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EVALUATION OF "PROPYLENE OXIDE" AS A FUMIGANT

EVALUATION OF "PROPYLENE OXIDE" AS A FUMIGANT

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The results indicate that propylene oxide is inferior to ethylene oxide as a fungicide. It has no superiority when compared with methyl bromide and chloropicrin, which have the advantage of non-explosive.

These results show that the reagent has limited use as a fungicide.

(Received January 27, 1964)

Introduction

To date, use of a fumigant in our country has been limited to extermination of a virus and insect which hamper the preservation of grains or for the sterilization of agricultural soil. However, as the concern for good hygiene becomes greater, an attempt has been made for the utilization of a fumigant (besides the preservation of food by additives) from the view point of preinstalling the fungicide in the manufacturing materials and the manufactured goods or in the packaging materials which are easily contaminated by a micro-organism. Thus, the utilization of a fumigant is extended widely and even to the sterilization of medicinal containers. Under these circumstances, we have investigated the effects of several fumigants. In this paper, we report on the fungicidal and insecticidal properties of propylene oxide and its effects on the fumigating materials.

Experimental Method

The method is the same as in the previous report[1] so that the comparison can be made with the results obtained from ethylene oxide, methyl bromide or their mixtures. In order to examine the fungicidal power, penicillium islandicum or aspergillus or sometimes asp terreus are bred as parasites on an unpolished rice for 7-10 days at 28-30° and used in the experiment. For a micro-organism, the curry-powder, which is known to contain spore forming bacteria, is employed. Two grams of powder, or an appropriate amount to fill the tube, in case of particles, are packed in a pre-sterilized glass tube (diameter 1.7 x length 7.5 cm) with cotton at both ends. An imago, larva, chrysalis and egg of Kokuzo are placed in the bag along with rice for experimental use. A metallic container with a capacity of 1.5 m^3 (fan and temperature adjuster attached) is used as a fumigation container. For the fundamental experiment, the test materials are placed in a fumigation container and the reagent is passed through. However, for a small scale practical experiment, the test material was placed on the outer part or center part of a rice bag (30 kg content) and a flour bag (20 kg content), which are packaged by kraft paper bag. These were placod in a fumigation container and the reagent is passed through. The time of fumigation was 24 hours and the determinations on the fungicidal effects were conducted by a flow method for powder and an inspection method of particles unit for particles. As for the insecticidal effect, the observations were continued for a month after the fumigation under a breeding environment. The flour was fumigated with propylene oxide and the changes in its property as bread material were examined. Twenty kg of this flour was fumigated with 30 kg of unpolished rice for 24 hours in a 1.5 m^3 fumigation container using the reagent at 213 g/1.5 m^3. Bread test and its property changes on this material were examined by the methods of the Timotaki graph, Amylograph and Albeograph. Also, the movement of gluten and β-amylase were examined. The repeat experiment for bread was conducted using 250 g/1.5 m^3 of reagent under the same conditions and the result was confirmed.

1. Experimental results and observations

1) Fungicidal and Insecticidal effects

The amount of ethylene oxide, methyl bromide or its mixture were respectively determined for the comparisons sake as in the previous report, and a fundamental and a small scale practical experiment were carried out.

1) Fundamental experiment

The materials noted above were suspended in a fumigating container and fumigated with each reagent for 24 hours. The results are shown in Table 1. When these are compared with the case of ethylene oxide, it was observed that the insecticidal power was low. Thus, in order to confirm this phenomenon, the comparison was made with the results of practical experiments.

2) Practical experiment

The amount of reagent was determined from the basis of fundamental exporimont. The material was placed in the fumigating material as doscribod in experimental method and investigatod from the practical standpoint. Since the limit of explosion is narrowed and the insecticidal offocts are high when methyl bromide is mixed in the reagent as shown from the research of ethylene oxide, the mixtures of methyl bromide and the

Table 1. The Relationship of the Amount of Fumigant and the Fungicidal and Insecticidal Effect. (The values are extinction rate (%))

(1) 薬量	(2) 容器内温度 / (3) 供試料	(4) カレー粉粉末内の細菌	(5) *Asp. terreus* の被害粒	(6) *Asp. chevalieri* の被害粒	(7) *Pen. islandicum* の被害粒	(8) コクゾウ (成虫・幼虫・サナギ・卵)
202g/1.5m³	27°	99.9	100	100	100	100
203g/1.5m³	22°	67.0	100	100	100	100
102g/1.5m³	27°	79.0	100	100	100	100
50.8g/1.5m³	27°	55.0	(9) 供試米粒の20%程度より菌糸の伸長が認められた.	(10) 無クン蒸区との差が認めにくい.	(11) 米粒面に形成の胞子は死滅しているが, 被害粒のごく一部より2週間後に菌糸の伸長を認めた.	100

Key to Table 1:

1. Amount of reagent
2. Temperature of container
3. Test material
4. Bacterium in curry powder
5. Damaged particle in Asp. terreus
6. Damaged particle in Asp. chevalieri
7. Damaged particle in Pen. islandicum
8. Kokuzo (imago, larva, chrysalis and egg)
9. Fibroid bacilli are observed in about 20% of test rice
10. No significant difference from unfumigated area
11. Spore formed on rice surface is extinct, but fibroid bacilli are observed two weeks later on the part of damaged particles.

reagent (propylene oxide) were used in this experiment and its usefulness investigated. The results are shown in Table 2. A difference was observed in the values of propylene oxide alone comparing it with the values of the fundamental experiment. We plan to explain this descrepancy from the measurements of gas penetration and absorption status. Although we felt the need for further work on the mixture of methyl bromide and propylene oxide, a superior property as an insecticidal fumigant has not been discovered from this work.

