INTERACTION OF ETHANEDINITRILE (C2N2) WITH CONTACT MATERIALS USED IN GRAIN STORAGE

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Introduction

The agricultural industry has relied heavily on the use of methyl bromide (MeBr) for the eradication of deep-seated insect infestations in a wide variety of applications ranging from soil to structural fumigation, for more than 50 years. The attraction of MeBr lies in its non-reaction with structural materials, quick penetration, non-flammability and effective toxicity to a range of pests. Its major disadvantage, however, is that it is now classed as an ozone-depleting chemical and is listed under the Montreal Protocol. This protocol requires its use to be progressively reduced and completely phased out by the year 2005. This scenario has forced researchers to come up with an effective alternative to MeBr.

In response to this challenge, CSIRO Entomology Stored Grain Research Laboratory (SGRL) has developed and patented ethanedinitrile (C_2N_2) as a fumigant to replace methyl bromide (MeBr) in a variety of applications. C_2N_2 is currently under evaluation for its use as a fumigant for soil, timber and commodities. However, it is necessary to establish that C_2N_2 does not have unacceptable impacts on the structures present in grain storage facilities.

As different types of materials like metals and plastics (PVC pipes and sheets etc) are present in a grain storage facility, it was imperative to study the interaction of C_2N_2 with such materials to ascertain its favourable as well as adverse effects. The objectives of this investigation were 1: To find out the relative sorption of C_2N_2 over time by the materials used and 2: To observe any discoloration of test materials that could potentially be an undesirable property of C_2N_2.

Materials and Methods

Metal sheets (copper, aluminium, galvanized steel and stainless steal) and plastic materials (Canvacorn™, Canvacorn 5000Q™, Land Mark and PVC), kindly provided by GRAINCO, Queensland, were cut into rectangular pieces (7.5 X 3.7cm). All materials were conditioned at a temperature of 30°C with a relative humidity (RH) of 70±3% for a period of 24h prior to their use.

Round flat-mouthed 250ml glass jars were filled with the pieces to a 20% (fill ratio) of total volume in the case of plastic and 10% fill ratio in the case of metals. The glass jars were closed air-tight with the help of an O-ring in the plastic lid as well as by additional wrapping by duct tape from the outside. Samples were kept at 30°C except when monitoring. All materials were tested in duplicate jars with a single dose of C_2N_2, introduced through the septum, at a rate of 100mg/L, with a control containing no material.

Sorption of C_2N_2 was monitored by measuring headspace concentration with a gas chromatograph (Varian3300 having TSD detector at 250°C and column (J&W Scientific, 30m X 0.53mm id) and injector temperature of 110°C and 125°C, respectively) over a period of two days with more frequent readings taken in the first 4 hours. C_2N_2 concentration was calculated using a standard curve prepared by external standards which were also incubated along with the samples. The data were statistically analysed and are presented in Figures 1 and 2. After the end of incubation, the test materials were placed side by side with the untreated samples to be visually rated for change in colour by 5 independent observers.

Results

The test materials were fumigated with C_2N_2 at relative humidity of 70% or higher. Normally, fumigation is carried out at humidity of less than 70%. However, a worst case scenario was tested based on a moisture content of 13.5 to 14.5% (equivalent to RH ~70% at 25°C). Generally, application of C_2N_2 to the metals (Figure 1) had no significant effect on its sorption when compared to the control. In contrast to metals, C_2N_2 sorption by plastic (Figure 2) materials was significantly higher with the exception of PVC. The maximum sorption of C_2N_2 occurred in Land Mark reducing the headspace concentration to < 5mg/L after 18h of application, which was significantly higher than other materials. The order of sorption among the test material was Land Mark > Canvacorn 5000Q™ > Canvacorn™ > PVC + Control. Land Mark resulted in almost complete sorption of applied C_2N_2 over 24h.

Observation for discoloration of test materials showed no effect of C_2N_2 application on metals. However, a marked change in colour was observed in Canvacorn 5000Q™ from sky blue to olivaceous grey. A slight but significant colour change, from light blue to dark blue, was also observed in Land Mark. However, no significant colour change was witnessed in PVC and Canvacorn™ in response to the applied dose (100mg/L) of C_2N_2.

Conclusions

The following conclusions were drawn on the basis of results of current investigation.

1. Applied C_2N_2 did not react with the metal surfaces significantly even under high relative humidity (70±3%) and temperature (30°C) conditions.
2. Sorption of applied C_2N_2 by different types of plastic material varied significantly, which could impact the effectiveness of fumigation.
3. C_2N_2 reacted significantly with the type of plastic material used. It caused a significant colour change in Canvacorn 5000Q™ and Land Mark, which may or may not be desirable depending upon how it affects its structural stability and aesthetic sense of the customer.
4. Further experimentation is warranted to determine a) The efficacy of C_2N_2 fumigation during the time course it takes for sorption and b) Its post application transformation/degradation.

