ChemicalWATCH Factsheet
A BEYOND PESTICIDES/NCAMP FACTSHEET

DEET

What is DEET?

DEET (N, N-diethyl-*m*-toluamide) is a commonly used, yet controversial, insect repellent applied in and around domestic dwellings, to the human body and clothing, cats, dogs, horses, and pet living and sleeping quarters. Scientists have raised concerns about DEET's toxic properties when used alone and in combination with other chemicals.

Repellents are the only registered pesticides intended to be applied directly to human skin. DEET is used to control biting flies, biting midges, black flies, chiggers, deer flies, fleas, gnats, horse flies, mosquitoes, no-see-ums, sand flies, small flying insects, stable flies, and ticks. There are currently 225 DEET products registered by the EPA. (EPA, 1998)

Scientists are not completely certain how DEET repels biting insects, but it most likely affects insects' ability to locate animals they feed upon. Scientists believe that DEET disturbs the function of special receptors in mosquito antennae that sense chemicals that are produced by humans and other animals. (NPTN, 2000)

DEET Toxicity

In studies using laboratory animals, DEET generally has been shown to be of low acute toxicity, which makes sense since it is directly applied to the skin. The oral rat LD_{50} (lethal dose for half of the test population) is two g/kg of body weight, requiring extremely high levels of exposure. (NIH, 1990) Therefore, toxicity concerns, with some notable exceptions, focus on more subtle impacts on human health.

DEET is slightly toxic by the eye, dermal and oral routes and has been placed in EPA's Toxicity Category III, slightly toxic, (the second lowest of four categories) for these effects. (EPA, 1998) Animals topically exposed to DEET have developed ocular and dermal reactions, including erythema, desquamation, and scarring in horses; profuse sweating, irritation and exfoliation in horses; and ocular reactions in rabbits including edema, tearing, conjunctivitis, pus, and clouding in the eyes. (NYDOH, 1991) Animal experiments indicate that DEET crosses the placenta, and that it is found in the placenta and fetus and in rats three months after birth. (NIH, 1990)

Studies have shown that DEET causes adverse effects in lab animals at high doses, including reduced body weights of pups and increased mortality rates of unborn and baby rats. It does not cause birth defects in rats and rabbits, except when fed high doses. Rats and mice did not develop cancer when fed high doses of DEET over their lifetime. EPA has classified DEET as a group D carcinogen (not classifiable as to human carcinogenicity). Further animal testing data is needed to completely evaluate DEET. (NPTN, 2000)

Duke Medical University pharmacologist Mohamed Abou-Donia, Ph.D. conducted numerous studies in rats, two of them published in 2001, which clearly demonstrate that frequent and prolonged applications of DEET cause neurons to die in regions of the brain that control muscle movement, learning, memory and concentration. Rats treated with an average human dose of DEET (40 mg/kg body weight) performed far worse than control rats when challenged with physical tasks requiring muscle control, strength and coordination - effects consistent with physical symptoms in humans reported in the medical literature, especially by Persian Gulf War veterans. With heavy exposure to DEET and other insecticides, humans may experience memory loss, headache, weakness, fatigue, muscle and joint pain, tremors and shortness of breath. (Duke, 2002)

Adverse human effects, including skin hypersensitivity and eye irritations, have been reported. DEET is absorbed quickly through intact skin; 48% of the applied dose is totally absorbed within six hours. Accumulation on skin has been demonstrated. (NIH, 1990) Dermal application of insect repellents containing DEET can produce a variety of skin reactions in humans. Cases of localized skin irritation, large painful blisters, and permanent scarring of the skin at the crease of the elbow has been reported in soldiers who applied solutions of 50 to 75 percent DEET. Results from surveys of Everglades National Park employees indicate a variety of dermal reactions, including rashes, irritation of skin and mucous membranes, and numb or burning sensations of the lips among park workers who were highly exposed to DEET-containing repellents. Field trials of a 60% DEET formulation on 600 lumbermen resulted in cases of contact dermatitis, conjunctivitis, and aggravation of pre-existing acne conditions. Several cases of young children developing toxic encephalopathy (severe brain involvement) have been associated with the use of DEET, including one death, following repeated exposure to 10% DEET. The toxic encephalopathy was characterized by agitation, weakness, disorientation, ataxia, siezures, coma and death. (NYDOH, 1991)

Generalized seizures have also been temporally associated with the use of DEET containing insect repellent on skin. Signs and symptoms of more subtle neurotoxicity have been associated with extensive dermal application of DEET on adults, in-

The Dos and Don'ts of DEET

EPA requires that child safety claims be removed from all end-use product labels, as they are misleading and irreconcilable with the intended use and pesticidal ingredients of DEET products, and that all DEET labels inform users to take the following precautions:

- Do not allow young children to apply this product;
- Do not apply near children's hands or face;
- Apply only enough to cover exposed skin and/or clothing;
- Do not apply over cuts, wounds and irritated skin;
- Thoroughly wash all treated skin with soap and water after returning indoors;
- Wash treated clothes before wearing again; and,
- Do not spray aerosol forms inside. (EPA, 1998)

cluding insomnia, mood disturbances and impaired cognitive function. (NYDOH, 1991)

In 1987, a rash of pet poisonings and deaths following the use of Hartz Blockade™, a flea and tick spray with a formulation of 8.5% DEET and 0.45% fenvalerate, resulted in a recall by Hartz Mountain. EPA calculated that a single one-ounce application of EPA-registered Hartz Blockade™ to a cat constituted a dose equivalent to the oral rat LD_{50}, and that cats, especially kittens, are more sensitive than rats to DEET. As a result, EPA now requires additional warnings on the label. (Streitfeld, 1991) One veterinary textbook refers to seven reports of cat poisonings after DEET exposure, resulting in seizures, tremors, vomiting, and ataxia and lethargy in several cases.

