piperonyl butoxide (PBO)

Review Date: 11/08/2010
CAS #: 51-03-6

Type	Chemical synergist that increases the effectiveness of other active ingredients.
Controls	Can be found along with other active ingredients in products registered for use in control of flying and crawling insects.
Mode of Action	Prevents a pest from detoxifying other pesticide chemicals.

Thurston County Review Summary:

Piperonyl butoxide (PBO) is a chemical that is added to insecticides to increase the toxicity and effectiveness of other active ingredients. If a product contains PBO, it is always combined with at least one other active ingredient. This review is only about the hazards and risks associated with the use and exposures to PBO itself and not the potential effects of PBO combined with another chemical.

Thurston County rates PBO as conditional. The conditional rating is based on the risk associated with potential PBO exposures (related to specific product applications) and due to inconclusive data concerning carcinogenicity and mutagenicity potenial. PBO is considered moderate in hazard for the potential to move off the site of application with rain or irrigation water, and moderate in hazard for persistence and the potential for bioaccumulation. The risk to birds, mammals, and aquatic organisms appears to have been reduced by the restrictions the EPA has required for specific PBO product applications (Reference 1); therefore, PBO is rated low in hazard for the potential to cause wildlife toxicity.

MOBILITY

Property	Value	Reference	Rating
Water Solubility (mg/L)	14.3 mg/L	3	Low
Soil Sorption (Kd=mL/g)	Not found		
Organic Sorption (Koc=mL/g)	399-830	1	Moderate

Mobility Summary:

Piperonyl butoxide is not very soluble in water and adheres moderately to soil with organic matter. The hazard of piperonyl butoxide to move off the site of application with rain or irrigation water is rated moderate.

PERSISTENCE

Property	Value	Reference	Rating
Vapor Pressure (mm Hg)	<0.0000001	1	High
Biotic or Aerobic Half-life (days)	13	3	Moderate
Abiotic Half-life (days)	Not found		
Terrestrial Field Test Half-life (days)	4.3	5	Low
Hydrolysis Half-life (days)	250	3	High
Anaerobic Half-life (days)	24	5	Moderate
Aquatic Field Test Half-life (days)	0.5 - 1.64	5	Low

Persistence Summary:

PBO degrades mostly by sunlight and biological activity in soil. In aquatic settings, sunlight will likely be the major cause of chemical breakdown and in clear water it can reach half of the applied concentration in hours. Overall, the pesistence hazard of PBO is rated moderate because it is likely to take more than a week but less than two months to degrade to half of the applied concentration.

BIOACCUMULATION

Property	Value	Reference	Rating
Bioaccumulation Factor	Not found		
Bioconcentration Factor	2,175	3	Moderate
Octanol/Water Partition Coefficient	4.95	1	High

Bioaccumulation Summary:

Piperonyl butoxide has a much stronger attraction to organic solvents than it does to water indicating that it may accumulate in fish or animal tissue. Bioconcentration studies indicate that there is a moderate amount of accumulation in fish tissue, however, when the fish are moved to clean water up to 90% of the PBO leaves the fish within a few days (Reference 5). The hazard for bioaccumulation is rated moderate.

ACUTE TOXICITY HAZARD - ECOTOXICITY

Test Subject	Value	Reference	Rating
Mammalian (LD50)	4570 mg/kg	1	Low
Avian (LD50)	>2,250 mg/kg bw	1	Low
Honey bee or insect (LD50)	> 25 µg/bee	1	Low
Annelida -worms (LC50)	Not found		
Fish (LC50)	1.9 ppm	1	Moderate / high
Crustacean (LC50)	0.51 ppm.	1	High
Mollusk (LC50)	0.23 mg/l	5	High
Amphibian (LD50 or LC50)	0.21 ppm	1	High

Acute Toxicity Testing and Ecotoxicity Summary:

Single-dose toxicity studies using PBO alone indicates that it is low in toxicity to mammals, birds, and insects; and moderate to high in toxicity to fish and other aquatic organisms (including frogs). Risk assessments for aquatic organisms, from potential overspray and runoff of PBO, calculates the worst-case risk to be at least 40 times less than the lethal dose to the most sensitive tested species (oyster), and 5 times less than the no observeable adverse effect level (NOAEL) for chronic toxicity (Reference 5). Risk to birds from a single application (at the highest application rate) is at least 8 times less than the EPA's calculated level of concern (Reference 5). Risk to birds from the maximum allowable use of 10 applications per year, is also less than the long-term exposure level of concern. Mosquito abatement products were noted to be of concern to aquatic invertebrates and amphibians, but the EPA believe they mitigated these concerns by establishing specific product label requirements for release heights, droplet size, and application rates. The risk to aquatic organisms, mammals, and to birds from PBO (when used as a pesticide) is rated low.

Incidents reported to the EPA show that products containing PBO with other active ingredients, have the potential to cause adverse effects to aquatic species and to beneficial insects. To better understand the potential impacts on the environment from chemicals combined with synergists (like PBO), the EPA may require product-specific testing for ecotoxicity (Reference 1).

