

To Bite or Not to Bite

Durable Mosquito Repellents for Textiles

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TEXTILES HAVE been manufactured using various techniques since time immemorial. Human ingenuity and imagination, craftsmanship and resourcefulness are evident in textile products throughout the ages; we are to this day awed by the beauty and sophistication of textiles sometimes found in archaeological excavations.

After fabricating the mansions of fashion and comfort, textiles are now moving towards high-tech era of performance, which has brought up diversification and expansion of technologies. This realisation of technologists has coincided with rapid developments in technology and brought about a surge in research-and-development activities in textiles. Mosquito-repellent textiles are one revolutionary way to advance the textile field.



Mosquitoes have a complex method of detecting hosts and different types of mosquitoes react to different stimuli. Mosquitoes are incredibly unsafe insects and are responsible for propagating ailments like malaria, encephalitis (inflammation of brain) and dengue fever.

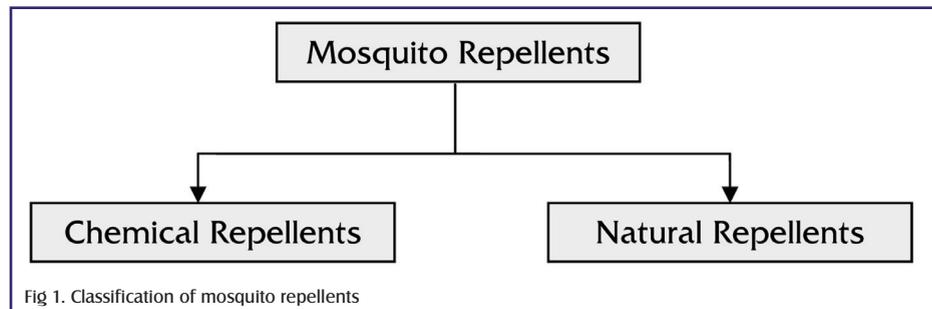


Fig 1. Classification of mosquito repellents

At present, there are very few durable repellents that can be applied to clothing and almost all the repellents are designed to be applied directly on the skin. This poses a great risk to the individuals using them and hence, with a view to reducing this risk and at the same time meeting the needs of industry, Sarex has developed durable mosquito repellents for textile substrates, namely Saraguard MOSQ for polyester and Repello MSQ for cotton.

Chemical Repellents

- DEET (Di-Ethyl Meta Toluamide)
- Allethrin
- Permethrin (Synthetic analogue of pyrethrum)
- Malathion

Natural Repellents

There are various natural mosquito repellents, which are as follows:

- Citronella oil
- Castor oil
- Clove oil
- Cedar oil
- Rosemary oil
- Peppermint oil
- Lemongrass oil
- Geranium oil
- Chrysanthemum

Among all the above-mentioned natural repellents, Chrysanthemum was found to be the best repellent.

Advantages of mosquito repellent finishing:

- No loss by abrasion
- No loss due to skin absorption

- No removal of the active compound by sweating
- Slower evaporation because of lower temperature, except when clothing is exposed to sunlight
- Better adherence to cotton and synthetic fibres.

There are two types of mosquito repellents, classified on the basis of their actions. These are:

Repellent Insecticides
Contact Insecticides

Repellent Insecticides are substances that are mainly used to repel insects and pests rather than causing death. Several mosquito repellents are available in today's market, of which an estimated 110 million people safely use DEET worldwide each year.

Contact Insecticides are the substances that contain neuro-toxins for pests and insects. They make the insects and pests unconscious when they come in contact with them.

Mechanism of Repellent Action

The action of repellent agents for blood-sucking mosquitoes can be broadly divided into two types, acting on the olfactory or tactile senses. The olfactory mode is called transpiration repellency, keeping mosquitoes away without them touching the surface of the finished fabric. This works by blocking the insects' humidity-sensing holes, which means they cannot locate humans. Mosquitoes



Technical Briefing: Mosquito Repellents

Fabric	Dose (g/m ²)			
	Permethrin	Cyfluthrin	Deltamethrin	Lambdacyhalothrin
Wide-mesh netting (more than 2 mm)	0.10–0.25	0.05	0.008–0.012	0.005–0.008
Standard mosquito mesh (1.5 mm)	0.20–0.50	0.03	0.01–0.025	0.010–0.015
Cotton cloth (sheeting, shirts)	0.70–1.20	0.05	—	—
Thick fabrics, jackets, trousers	0.65–1.25	0.05	—	—

Table 1: Dosages of insecticide needed to impregnate different types of fabric

usually use the warm and humid convection rising from the human body as a guide for contacting humans by sensing an increase in atmospheric carbon-dioxide concentrations.

The tactile mode is called direct-contact repellency, and this drives insects off the processed surface before they can suck blood, even after they have touched the surface of the fabric. It is believed that these repellent substances work on the insects' peripheral nervous system when contact is made, causing them to enter a confused state and inhibiting their behaviour at sub-lethal doses, before knockdown and lethal action.

Dosages of Insecticide

Table 1 gives dosages of insecticide needed to impregnate different types of fabric

Mosquito Repellency Evaluation

Cone Test, Wire-Ball Test, Cylinder Test and Field Test.

