Hazardous Gas Sensor in Fumigation Chamber for Orchid Export Industry

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Abstract—Thailand is the top first leading grower and exporter of tropical orchids in the world. A fumigation chamber is an important process for export. However, the weakness of the chamber is the danger of methyl bromide leaking to the fumigation area and free space next to the fumigation chamber. It is risk of dispersing concentrated substances from fumigation by methyl bromide. Methyl bromide is odorless and colorless. Workers and those involved may get poison from methyl bromide. The key objective of this research was to develop a cheap sensor for detecting methyl bromide. The results showed that the developed signal sensor module is as effective as a commercial device. The tendency value is only 5 percent different.

Keywords: Methyl bromide, gas sensor, orchids, fumigation chamber

I. Introduction

The world orchid market is worth around 13,000 million baht. Most of the orchids is tropical orchids. The orchid markets are in over 84 countries. The major countries are Japan, the United States and Europe. Thailand is the world's first producer and exporter of tropical orchids. Thailand has 22,000 rai of cut-flower orchids with 49,000 tons of orchids and 2,500 rai of plantation. The number of orchid growers is about 3,000. In 2016, the export was 25,884 tons worth 3,312.06 million baht. According to the export of cut-flower orchids in Thailand in 2016, it showed that the export to Japan was 29 percent, the export to the United States was 24 percent and the export to Europe was 13 percent. It was increasing steadily (Department of International Trade Promotion, 2017).

Nowadays, the largest importers in the world including Japan, the United States and Europe become stricter about pesticide inspection and pest control system of the origin country. Operators operate Methyl Bromide fumigation before exporting to eliminate pesticide residues in exported orchids. However, residual insects are detected in exported orchids which is a result of a non-standard fumigation chamber system that does not have an appropriate air circulation system inside a fumigation room (Environmental Protection Agency, 1986). Staff who controls fumigation process must have fumigation training and must inspect every step which may cause errors. As methyl bromide is odorless and colorless, workers can get poison from methyl bromide non-inflammable. It is produced both in biology and industry sectors and has the shape of a triangular pyramid structure (Tetrahedral). The gas is well known as an ozone-depleting chemical and was extensively used as an insecticide in the early 2000. Most countries limit the use of this chemical. The chemical name of methyl bromide is Bromomethane and can be classified as Alkyl bromide.

Methyl bromine is odorless and colorless with normal pressure and temperature. The liquid gas

of methyl bromide can be prepared as liquid of 14.4 pounds per gallon under medium pressure. By the method of high-concentration substance extraction, methyl bromide passes through primary metabolism by eliminating nucleophile of ion bromide. The reaction of organic matter in water separates bromide ion and methanol. This is the variation of Glutathione which is an important part of metabolism and detoxification process for methyl bromide (Gehring et al, 1991).

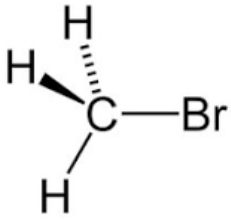

Figure 1 Chemical equation of methyl bromide:

CH_3Br

Source:http://www.futurasciences.us/dico/d/chemistry-methyl-bromide-50003893/ (Online Available: 2018)

which affects several systems of the body.In the short-term, it may cause headache, dizziness, vomiting, blurry vision and stutter. If exposed to high concentration, unconsciousness and seizures may occur and lead to death (Methyl bromide substance, 2018). As a result, the fumigation chamber system must be developed to comply with the conditions of trading partner countries in order to build trust among those partners, reduce returned products and suspended import of Thai orchids in the future. For the safety of workers, this research will control work processes with several methyl bromide detection systems that use an automated control system, a vertical forced-air circulation system and a circulating gas storage system in order to reduce the amount of methyl bromide in the process (Yang & Liu, 2017) to standardize the fumigation chamber system for premium cut-flower orchids to be exported. This enables Thailand to maintain being one of the manufacturers and exporters of high-quality orchids, which is consistent with Thailand 4.0 policy that promotes innovation in value-added agricultural products with the use of advanced technology. Methyl bromide is used extensively in pest control in agricultural products, including orchid flowers. Methyl bromide is implemented under the Montreal Protocol with the effect of ozone depletion. Methyl bromide is a bromine compound with the formula of CH3Br as in Figure 1. This gas is odorless, colorless.

Inhalation of methyl bromide causes headache, spasms, dizziness, wheezing, vomiting, haunting, abdominal pain, loss of speech and interaction. When methyl bromide touches the skin, it may cause itchiness and tingled. It can also be absorbed into skin. The symptoms of absorption are redness and pain. When methyl bromide comes into contact with eyes, the eyes become blurred and temporarily lose sight.

Methyl bromide is a natural substance in oceans, plants and soil. Methyl bromide added to the atmosphere by humans contributes to a thinner ozone layer which can increase UV ray to the surface of the earth. It not only creates the potential impact on human health and the environment but also on agricultural crops (Liu, 2016).

Figure 2 Fresh orchid flowers for export
Source: Photo by the writer

After a florist cuts orchid flowers from an orchid farm, preparation of orchids is an important step before the event.

Figure 2 shows fresh orchids. Figure 3 and 4 show the orchids prepared by the different colors of orchids. In preparing a fumigation area, it must be ensured that there is enough space on all sides and space above work area. If the bag is too close to the wall or pole, fumigation should not be performed unless it can be done safely and efficiently.