ACUTE TOXICITY - Risk Assessment

Subject and Scenario	Dose of Concern	Exposure	Margin of Safety	Route	Reference	Rating
Residential applicator of liquid spray products	0.89 mg/kg/day	0.033 mg/kg/day	27	Incidental ingestion	1	Low
Toddler bystander near outdoor misting system	0.013 mg/kg/day	0.010 mg/kg/day	<2	Inhalation	1	High
Adult bystander near outdoor misting system	0.013 mg/kg/day	0.0054 mg/kg/day	2.4	Inhalation	1	Moderate
Toddler- indoor aerosol application (2x 16oz cans)	0.013 mg/kg/day	0.013 mg/kg/day	0	Inhalation	1	High

Acute Toxicity Risk Assessment Summary:

Short-term residential exposures from pesticide contact with skin were not evaluated because skin absorption toxicity testing did not produce an adverse effect. The residential exposures that were evaluated included inhalation and ingestion. Residential applicator exposures from mixing and applying PBO products are rated low in hazard because potential exposures were at least 27 times less than the level of concern.

There were several potential exposures that were identified in the risk assessments that exceeded the EPA's level of concern. To address these risks, the EPA restricted several application methods and locations. The changes include restricting carpet dust applications to spot treatments, prohibiting the use of products in metered release devices in residential areas, daycares, nursing homes, schools, and hospitals, and restricting the use of outdoor misting systems by establishing a maximum use rate. To protect occupational applicators, product and label changes also include that wettable powder products will be replaced with water soluble packages, power dusters are no longer an approved application method, indoor crack and crevice applications will be limited to a rate of 0.56 lbs. of active ingredient per 1000 square feet, and specific respirator use is required for certain application methods.

Even with the label change for outdoor misting systems to spray for one half of a minute in duration (down from one minute) the potential exposures to a toddler nearby could still reach over half the dose of concern and is rated high in hazard by Thurston County. The potential exposures to toddlers after the use of indoor aerosol sprays (2 x 16 ounce cans with 0.05 pounds of active ingredient per can) is also rated high in hazard by Thurston County. All of the other exposures of concern were either eliminated or mitigated by the EPA through label and registration changes (requiring lower application rates or with the use of protective clothing for occupational applicators). The remaining short and intermediate term post-application exposures are rated moderate to low in hazard.

CHRONIC TOXICITY HAZARDS

Property	Value	Adverse Effect	Reference	Rating
Carcinogenicity	Group 3	Not classifiable as to its human carcinogenicity	1, 2, and 4	Moderate
Mutagenicity	- -	Questionable positive mutation effect	1	Moderate
Neurotoxicity - (NOAEL)	Not found	"Not evident"	1	Low
Endocrine Disruption	- -	"No toxicologically significant evidence"	1	Moderate
Developmental Toxicity (NOAEL)	630 mg/kg/day	Decrease in maternal weight gain	1	Check risk
Reproductive Toxicity (NOAEL)	89 mg/kg/day	Decrease in pup body weight gain	1	Check risk
Chronic Toxicity (NOAEL)	15.5 mg/kg/day	Hepatocellular hypertrophy, +	1	Check risk

Chronic Toxicity Hazard Summary:

The EPA classifies piperonyl butoxide in Group C- possible human carcinogen (but did not require a cancer risk assessment), the International Agency for Research on Cancer lists it in Group 3 - not classifiable as to human carcinogenicity, and the National Toxicological Program states that it is not carcinogenic. Mutagenicity testing was negative for all tests except the in-vitro mammalian cell assays in which there was a "questionable positive effect for mutation" however, the EPA did not state that PBO was considered a mutagen. There did not appear to be evidence of endocrine disruption in the human health toxicity studies but there may be endocrine effects on avian reproduction and their hatchlings. The EPA may require future evaluation of endocrine system effects. Piperonyl butoxide does not appear to be a developmental or reproductive toxicant nor is it considered neurotoxic. Based on the inconclusive nature or variablity of the data for several chronic toxicity effects, Thurston County rates the long-term toxicity hazards associated with piperonyl butoxide as moderate.

CHRONIC TOXICITY - Risk Assessment

Subject and Scenario	Dose of Concern	Exposure	Margin of Safety	Route	Reference	Rating
Revised applicator exposures were not evaluated						
Long-term contact exposures were not evaluated						
Incidental ingestion exposures were not evaluated						
Long-term combined exposures were not evaluated						

Chronic Toxicity Risk Assessment Summary:

The long-term exposure assessments found for post-application exposures, that did not include dietary exposures (which are not included in Thurston County's review criteria), were applicable only to occupational applicators. However, the exposures of concern identified by the EPA were not just for long-term exposures, they were also for short-term and intermediate-term exposures and were discussed in the Acute Risk Assessment section.

"There were no risks of concern for professional applications to pets or other animals" (Reference 1).

Metabolites and Degradation Products:

PBO-alcohol, PBO-aldehyde, and PBO-acid (Reference 1).

Comments:

Piperonyl butoxide is considered a mild eye and skin irritant (EPA Toxicity Category IV) and is considered a skin sensitizer (Reference 1).

References

1. USEPA. Prevention, Pesticides and Toxic Substances. EPA 738-R-06-005. Reregistration Eligibility Decision (RED) for Piperonyl Butoxide. List B Case No. 2525. June 2006.
2. International Agency for Research on Cancer. Agents Classified by the IARC Monographs, Volumes 1,100. (Accessed 11/5/2010). http://monographs.iarc.fr
3. International Union of Pure & Applied Chemistry. Pesticide Properties Database, piperonyl butoxide (Ref: ENT 14250). Accessed 11/5/2010. http://sitem.herts.ac.uk/aeru/iupac/
4. National Toxicological Program, Department of Health and Human Services. Abstract for TR-120 - Piperonyl Butoxide (CASRN 51-03-6). Report Date: 1979.
5. Glynne Jones, Denys. Academic Press. Piperonyl butoxide: the insecticide synergist. 1998.