2. The quality of propylene oxide fumigated flour as bread material.

Employing the fumigated flour according to the method described above, the following investigations were carried out to examine the change in its property as bread material. For the convenience of experiment, the bread material was taken out 6 days and 20 days after fumigation from the paper bags in room and examined for whether there was a difference in the results due to elapsed time. For all other materials, the change in their properties were examined 30 days after fumigation.

Table 2. Fungicidal Effects of Each Reagent Depending on the Location of Test Material

	(1) 薬剤名と投薬量	(2) 試料区分 / (3) 試料挿入位置	(4) 容器内空間	(5) 小麦粉袋内 外側 (a)	(5) 小麦粉袋内 中心部 (b)	(6) 玄米袋内 外側 (a)	(6) 玄米袋内 中心部 (b)
(7)	酸化プロピレン 213 g/1.5m³	カレー粉内の Spore forming Bacteria	—	60	53	72	56
		Asp. chevalieri の被害粒	—	+++	++++	+	+++
		Pen. islandicum の被害粒	100	100	100	100	100
		コクゾウの成・幼虫, サナギ, 卵	100	100	100	100	100
(8)	酸化プロピレン 200 g / 臭化メチル 130 g / 1.5m³	カレー粉内の Spore forming Bacteria	93	93	85	90	87
		Asp. chevalieri の被害粒	100	100	100	100	100
		Pen. islandicum の被害粒	100	100	100	100	100
(9)	酸化プロピレン 250 g / 臭化メチル 66 g / 1.5m³	カレー粉内の Spore forming Bacteria	95	85	80	88	81
		Asp. chevalieri の被害粒	100	100	++	100	++
		Pen. islandicum の被害粒	100	100	100	100	100
		コクゾウの成・幼虫, サナギ, 卵	100	100	100	100	100

(10) 注) 被害粒を粒数検査した場合の状態は，無クン蒸のものを卌とし，これとの比較により標示した．(数値は死滅率 (%))

Key to Table 2:

1. Reagent and its amount
2. Test material
3. Location of text material
4. Space in container
5. Inside the flour bag (a) outer part (b) center part
6. Inside the unpolished rice bag (a) outer part (b) center part
7. Propylene oxide 213 g/1.5m³ — Spore forming bacteria in curry powder; Damaged particles of Asp. chevalieri; Damaged particles of Pen. islandicum; Imago, larva, chysalis and egg of Kokuzo
8. Propylene oxide 200 g, Methyl bromide 130 g / 1.5m³ — Spore forming bacteria in curry powder; Damaged particles of Asp. chevalieri; Damaged particles of Pen. islandicum
9. Propylene oxide 250 g, Methyl bromide 66 g / 1.5m³ — Spore forming bacteria in curry powder; Damaged particles of Asp. chevalieri; Damaged particles of Pen. islandicum; Imago, larva, chrysalis and egg of Kokuzo
10. When the damaged particles are inspected, the unfumigated material is indicated as ++++ and a comparison with this is shown. (number is extinction rate (%))

1) Bread test

In the investigations of expansion of raw bread material whose flour was examined prior to bread manufacturing, only the phenomenon of rotation of the fumigated material at the bottom of unfumigated flour was observed. The raw material bread was made by mixing in the proportion of yeast 2, sodium chloride 1.7, sugar 4, shortening 3, and water 64.5 for flour 100. Bread was manufactured by first fermentation for 90 minutes and second fermentation for 45 minutes at 30°. Next, these were placed for 15 minutes at 25° and after leaving these in a 37° oven with 90% humidity for 15 minutes, a general method of baking at 218.3° and humidity 18% for 20 minutes was adopted.

Bread, thus prepared, was examined as to its weight, volume or its function and the results shown in Table 3 were obtained. From these values, it was recognized from the volume that the fumigated flour was superior.