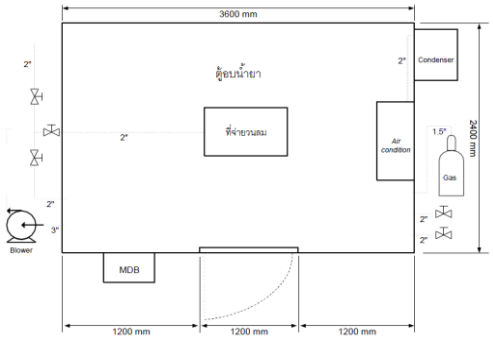

Figure 3 Fumigation room
Source: Photo by the writer

Figure 4 Preparation of orchids before export (continued)

Source: Photograph by the writer

II. Objectives

1. To design and create a cheap methyl bromide sensor in fumigation chamber for export of fresh orchid industry.
2. To create safety for operators both inside and outside a fumigation chamber.

III. Design of fumigation process

This section describes the design of orchid fumigation chamber and the sensor developed for the experiment, issues to consider for the fumigation chamber and the release of the substance into the atmosphere. The chamber size must be related to the amount of substance, the product type and how to deal with such product. The design should be easy for maintenance and the cost of requesting for a permission in order to specify equipment according to standards to increase efficiency and ease of use. In the event that the chamber is used continuously or loaded with heavy materials, strong construction is required in accordance with safety engineering principles. The design of the orchid fumigation chamber as shown in Figure 5 consists of; 1. a chamber with the size of 3.6 x 2.4 x 2.5 meters; 2. a gas cylinder and; 3. a specially designed air circulation system to enable thorough air circulation. Figure 6 shows a 3D orchid fumigation chamber drawing.

Figure 5 An orchid fumigation chamber design

Source: Photograph by Phumpho Corporation Company Limited

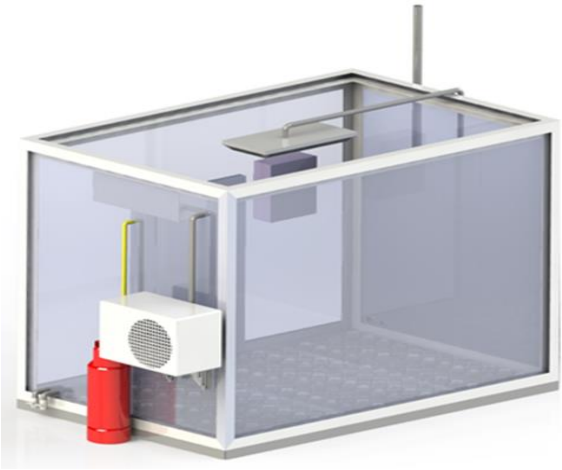

Figure 6 A design of 3D orchid fumigation chamber

Source: Photograph by Poompoh Corporation Co., Ltd.

In this research, a commercial sensor is compared to the developed sensor or Fumiscope version 5.1.Fumiscope is a portable tool for measuring gas concentration in the air. It is the calibration for methyl bromide measurement in the concentration used in fumigation. However, this sensor is not suitable for real-time operation. The developed sensor comes with the gas sensor, the temperature sensor and the humidity sensor and it transfer real-time data to a memory card in order to compare the data of the commercial sensor. Figure 7 shows Fumiscope and the test setting of the developed sensor.

Figure 7 Comparison of Fumiscope Version 5.1 and the developed sensor for measuring methyl bromide in the experiment

Source: Photograph by the writer

IV. Results

This section discusses the comparison between Fumiscope Version 5.1 and the developed sensor. The methyl bromide was added in the orchid fumigation chamber. It was required to wait until Fumiscope showed the content of methyl bromide reached 100 percent. After that, it the content of methyl bromide was reduced to 20 percent. This process was recorded in the microcontroller. The results are demonstrated in Figure 8. When compared to the ratio in the range of 20 - 100 percent, it was found that the tendency values were only 5 percent different. The above sensor could detect the amount of methyl bromide. When working with the system control system, the system could prevent workers from entering the chamber before any residual substances in the fumigation chamber would completely evaporate.

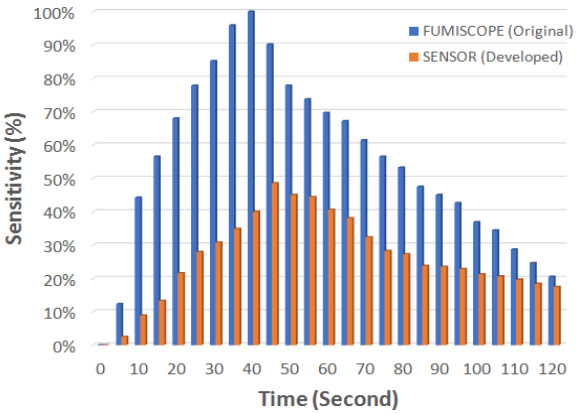

Figure 8 A comparison of results of Fumiscope Version 5.1 and of the developed sensor
Source: Photograph by the writer

V. Summary and discussion

The cheap sensor for detecting methyl bromide in this research can measure the amount of methyl bromide in a fumigation chamber. The different sensitivity value between Fumiscope and the developed sensor was 5 seconds delayed. The delay did not affect the orchid fumigation process. The tendency values were only 5 percent different. The results show that the developed sensor module is as effective as a commercial device. This sensor can be used to monitor the amount of methyl bromide gas for safety operation.

VI. Acknowledgement

This research was sponsored by Phumpho Corporation Company Limited in 2018. The company also provided measuring equipment as well as a fumigation chamber specially designed for the experiment.

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