Mice eliminate the majority of DEET absorbed through their skin in one to three days, but trace amounts of DEET were discovered in the mouse tissue one to three months after application. (NPTN, 2000) In humans, DEET can penetrate through human skin, and, once in the body, it is eliminated in the urine. Peak concentrations in the urine occur several hours after application. (NPTN, 2000)

Synergistic Effects

Dr. Abou-Donia's two most recent studies focus on mixtures of DEET with other chemicals commonly used in conjunction with DEET. The first studied the effects of two-months of daily skin applications with a mixture of DEET and permethrin, an insecticide commonly used in mosquito control (Abou-Donia, 2001, *Exper. Neurol.*). The second studied the effects of 60 days of exposure to DEET and permethrin, and 15 days of exposure to pyridostigmine bromide, an anti-nerve gas agent. Rats experienced severe brain and behavioral deficits (Abou-Donia, 2001, *J. of Toxicol. & Enviro. Health*, 2001). In each study, the treated animals initially appeared to be normal, but, when challenged with neurobehavioral tasks that required muscle control, strength and coordination, the rats demonstrated serious impairments. A detailed analysis of their brains show that a large number of brain cells die within the cerebral cortex (controls muscles and movement), the hippocampal formation (controls memory, learning and concentration), and the cerebellum (synchronizes body movements). Many of the surviving brain cells show signs of degeneration and damage consistent with the presence of harmful byproducts called oxygen free radicals, which can damage DNA and cell membranes in the brain and nervous system. The most severe brain cell changes and sensorimotor deficits are seen among rats exposed to combinations of DEET, permethrin and the anti-nerve gas agent. The findings confirm Dr. Abou-Donia's 1996 and 2001 animal studies demonstrating that previously thought to be harmless doses of these three chemicals prove highly toxic to the brain and nervous system when used in combination. According to Dr. Abou-Donia, "Never use insect repellents on infants, and beware of using them on children in general. Never combine insecticides with each other or use them with other medications. Even so simple a drug as an antihistamine could interact with DEET to cause toxic side effects. Don't spray your yard for bugs and then take medications. Until we have more data on potential interactions in humans, safe is better than sorry." (Duke, 2002)

Environmental Fate

Because EPA has categorized DEET to be an "indoor residential" use pesticide, a limited set of toxicity data is required to determine precautionary label statements and for assessing environmental fate and hazards in case of spills. In the soil, DEET breaks down fairly slowly and has a moderate potential to move through soil and into the groundwater. (NPTN, 2000)

Regulatory History

DEET was registered in 1957 with limited health and safety information. Since EPA began reviewing DEET for health and environmental effects in the 1980's, the evaluation has been slow and incomplete. A December 1980 *Registration Standard*, EPA identified the need for additional carcinogenicity, teratogenicity, reproductive effects and mutagenicity data that, to this day, are incomplete. The Chemical Specialties Manufacturers Association (CSMA) had, at the time, formed a "DEET Steering Committee" and successfully negotiated with EPA the waiver of some of these data requirements.

In addition, the agency relaxed its prohibition against the registration of any DEET formulation that exhibits adverse effects on the cornea. Whereas previously those formulations persisting seven days or more were illegal, now 21 days or longer is considered acceptable. By July 1988, the registrants had yet to even begin the required 4 1/2 year carcinogenicity studies. At present, EPA lacks the bulk of the chronic effects information and is apparently contemplating yet another data call-in.

Most recently, a 1998 *Reregistration Eligibility Decision (RED)* factsheet issued by EPA states that the agency had deferred its decision on the combination DEET/sunscreen products until it has solicited the views of various governmental agencies and other groups. The agency has not yet updated its position. Sunscreen products are intended for frequent, generous use, and DEET products are intended for spare, infrequent use. The use of combination products may promote greater use of DEET than is needed for pesticidal efficacy and pose unnecessary exposure to DEET.

Citing health risks and evidence that higher DEET concentrations are not more effective in repelling insects, Health Canada, in April 2002, banned insect repellents with more than 30% active ingredient DEET. As of December 2004, retailers must discontinue sale of these products. Two-in-one products that mix sunscreen and insect repellent have also been banned.

DEET ChemicalWATCH Fact Sheet Bibliography

Abou-Donia, Mohamed, et al. 2001. "Neurotoxicity Resulting From Coexposure to Pyridostigmine Bromide, DEET, and Permethrin." *Journal of Toxicology and Environmental Health* (64):373-384

Abou-Donia, Mohamed, et al. 2001. "Subchronic Dermal Application of N,N-Diethyl m-Toluamide (DEET) and Permethrin to Adult Rats, Alone or in Combination, Causes Diffuse Neuronal Cell Death and Cytoskeletal Abnormalities in the Cerebral Cortex and the Hippocampus, and Purkinje Neuron Loss in the Cerebellum." *Experimental Neurology* 172:153- 171.

National Institute of Health (NIH). 2002. DEET. Hazardous Substance Database. <http://toxnet.nlm.nih.gov/cgi-bin/sis/search/f?./temp/~BAAVhaiSW:1>.

National Pesticide Telecommunication Network (NPTN). 2000. *DEET General Fact Sheet*. December. Oregon State University. Corvallis, OR.

New York State Department of Health (NYDOH). 1991. *Background Information on DEET*. New York State Bureau of Toxic Substance Assessment. Albany, NY.

Streitfeld, David. 1991. "Blockade: The Beef Goes On." *The Washington Post*. February 5, p. C5.

U.S. EPA. 1998. "Reregistration Eligibility Document: DEET." Office of Pesticide Programs, Washington D.C. < http://www.epa.gov/pesticides/reregistration/status.htm#D>.