Table 3

	(1) クン蒸終了直後		(2) クン蒸終了6日後		(3) クン蒸終了20日後	
	(a) 無クン蒸小麦粉	(b) クン蒸小麦粉	(a) 無クン蒸小麦粉	(b) クン蒸小麦粉	(a) 無クン蒸小麦粉	(b) クン蒸小麦粉
Weight (g)	140, 141	142, 141	144, 143	144, 143	145, 144	143, 143
Volume (ml)	650, 645	665, 670	650, 655	675, 670	665, 660	675, 670
Volume	8.75	9.07	8.75	9.07	8.75	9.07
Skin color	7.25	7.00	7.00	7.00	7.00	7.00
Shape uniformity	4.37	4.37	4.37	4.37	4.37	4.37
Baking uniformity	2.60	2.60	2.60	2.60	2.60	2.60
Skin property	3.50	3.50	3.50	3.50	3.50	3.50
Form	13.13	12.65	13.13	13.13	13.13	13.13
Inside color	8.75	8.75	8.75	8.75	8.75	8.75
Flavor	8.75	8.60	8.75	8.70	8.75	8.75
Taste	17.52	16.89	17.52	17.00	17.52	17.42
Tactile sense	13.13	13.13	13.13	13.13	13.13	13.20
Total	87.75	86.56	87.50	87.25	87.50	87.79

Key to Table 3:

1. Right after the completion of fumigation (a) Unfumigated flour (b) Fumigated flour
2. 6 days after fumigation (a) Unfumigated flour (b) Fumigated flour
3. 20 days after fumigation (a) Unfumigated flour (b) Fumigated flour

However, characteristic fumes which were irritating to eyes was dispersed during the process of baking from the fumigated flour aged more than 20 days. A characteristic taste of bread was lost perhaps due to this evaporation. Since this phenomenon is related to the value of utility as a fumigant, the experiments were repeated and the same results were obtained.

Thus, if the reagent sterilized incompletely and affected the property of the fumigating material, the value as a fumigant is doubtful. Now, the effects of the reagent on the property of flour were investigated by the measurements described below.

2) Investigation by Timotaki graph

The amount of carbon dioxide evolution in the bread material and its changes with time or the amount of carbon dioxide maintained by bread material were investigated by Timotaki graph. From these, the results of Table 4 were evaluated. For the fumigated flour, the total value of carbon dioxide evolution was low, but the amount of carbon dioxide maintained by bread material was greater.

Table 4. Comparative Values on the Amount of Gas by Timotaki Graph

	Total Carbon Dioxide (ml)	Maintained Carbon Dioxide (ml)
Unfumigated flour	2372.15	1257.01
Fumigated flour	2204.35	1337.86

3) Investigation by Amylograph

The results of the measurement on the movement of bread material in oven are shown in Figure 1. The effect of flour on amylase by fumigation was not observed.

4) Investigation by Albeograph

Employing Alboograph, the hardness and elongation of the bread materials were examined and shown in Figure 2. There was not much difference in viscosity and stability, but a slight decrease in elongation was observed for the case of fumigated flour.

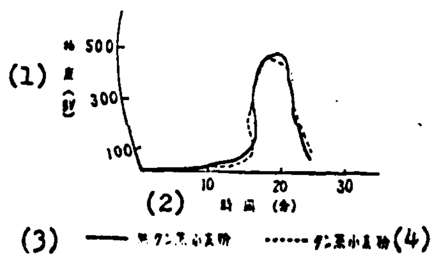

Figure 1.

Amylograph

Key: 1. Viscosity
2. Time (minute)
3. ——Unfumigated flour
4. -----Fumigated flour

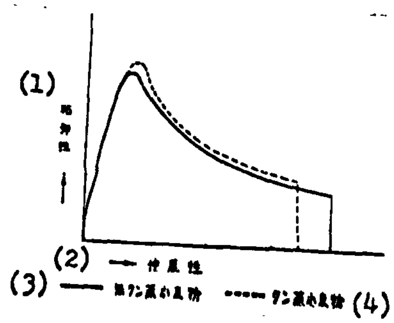

Figure 2.

Albeograph

Key: 1. Viscoelastic property
2. Elongation property
3. ——Unfumigated flour
4. -----Fumigated flour

5) Effects on gluten and β-amylase.

Since a fumigation may possibly affect the gluten or the l-amylase in flour, the amount of gluten was measured by simple quantitative method and the values for unfumigated flour 40.5 vs fumigated flour 40.0 were obtained. Also, the measurements were compared with the value from l-amylase. Maltose value for unfumigated flour was 267.0 mg. and for fumigated flour it was 256.3 mg. No significant difference is observed for either one.

Summary

Propylene oxide was investigated for its suitability as a fumigant and the following information was obtained.

1. The fungicidal power is inferior to ethylene oxide as reported earlier. Also, a suporior property was not observed when compared with non-explosive methyl bromide and chlorpicrin.

2. Much information was obtained from the investigation of fumigatod flour as bread material. Among these, besides a small change in composition, an irritating material is evaporated during the baking process of fumigated flour aged for 20 days and the taste of bread is decreased. Thus, the fumigation of flour by this reagent loses its value. Therefore, propylene oxide is doubtful as a fumigant.

Cooperation of members of the Grain Process Research Laboratory in conducting Amylograph and Albeograph experimont is appreciated and thanks are duo to Dr. Sato, Head of the Nutrition Department for encouragement and Sanko Chemical Industrial, Inc. for supplying the tost materials.

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