

INSECT REPELLENTS

TOPIC FACT SHEET

Why use insect repellents?

Insect repellents are used to repel **mosquitoes**, **ticks**, flies, and other biting insects. Mosquitoes can **transmit diseases** such as Zika, Malaria, and West Nile virus. Ticks can **transmit** Lyme disease, Rocky Mountain Spotted Fever, and other diseases. Repellents are not meant to kill insects, but to keep them away to prevent bites and the spread of disease.

How many kinds of insect repellents are there?

There are multiple **active ingredients** in insect repellents registered with the Environmental Protection Agency (EPA). **DEET**, **picaridin**, IR3535, and oil of lemon eucalyptus are referred to in this fact sheet as common insect repellents. The **Centers for Disease Control and Prevention** (CDC) recommends using products with one of these EPA registered ingredients. They can be applied to human skin and some can be used on clothing. They come as sprays, wipes, or lotions. Find the repellent that is best for you with **EPA's repellent search tool**.

Oil of lemon eucalyptus and IR3535 are based off of chemicals that occur in nature but are man-made ingredients. Because they are related to substances found in nature, they are both considered to be **biopesticides**. Oil of lemon eucalyptus (OLE) may also be listed on products by its chemical name, p-menthane-3,8-diol (PMD).

How do insect repellents work?

Mosquitoes and ticks are attracted to skin odors and the carbon dioxide we exhale. They also use heat, movement, and visual cues to find a possible host.^{1,2} Repellents affect an insect's senses such as smell and taste to prevent it from finding a human or animal host.^{2,3,4}

How effective are common insect repellents?

Length of protection and efficacy of repellents can vary. They must undergo testing to show they are effective before they can claim to control mosquitoes or ticks. Look for label claims on your repellents. The **CDC** recommends using products that are registered with the **EPA**.

Higher concentration repellents may protect people for longer. However, they are not better at keeping insects away.^{5,6,7} Repellents with less than 10% of an active ingredient may only offer protection for short periods of time (1-2 hours).⁵ Sweat, water contact, and rubbing from clothing can affect how long a repellent may be effective.^{6,7,8} Water resistant repellents are available.

If you choose to use a DEET product, the **CDC** recommends products with DEET concentrations of 20% or more.⁹ Products with more than 50% DEET offer no extra protection.^{5,10} Consider using a variety of methods to prevent bites. You may cover exposed skin with clothing or alter the landscaping in your yard to make it less **tick** or **mosquito** friendly.



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NPIC fact sheets are designed to answer questions that are commonly asked by the general public about pesticides that are regulated by the U.S. Environmental Protection Agency (US EPA). This document is intended to be educational in nature and helpful to consumers for making decisions about pesticide use.

Can some people react to insect repellents?

All chemicals, including insect repellents, have some degree of toxicity. However, the toxicity can vary by product and by route of exposure (eating, breathing, touching). Each product is also marked with a **signal word**. This indicates the toxicity of the whole mixture.

Applications to skin are the most common use of repellents. They are low or very low in toxicity when used on the skin. Inhalation is possible when using a spray. If hands are not washed after use, residues could be eaten by mistake. Consider taking steps to avoid exposures in the ears, eyes, and mouth. You can also keep the risk low by following the label directions. **Tables 1 and 2** below can be used to compare the toxicity of different ingredients in repellents.

Table 1. Short-Term Toxicity of Active Ingredients in Common Insect Repellents*

Repellent	Oral	Inhalation	Dermal	Eye Irritation	Skin Irritation
DEET ¹¹	Low	Very low	Low	Low	Very low
Picaridin ¹²	Low	Very low	Low	Low	Very low
IR3535 ¹³	Very low	Very low	Very low	Moderate	Very low
Oil of Lemon Eucalyptus ¹⁴	Very low	Very low	Very low	High**	Very low

* None of these ingredients are expected to cause more severe reactions with multiple exposures over time (sensitizers).

** If oil of lemon eucalyptus gets into the eye, washing the eye immediately can reduce irritation and risk of long-term damage. Follow First Aid instructions on the **product label**.

Table 2. Short-Term Toxicity of Insecticide Active Ingredient Used to Treat Clothing

Insecticide	Oral	Inhalation	Dermal	Eye Irritation	Skin Irritation
Permethrin ¹⁵	Low	No Acceptable Data	Low	Low	Very low

Permethrin is not an insect repellent, but kills insects on contact. It is sometimes used to treat fabrics. For additional information about **permethrin-treated fabrics**, see page 6.

