TOXICITY OF PROPYLENE OXIDE IN COMBINATION WITH VACUUM OR CO_2 TO *T. castaneum*

A. A. Isikber[1*], S. Navarro[2], S. Finkelman[2] and A. Azrieli[2]

[1]Department of Plant Protection, Faculty of Agriculture, University of Kahramanmaras Sutcu Imam, 46060 Kahramanmaras, Turkey, e-mail: <isikber@yahoo.com >
[2]Department of Stored Products, Agricultural Research Organization, The Volcani Center, P.O.Box 6, Bet-Dagan 50250, Israel, e-mail: <vtshlo@netvision.net.il>

Propylene oxide (PPO) is an FDA approved fumigant to control microbial contamination in dry and shelled walnuts. PPO boils at 35°C under NTP, is a liquid, and has a low toxicity. It is also not an ozone depleter and is environmentally benign. Methyl bromide is phased out as a fumigant under the Montreal Protocol and phosphine is not applicable or practical for all stored commodities due to its slow action. Therefore, considerable research is under way worldwide to find out chemical and non-chemical alternatives to Methyl bromide.

PPO has been recently demonstrated by preliminary tests to have insecticidal properties under vacuum conditions and to show potential as fumigant by killing all stages of the confused flour beetle, the Indian meal moth and the warehouse beetle. PPO is flammable from 3 to 37% in air and therefore, to avoid flammability it can be applied under low pressure or CO_2-enriched atmospheres. PPO effectiveness at low pressure or in a combination with CO_2 requires elucidation to clarify the efficiency of each treatment alone or in combination. Therefore, this study was carried out to determine (1) the efficacy of low pressure (100 mm Hg) and CO_2 (92%) alone, (2) toxicity of PPO alone during short exposure time using wide range of concentration, and (3) efficacy of PPO in combination with low pressure (100 mm Hg) and CO_2 (92%).

The insect used in this study was red flour beetle, *Tribolium castaneum* (Herbst). 50 larvae and adults a week olds, and 50 pupae and 100 eggs 2-3 days olds was used for the tests. All the tests were carried out in 3-liter desiccators at a temperature of 30°C and 70% relative humidity. Prior to each test, each stage of *T. castaneum* was confined in metal cage with a small amount of diet. For PPO fumigation, PPO was introduced as liquid into the desiccators by using gas-tight micro-syringe. Concentrations of 8.6, 17.2, 25.8, 34.4, 68.8, 103.2, 137.6 mg/L were tested for each stage of the insect. For PPO treatment with low pressure and CO_2, after insects were placed in the desiccators, 100 mm Hg vacuum was obtained by evacuating air with a vacuum pump. For 92% CO_2, the CO_2 concentration was obtained after evacuation of the jar and restoring the atmosphere pressure by CO_2. Thereafter, PPO was injected into the desiccators. Each of the combinations with CO_2 and low pressure in the desiccators was tested with four to six dosages of PPO namely, 4.3, 8.6, 17.2, 25.8, 34.4 and 44.8 mg/L plus vacuum (100 mm Hg) and 92% CO_2 treatment alone and control. The gas mixture in fumigation chambers was stirred for 15 min and the exposure time was 4 h. During the experiments the concentrations of PPO were monitored using a gas chromatograph and CO_2 concentrations using a thermal conductivity detector. After each experiment, each stage of the insect was kept at 26°C and 75% relative humidity until controlling for mortality. Probit analysis was applied to data on mortality of each stage of the insect.

For PPO alone, eggs, larvae, pupae and adults required a concentration of 30.1, 83.5, 146.5 and 55.4 mg/L respectively to achieve LD_{99} for 4 h. As seen from the results, there was a remarkable difference in susceptibility between the stages of the insect tested. The order of tolerance of the life stages at LD_{99} to PPO alone was pupa > larva > adult > egg. There was not any or negligible mortality of all life stages except egg stage (53 to 62%), when exposed 92% CO_2 and vacuum (100 mm Hg) alone for 4 h. However, propylene oxide in combination with both 100 mm Hg and 92% CO_2 reduced the LD_{50} and LD_{99} values of all life stages significantly. PPO in combination with 92% CO_2 and 100 mm Hg decreased LD_{99} value from 146.5 mg/L to approximately 20 mg/L for the most tolerant stage, pupae. Both combination treatments also produced a significant decrease in the LD_{99} of the larvae and adults (6.2- to 8.7-fold) compared with exposure to propylene oxide alone

The results obtained from this study suggest that the combination of propylene oxide with CO_2 or vacuum can be a potential as fumigant for replacing Methyl Bromide in some critical applications. However, further research is needed to obtain data on its absorption by different commodities and its penetration through the mass of commodities.