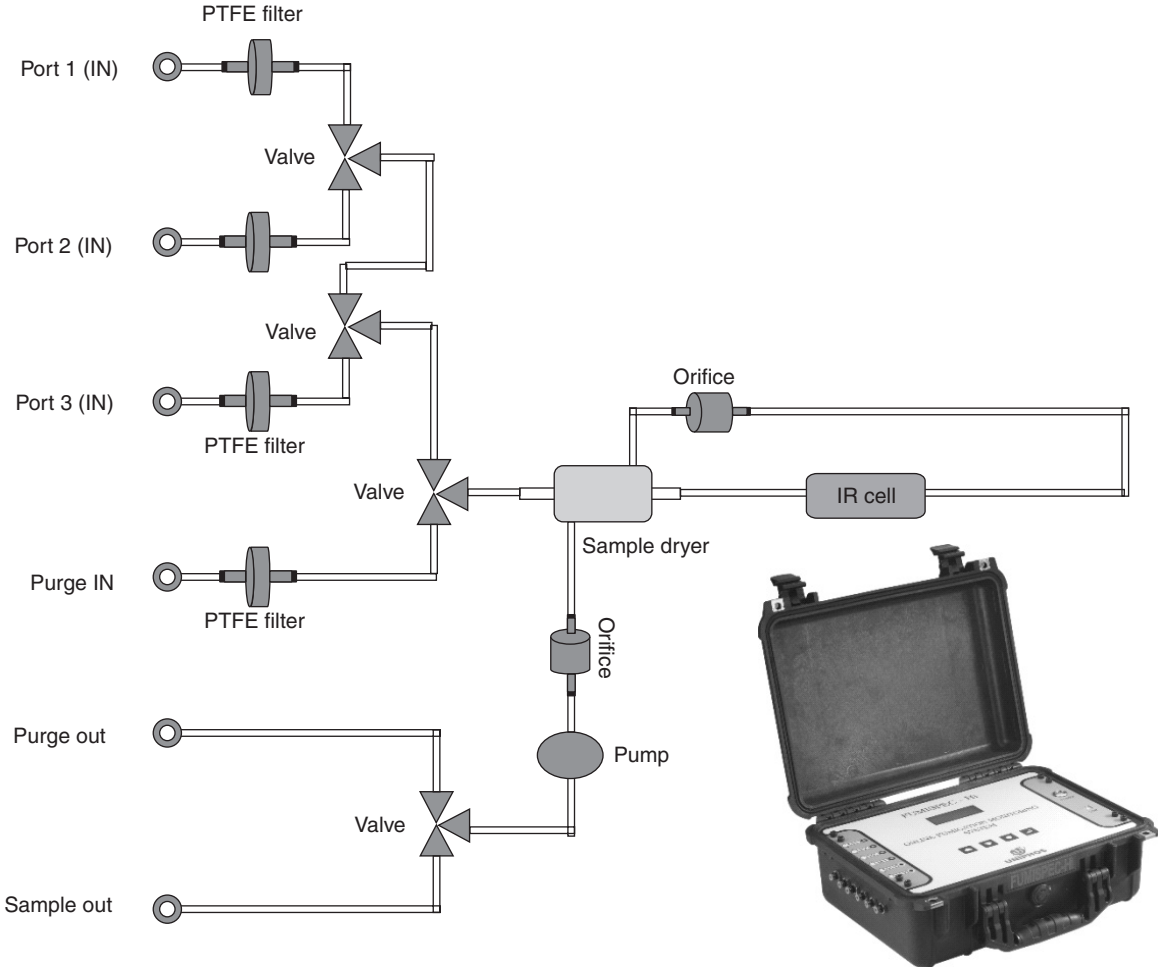

Fig. 4. Block diagram of 3-Port SO_2F_2 fumigation monitor

The concentration vs digital counts is plotted which is as shown in Fig. 5. The calibration curve is found to be exponential which is fitted using suitable techniques to give a linearized output. The R-square value after curve fitting is found to be 0.999.

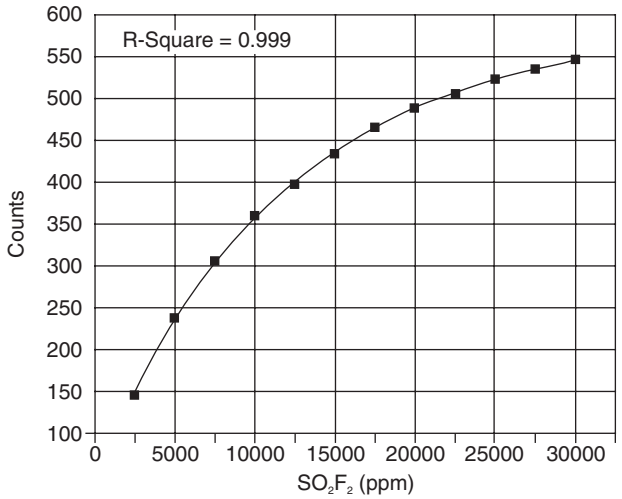

Fig. 5. Calibration curve for a 3-Port SO_2F_2 fumigation monitor

The instrument can be programmed to take samples sequentially from three different locations for analysis. Being a microprocessor based unit, it has data logging facility and is capable of storing upto 4000 data with gas concentration, date, time and silo number. The stored data can also be downloaded to a personal computer or a printer.

REFERENCES

Derrick M, Burgess H, Baker M, Binnie N (1990) Sulfuryl fluoride (vikane): A review of its use as a fumigant. Journal of American Institute of Conservation **29**: 77–90.

Mühle J, Huang J, Weiss RF, Prinn RG, Miller BR, Salameh PK, Harth CM, Fraser PJ, Porter LW, Greally BR, O'Doherty S, Simmonds PG (2009) Sulfuryl fluoride in global atmosphere. Journal of Geophysical Research **114**: 1–13.