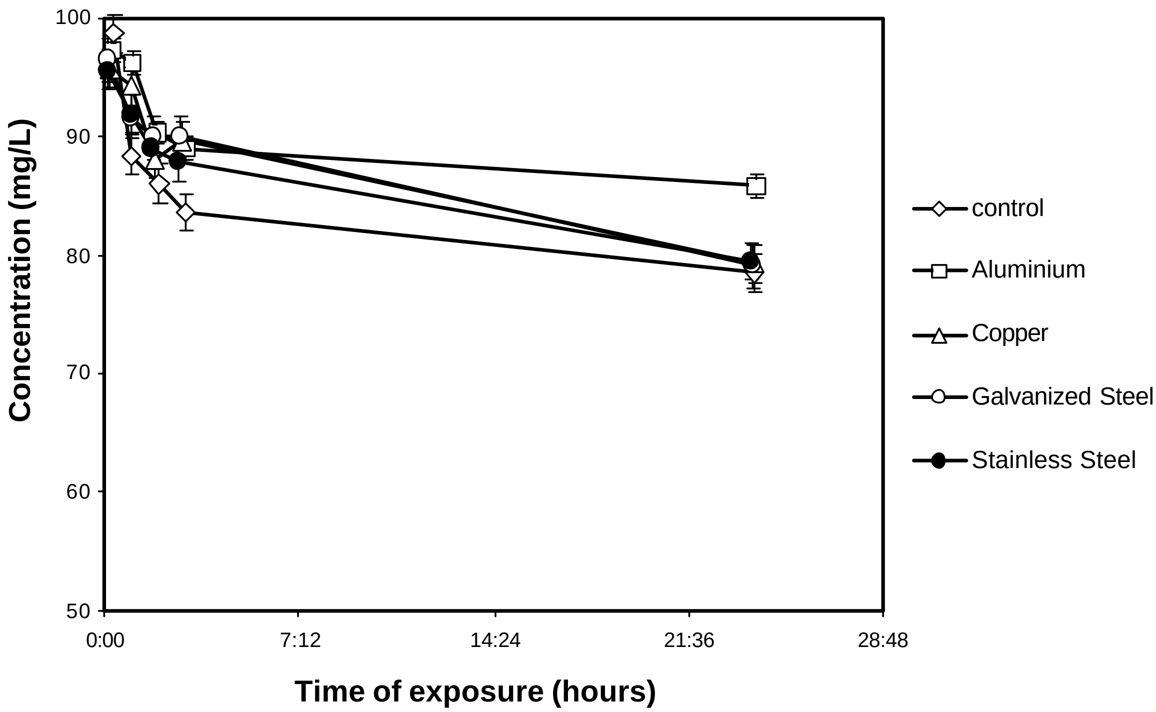

Figure 1. Sorption of Ethanedinitrile (C2N2) by different types of metals

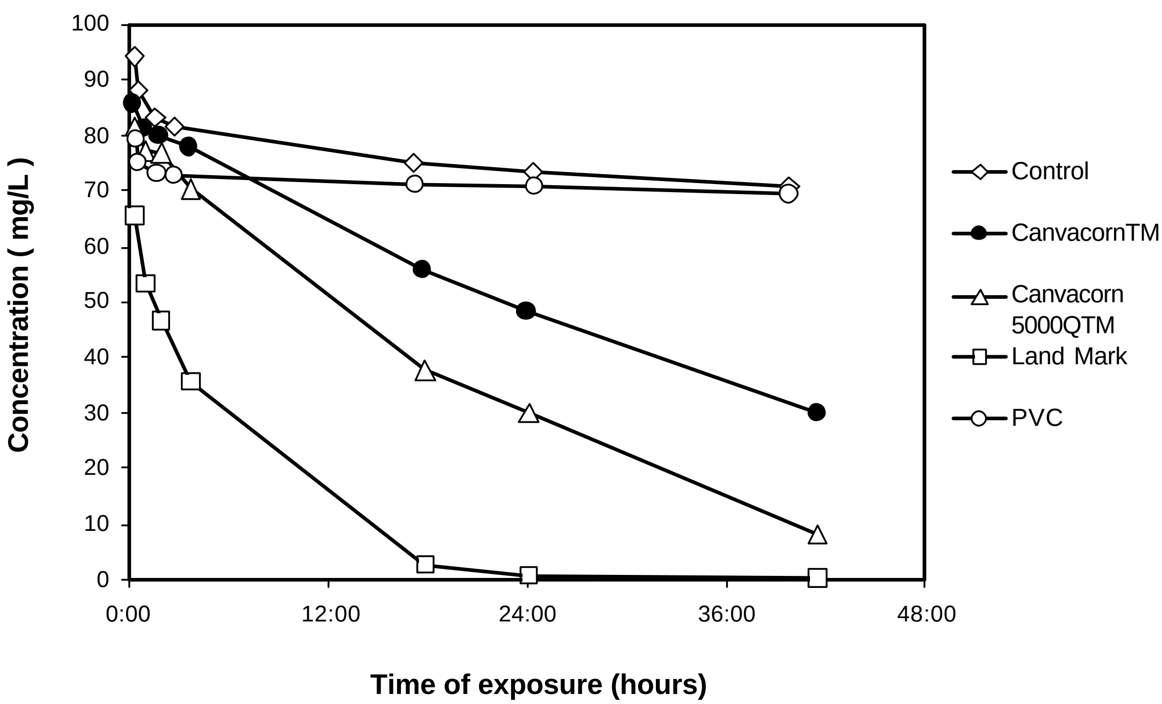

Figure 2. Sorption of Ethanedinitrile (C2N2) by different types of plastic material.