Comparison of a Novel Liquid Crystal Monitor for Organophosphate Pesticides to a Conventional Sampling Method

A. Barteková, P. Raynor, J. Adgate
University of Minnesota
Division of Environmental Health Sciences
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About the Project

• This study is a joint effort between Platypus Technologies, LLC, which has fabricated the Platypus™ OP Monitors, and the Department of Environmental Health Sciences at the University of Minnesota, where the monitors have been tested under laboratory conditions.

• The monitors have been developed for the measurement of environmental exposure to organophosphate (OP) pesticides.

• They are designed to be small, inexpensive, and wearable.
Study Objectives

• Develop methods to test the OP monitors in the laboratory
• Gain experience reading the OP monitors with a flatbed scanner
• Validate the performance of the monitors in the laboratory under realistic conditions of concentration, temperature, and relative humidity for both the vapor alone and aerosol
• Confirm the performance of the monitors in field tests
OP Pesticides

- Account for about half of the insecticides used in the United States currently (CDC, 2005)
- About 40 OP pesticides are registered for use in the U.S. (CDC, 2005)
- More worldwide
- Examples
  - Malathion
  - Parathion
  - Chlorpyrifos
  - Terbufos
  - Diazinon
**OP Pesticide Effects**

- Inhibition of the enzyme acetylcholinesterase that degrades acetylcholine following stimulation of a nerve.
- Accumulation of acetylcholine lead initially to excessive stimulation of the central nervous system (CNS) followed by depression of the CNS.
- Populations potentially affected by airborne exposures to semi-volatile aerosol during spraying or to residual vapor after spraying:
  - Applicators
  - Farm workers
  - Families of applicators and farm workers
  - Neighbors
R&D Monitors
OP Pesticide Detection

Surface

Gold film
Ligand
Metal salt
Liquid crystal: Homeotropical alignment

Surface

Pesticide
Planar alignment
Ligand alignment
Test Plan

• Use diazinon as a test compound
• Calibrate monitor response to NIOSH Method 5600 (sampling with filter/XAD-2 tube)
• Evaluate monitor response to cumulative exposures of diazinon vapor as a function of concentration
• Evaluate monitor response to diazinon vapor as a function of temperature and humidity
• Compare response of monitors to diazinon vapor to their response to diazinon aerosols
Diazinon

• Organophosphate insecticide, restricted use
• All residential products eliminated in U.S. in 2004
• 4 million lb/yr still used for agriculture
• PEL for diazinon is 100 μg/m³ (~8 ppb) for an 8 hr TWA
• TLV for diazinon is 10 μg/m³ (~0.8 ppb) for an 8 hr TWA
Experimental Apparatus
Experimental Apparatus
Chamber with Heating Jacket
Chamber with Monitors
Cumulative Exposure Tests

- Temperature: 30 °C
- Relative humidity: 50%
- 3 diazinon vapor concentrations: 10 ppb (low), 25 ppb (mid), 100 ppb (high)
  - Actual concentrations averaged 8.4, 21, and 93 ppb
- 4 levels of integrated concentration-time: 200 ppb-hr, 400 ppb-hr, 600 ppb-hr, 800 ppb-hr
  - Actual values ranged from 170 to 770 ppb-hr
- Three blocks of tests to minimize influence of lot-to-lot variability of monitor response on tests
Cumulative Exposure Results

![Cumulative Exposure Results Graph]

Monitor response normalized to low concentration standard condition (mm)

- **Low**
- **Mid**
- **High**

Cumulative exposure (ppb-hr)
Is Liquid Crystal Saturated?

![Graph showing the concentration of liquid crystal in the air vs. concentration accessible by monitor (ppb). The graph indicates a linear relationship between the two values, with a saturation point at around 20 ppb.](image-url)
Cumulative Exposure Results

Monitor response normalized to low concentration standard condition (mm)

- Low
- Mid
- High

Cumulative exposure (ppb-hr)
Other Results

• Effects of Temperature
  – Influences vapor pressure, which is reflected in higher monitor response at higher temperatures
  – More work is needed to discern monitor response as a function of temperature for constant concentration

• Effects of relative humidity (RH)
  – No RH effect has been observed yet in our tests
  – Some concerns from manufacturer at 37 ºC and 95% RH

• In preliminary tests, monitor response to diazinon droplets appears to be minimal
Conclusions

- Platypus™ OP Monitors can provide a predictable response to cumulative exposures of diazinon vapor in laboratory tests.
- Monitors are not successful for concentrations of diazinon vapor greater than about 25 ppb.
- Temperature and humidity effects on monitors need to be tested further, but so far the influence of these factors seems to be small.
- The monitors do not appear to detect diazinon droplets well, possibly limiting effectiveness during direct spray applications.
Next Step: Field Sampling
Contact Information

Pete Raynor
University of Minnesota, School of Public Health
Division of Environmental Health Sciences
Mayo Mail Code 807, 420 Delaware St. SE
Minneapolis, MN  55455

(612) 625-7135

praynor@umn.edu
http://enhs.umn.edu/