DEET: While uncommon, products with DEET can cause short-term eye or skin irritation.¹⁶ People who have inhaled DEET repellents have reported coughing and respiratory irritation. If eaten, they can cause stomach and digestive irritation. Although rare and largely due to accidents or overexposures, neurological effects have been reported. The EPA found inconclusive evidence linking seizures in children to DEET exposure.¹¹

Picaridin: People have reported skin and eye irritation from products with picaridin.^{12,17} Vomiting has also been reported.¹⁷

IR3535: IR3535 is an eye irritant. Human and animal studies show if it is undiluted, it can cause skin irritation. In studies with diluted IR3535, skin irritation was not reported.^{18,19}

Oil of lemon eucalyptus: Oil of lemon eucalyptus can cause significant eye damage. Washing eyes after an exposure can reduce the risks of long-term harm. It has been linked to skin irritation in animal studies. Rats fed oil of lemon eucalyptus had trouble walking. They also had changes in their breathing and were lethargic.¹⁴

If you or someone you know is having a reaction to an insect repellent, carefully follow the First Aid instructions on the product label. For more advice, contact the Poison Control Center at 800-222-1222.

Has anyone studied effects of long-term exposure to common insect repellents?

Repellents are often used for a few days or weeks. However, various jobs and other conditions may result in daily use of a repellent for extended periods. In a few studies, animals were treated with common repellents every day for long periods of time. They sometimes had irritated skin. Symptoms were limited to skin irritation and did not include other systemic effects.^{12,14,16,19,20}

Are common insect repellents likely to contribute to the development of cancer?

Agencies use many studies to find links between certain substances and cancer. The EPA lists the ingredient DEET as “not classifiable as to human carcinogenicity.”²¹ This indicates that data has not been conclusive enough to state if it is or is not likely to cause cancer.

Other common repellent active ingredients have not had full assessments done to determine the cancer risks. However, one of the signs that a chemical could be linked to cancer is if it affects genes or cell DNA in a lab. None of the common repellent ingredients have been shown to damage genes in lab tests.^{11,12,22,23}

What precautions can I take when using insect repellents?

Repellents have been tested and designed for use in certain ways. Only use a repellent in ways that are described on the label. Following the label directions and the tips below can minimize your risk.

- Apply just enough of a repellent to cover exposed skin. Avoid over-applying repellents. **Follow label directions** to find out how long to wait before reapplying.
- Do not use **under clothing**.
- Do not apply on open cuts, irritated, or sunburned skin.
- Do not spray repellents on the face, in ears, or near the eyes or mouth. To apply repellent to the face, first apply it to your hands and then rub it onto your face.
- Wash skin and treated clothing when returning indoors.
- Wash clothing prior to wearing again.
- Mixing a repellent with sunscreen can affect how your skin absorbs the products.^{8,24} For additional information about **sunscreen and repellents**, see page 4.

Can insect repellents be used on children?

Children may be more likely to mishandle a bottle or lick treated skin, increasing their risks. Check the product label to see if there is a minimum age for use. If no age limit is on the label, the EPA has not put age restrictions on the product. Here are a few tips from professional organizations:

- The **American Academy of Pediatrics** (AAP) does not recommend insect repellents for children younger than two months.²⁵
- Oil of lemon eucalyptus products should only be used on children older than three years old.^{26,27}
- The CDC recommends that DEET can be used on children older than two months.²⁶ The AAP recommends that products applied to children should not have more than 30% DEET.²⁵
- Check with your doctor for other recommendations or restrictions for children. NPIC does not make repellent recommendations.

Take precautionary steps to reduce a child's contact with a repellent:

- Use clothing or mosquito netting to protect infants less than two months old from biting insects.
- Do not let children handle or apply repellents.
- To apply repellent to a child's face, first spray it on your hands and carefully rub it on their face, applying lightly around the ears.
- Avoid applying repellents around a child's eyes and mouth.
- Do not apply repellents to children's hands because they tend to put them in their mouths.
- Wash treated skin as soon as a child returns indoors.



Image courtesy of James Gathany, pixnio.com

Can insect repellents be used while pregnant or breastfeeding?

According to the [CDC](#), EPA-registered repellents may be used during pregnancy and while breastfeeding.⁹ Repellents may reduce risks from insect-spread diseases that could affect a developing baby. The American College of Obstetricians and Gynecologists ([ACOG](#)) recommends use of an EPA-registered repellent with DEET for pregnant mothers in areas with risk of Zika.²⁸ Consult a healthcare professional for more information.

