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# Anti-mosquito Clothing

## What is anti-mosquito clothing?

Anti-mosquito clothing is a kind of personal protection technology where the fabric is specially treated with insecticide during its manufacturing. In addition to the garment itself being a physical barrier, the impregnated insecticide provides an additional repelling and knock-down effect to minimise the potential of mosquito biting.

Long lasting insecticidal net (LLIN) is an example of such technology that is recommended by the World Health Organization to be used in malaria-endemic regions. LLINs are bed nets treated with insecticide and provide effective protection against mosquitoes that feed during the night e.g. genus *Anopheles*. On the other hand, the anti-mosquito clothing can provide effective and long-lasting protection during daytime against day-biting vectors of the genus *Aedes*.

## Development of anti-mosquito clothing

Insecticide-impregnated garment was developed and deployed by the U.S. Army after they had suffered over 50,000 casualties due to malaria during the Vietnam Conflict. Nowadays, insecticide-treated clothing products are available in the market in various forms, e.g. travel clothing for recreational purpose. Scientists are now evaluating the efficacy and feasibility of using insecticide-treated school uniforms to protect school children from mosquito-borne diseases e.g. dengue fever in the developing countries.

## What is the insecticide used in anti-mosquito clothing and how does it work?

Permethrin is the only insecticide currently used for fabric impregnation, which is able to produce both quick knock-down effect and repellent effect. Permethrin kills its target by impairing the nervous system of the arthropod upon absorption. Although being a potent insecticide, permethrin has a low toxicity to human, which along with its poor absorption makes it a suitable substance to be impregnated into clothing.

## Important points-to-note:

1. Permethrin-impregnated clothing cannot offer protection to the bare skin against insect bites. Insect repellent should be applied on exposed part of the body in order to have maximum protection against mosquito-borne diseases.
2. In general, the anti-mosquito clothing is durable to withstand regular washing. However, the level of permethrin may become too low to offer enough protection if the number of washes exceeds the suggested number. Follow the directions and precautions on the label of the products.
3. Similarly, the anti-mosquito effect may wear off upon subsequent washing, ironing and exposure to hot water. Wash and store the permethrin-treated clothing according to the instructions and precautions on the label of the products.
4. Wash the permethrin-impregnated clothing separately from non-treated clothing as small amount of permethrin may come off upon washing.
5. Use a single pesticide continuously on a mosquito population will inevitably produce resistance. Only use the permethrin-treated clothing when there is a need.

### References

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# Icaridin and IR3535

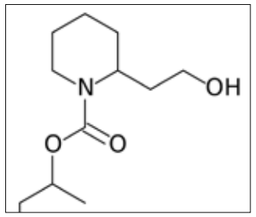

*Fig. 1 Chemical structure of Icaridin*

DEET (N,N-Diethyl-3-methylbenzamide) has been the leading insect repellent for decades, but its skin irritating effects, especially in high concentration, and plasticizing property have aroused the demand of alternative insect repellents. Icaridin (1-piperidinecarboxylic acid, 2-(2-hydroxyethyl)-1-methylpropylester) and IR3535 (3-[N-Butyl-N-acetyl]-aminopropionic acid, ethyl ester) are two active ingredients of insect repellent, which are also recommended by the World Health Organization and the U.S. Centres for Disease Control and Prevention (CDC) for prevention of mosquito bites.

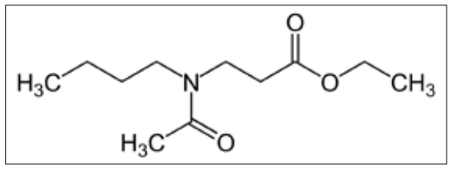

*Fig. 2 Chemical structure of IR3535*

## History

Icaridin is a derivative of piperidine developed in the 1980s. It has been introduced to the U.S. since 2005 and was approved by Health Canada in 2012. It is considered to be the repellent of first choice by the Public Health Agency of Canada for travellers aged from 6 months to 12 years old, and is now widely used in Europe and Australia.

IR3535 is a synthetic amino acid, which is structurally similar to the natural substance beta-alanine. It was first made in the early 1970s and was commercially available in the U.S. in 1999.

## Mechanism

The repelling mechanisms of icaridin and IR3535 on biting insects are not fully understood. It is thought to act on insect olfactory sensory system similar to DEET. A study has revealed that icaridin and IR3535 strongly inhibit the functions of insect odorant receptors.

## Efficacy

Icaridin and IR3535 exhibit satisfactory protection against insect bites. Insect repellents containing 20% icaridin or IR3535 can offer at least 3-4 hours of protection against mosquito bites.

## Risks to human health

Icaridin and IR3535 have been used in Europe for 20 years with no substantial adverse effects to human health. Both active ingredients are safe for use in pregnant or breastfeeding women when following the label directions.

## Comparison with DEET

Icaridin and IR3535 are non-greasy and almost odourless. They do not damage plastics and synthetics. They are also less irritating to the skin than DEET. However, icaridin and IR3535 offer a slightly shorter duration of protection than DEET and fewer studies assessing their efficacy on biting insects have been conducted. The safety of their use in humans has been less studied as well. Insect repellents containing icaridin or IR3535 are less available in the market and are sold at a higher price.

## Recommendations

Icaridin and IR3535 can be applied to exposed skin or to clothing if required. Consumers are advised to carefully read the product label instructions and precautions before use. Both products should be re-applied in accordance with the directions on the label. The U.S. CDC has advised that icaridin and IR3535 should not be used on infants younger than 2 months old while the Health Canada has permitted the use of up to 20% icaridin on children aged 6 months or above.