

5. PRODUCTION, IMPORT/EXPORT, USE, AND DISPOSAL

5.1 PRODUCTION

No information is available in the TRI database on facilities that manufacture or process DEET because this chemical is not required to be reported under Section 313 of the Emergency Planning and Community Right-to-Know Act (Title III of the Superfund Amendments and Reauthorization Act of 1986) (EPA 2005).

DEET was developed in 1946 by the U.S. Army and has become the world's standard insect repellent. As of March 2017, there were 27 companies in the United States that manufactured approximately 119 federally active consumer products containing DEET (NPIRS 2017). DEET is produced globally, with commercial production achieved via reaction of *m*-toluoyl chloride and diethylamine in benzene or ether as a solvent (O'Neil et al. 2013). Data for production volumes were not located. DEET is designated by the U.S. EPA as a registered "pesticide" (type of pesticide is an insect and acarid repellent). EPA (1998b) reregistered its use in products available to the general public, except for products and formulations that combine DEET and sunscreen, or those that are corrosive to the eye or cause corneal involvement or irritation persisting for ≥ 21 days.

In the environment, *Pectinophora gossypiella*, commonly known as the pink bollworm, naturally produces DEET; however, this source would not accumulate levels of environmental significance (Knepper 2004).

5.2 IMPORT/EXPORT

The U.S. EPA estimated that the annual U.S. production and import volumes of DEET range from approximately 2.6 to 4.5 million pounds (EPA 2007; ILS 1999).

5.3 USE

DEET is used globally. The major use for DEET is as an insect and acarid repellent intended to repel, but not kill, biting insects. Commercial products are used in residential settings and are applied directly on the human body or hair and/or personal clothing, footwear, shoes, and hats while being worn, on cats, dogs, and horses, or on pet living and sleeping quarters (EPA 2014m). Data from 1998 and the Centers for Disease Control and Prevention (CDC) report there are over 225 commercial insect repellents that

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range in concentration from 4 to 100%; DEET use in formulations with dermal sunscreens were also reported (Brausch and Rand 2011; CDC 2009; EPA 1998b, 1998c, 2014l). In 1998, EPA (1998b) stated that the reregistration eligibility decision (RED) does not include products/formulations that combine DEET and sunscreen; however, in the EPA (2012c) environmental fate and ecological risk assessment for registration review of DEET, 10 end-use products/formulations with sunscreen were reported. As of March 2017, 27 companies in the United States reported the manufacture of approximately 119 consumer products containing DEET (NPIRS 2017). Products include lotions, creams, sticks, aerosol and non-aerosol sprays, foams, gels, and wipes or towelettes. According to EPA, as of February 2014, there were 123 active registrations for DEET, including co-formulations with other chemicals, formulations with sunscreen, and one registration for use on horses (EPA 2012c, 2014m). Formulations may range from 4 to 95% active ingredient, and a 100% technical-grade product also exists. Although agricultural uses have been reported (Aronson et al. 2012), DEET is currently registered by the EPA only as an insect and acarid repellent. Additional uses of DEET as a specialty solvent, surface plasticizer, pharmaceutical dermal penetration enhancer (Windhauser 1982), and other potential applications have been reported (Aronson et al. 2012; Carlson 2000; EPA 1998b, 1998c; Weeks et al. 2012). The chemical properties that enable DEET to dissolve certain plastics along with its strong smell are potential disadvantages for some applications (Wang et al. 2013).

Wang et al. (2013) evaluated DEET against other repellents for effectiveness against bed bugs moving into an area in which a CO₂ cue was present. Bed bugs are currently of international concern following a population rebound after the termination of DDT use. Filter papers in petri dishes were treated with a repellent over half of the surface and with the vehicle on the other half, entirely bathed in CO₂. After nine males and six large nymphs (immature bedbugs) were released at the center, the portion avoiding the repellent side was recorded over time. Complete effectiveness for 24 hours was found for 5% DEET as well as for two naturally occurring repellents (3-methyl-5-hexyl-2-cyclohexanone [isolongifolenone] or propyl dihydrojasmonate [isolongifolanone]). A minimum of 10% DEET was required to repel at least 93% of bed bugs for 9 hours, and 25% DEET was effective for 14 days. Two other substances were ineffective (7% picaridin repellent or 0.5% permethrin insecticide). Current production volumes for DEET were not available in the EPA Inventory Update Reporting Database or the Chemical Data Reporting Database. According to 1990 data, the EPA Registration Eligibility Decision document for DEET reported annual use of approximately 4 million pounds (active ingredient) and about 30% of the U.S. population used DEET annually as an insect and acarid repellent (EPA 1998b, 1998c, 2014l). Approximately 19% of households used it on household members, and about 4% of households that had cats and/or dogs applied DEET to pets. The average annual domestic use of DEET has been estimated as

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approximately 5–7 million pounds based on product sales (EPA 2004). According to the California Environmental Protection Agency, approximately 577,874 pounds (active ingredient) of DEET were sold in California alone in 2008 (Aronson et al. 2012).

Since 1998, in Germany, DEET has been replaced by 1-piperidine carboxylic acid 2-(2-hydroxy-ethyl)-1-methylpropylester (Bayrepel) in some products (Knepper 2004).

5.4 DISPOSAL

According to the Material Safety Data Sheet for one DEET product, the disposal method noted that waste must be disposed of in accordance with federal, state, and local environmental control regulations; the container must not be reused; it may be placed in the trash for disposal; absorbents should be disposed of in the trash (Sawyer 2010). It is assumed that most products containing DEET are discarded into landfills following their disposal in common household waste. Large spillages of DEET should be decontaminated by rinsing with a 5% solution of sodium hydroxide (WHO 1987).