There is currently no published data on the use of common repellents while breastfeeding.^{29,30,31,32} The [CDC](#) has indicated that use of EPA-registered insect repellents while breastfeeding is low risk. The World Health Organization (WHO) has listed DEET as "compatible with breastfeeding" when used as directed.³³

DEET: No harmful effects were seen in mothers or their infants that regularly applied DEET products during their second and third trimesters of pregnancy.³⁴ Inhalation, dermal, and feeding studies with animals show the ingredient DEET is low in developmental and reproductive toxicity. Inhalation and feeding studies showed no effect on animal reproductive organs.¹⁶

Picaridin: No effects on pregnancies or fetuses were found in studies when animals were fed or had their skin treated with concentrated picaridin before or during pregnancies.^{12,35}

IR3535: Multiple feeding studies show concentrated IR3535 is low in developmental and reproductive toxicity.^{19,22} There is some evidence of dose-related pregnancy loss in animals fed large doses while pregnant.²²

Oil of lemon eucalyptus: Only slight changes in weight gain were observed during pregnancy in rats with large doses of the ingredient put on their skin. There were no effects on fetal development.¹⁴



Image courtesy of Sammi Osborn, reshot.com

What about using insect repellents and sunscreen?

When a repellent is applied to skin, about 3-19% may be absorbed into the body.^{12,20,36,37,38} Mixing an insect repellent with sunscreen can affect how your skin absorbs both products.^{8,24} Using both can increase repellent absorption through skin. However, the effects of using both depend on which sunscreen and which repellent is used. Few or no studies address using IR3535 or oil of lemon eucalyptus with sunscreens.

The CDC does not recommend products that have both sunscreen and an insect repellent.²⁶ Many repellents work for many hours. Sunscreen may need to be used more often than a repellent. Therefore, combined products may not be used as often as they should be for sun protection. If you decide to use both, the CDC recommends applying sunscreen first, letting it dry, and then applying an insect repellent over the sunscreen.²⁶

Where do insect repellents go when washed from clothes or skin?

Water from washing clothing and bathing is treated at a nearby wastewater treatment plant.³⁹ Repellents are not on the EPA's **list of contaminants** that must be monitored by public water systems.⁴⁰ State and local regulations may vary. Consider contacting a **local water treatment** facility for information about water quality in your area.

Repellents may also be washed off of skin and clothing into lakes or rivers during recreation. A repellent will tend to travel with water if it is dissolved. It could travel either downstream or through soil. The solubilities of DEET and picaridin are variable.^{41,42} IR3535 is **soluble** in water and dissolves easily.¹⁹ Oil of lemon eucalyptus is moderately soluble.¹⁴ DEET, picaridin, and IR3535 are mobile or moderately mobile in soils. They are not likely to stick to soil.^{18,41,42}



Image courtesy of maxpixel.net

Do insect repellents break down in the environment?

The breakdown of repellents in air, water, and soils has not been widely studied. Reports for breakdown times of picaridin and DEET in soil or water are variable and range from days to weeks, or longer.^{35,42,43,44}

As for their movement in the environment, the four repellents are moderately **volatile** and can release vapors into the air.^{14,19,41,42} Once in the air, DEET, picaridin, and IR3535 do not stay there for long. Their **half-lives** in air range between 7 and 15 hours.^{17,18,42}

Can insect repellents affect wildlife?

DEET is slightly toxic to birds, fish, and aquatic invertebrates.⁴² Picaridin is practically non-toxic to birds, fish, and aquatic invertebrates.⁴¹ Few studies on the toxicity of IR3535 and oil of lemon eucalyptus to birds and fish are available. Scientists have not found effects on small organisms such as snails, mayflies, or water fleas from small amounts of DEET, picaridin, or IR3535 in natural waters.^{45,46,47}

What about natural, organic, or other types of insect repellents?

The health risks and efficacy of essential oils have not been as widely studied as common insect repellents. However, a variety of information is available, including from the **CDC**.⁴⁸

Some of these other repellents may be **minimum risk pesticides** and may not have to be registered with the EPA. There are no EPA-registered repellents that contain garlic oil, rosemary, lemongrass, thyme, or geraniol oils as active ingredients.



Image courtesy of pexels.com

What about permethrin-treated fabrics?

Do not apply **permethrin** to skin as a repellent. There are some products with permethrin that can be used to treat fabrics. Permethrin works on contact, meaning that an insect must touch the treated item to be harmed or killed.⁴⁹ Exposure to permethrin while wearing treated clothing is likely to be low because only a very small amount of product may be transferred onto skin from treated fabric.^{15,50} Additionally, skin absorption of permethrin is low.¹⁵

Do not apply permethrin to clothing while it is being worn. Only treat clothing, netting, or gear with products that have specific directions for **treating fabrics**. Do not over-treat fabrics. Use the correct concentration for treatment. Allow any treated items to dry thoroughly after treatment before handling or wearing.

Where can I find more information?

For more detailed information about insect repellents please visit the list of referenced resources below, call the National Pesticide Information Center, Monday - Friday, between 8:00am - 12:00pm Pacific Time (11:00am - 3:00pm Eastern Time) at 800-858-7378, or visit us on the web at npic.orst.edu. NPIC provides objective, science-based answers to questions about pesticides.

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