There are different types of testing methods for evaluation of mosquito-repellent textiles, such as cone test, wire-ball test, cylinder test and field test, etc. In the cone test, exposed mosquitoes might spend more time resting on the cone than on the treated surface.



Fig 2 - Cone test

In the wire-ball test, the treated fabric to be tested is wrapped around a wire frame and mosquitoes are introduced into this ball. In the cylinder test, the inside of a test cylinder is covered with the textile.

The field test is the most meaningful evidence for the efficacy of treated textile. The field test is especially performed in locations where floodwater mosquitoes are abundant.



Fig 3 - Field test

American Society for Testing and Materials (ASTM) Standard E951-83

Mosquito-repellency activity was assessed using the test cage described in the American Society for Testing and Materials (ASTM) Standard E951-83 – Laboratory testing of non-commercial mosquito repellent formulations on the skin. The flexor regions of the forearms of volunteers were outlined with five circular 29mm diameter test areas. A volume of

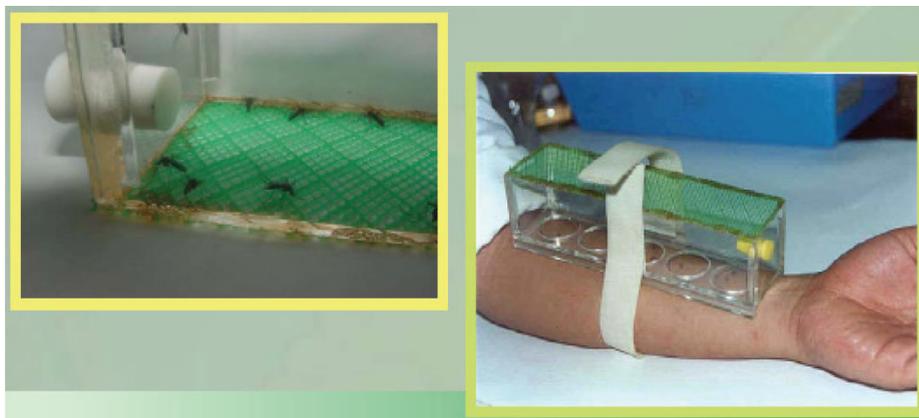


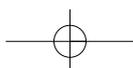
Fig.4 : Mosquito Repellency Evaluation by ASTM Standard E951-83

0.025 ml of serial dilutions of the essential oils in ethanol (95%) (0.0006 – 0.0379 mg/cm²) and 0.025 ml of the diluent was applied randomly to the marked areas of first, second, fourth and fifth circles. Ethanol 95% was applied at the middle, which was the third circle as the control test. The test cages were positioned securely on the arms of each volunteer with Velcro tapes to ensure that only the test areas were exposed for mosquito bites. Fifteen female mosquitoes, between four and seven days old, were introduced into each cage and the number of bites was recorded at the end of 120 seconds.

United States Department of Agriculture (USDA) Laboratory Method

The substrate of the insect repellent tent fabric of this invention may be any suitable fabric. For example, it may be a plain-weave polyester fabric or a 50/50 blend of polyester and cotton, woven as an oxford fabric. The fabric is coated with a composition which renders it insect-repellent.

Treatments were evaluated using *Aedes aegypti* mosquitoes to determine which would most effectively prevent bites and cause the highest knockdown (KD) of the insects entering the tents. Specifically, tests were conducted to determine the persistence of compounds applied to tents to keep out or kill mosquitoes. Efficacy assessments were made with weekly bioassays. Through the screen-door zipper opening of each tent were released from 75 to 80 seven-day-old laboratory-reared susceptible-strain female *Aedes aegypti* mosquitoes. Mosquitoes were free to land or fly about inside the tent for three hours. Each hour after release, mosquito KD, ie. mosquitoes dead or moving but unable to fly, and bite counts were recorded.



WHO/CTD/WHO/PES/IC/96.1 Method

Laboratory-reared stains of the Culex species of mosquitoes are released in an Excito repellency chamber, containing both finished and unfinished fabrics, to observe changes in behaviour in the form of moving away from treated fabric to untreated fabric. Observations are recorded after a period of 10 minutes and after 1/2 hour.

Application of Mosquito Repellent Textiles

Mosquito-repellent textiles can be used in:

- Anti-mosquito garments
- Bed sheets
- Wide-mesh netting jackets
- Head nets
- Bands and anklets
- Repellent ropes
- Bed nets
- Bed curtains
- Window curtains
- Bathroom curtains

Materials and Methods

Materials

100% cotton and 100% polyester fabrics.

Chemicals

Repello-MSQ – an outstanding wash-resistant mosquito-repellent finishing agent especially for cotton. It prevents vectors such as mosquitoes, ticks, etc, from landing or biting.

Saraprint-AC – a melamine formaldehyde resin used to enhance durability of the mosquito repellent for cotton, Repello-MSQ.

Saraguard-MOSQ – a unique product, developed especially for polyester in microcapsule form to repel mosquitoes. Fabrics finished with Saraguard-MOSQ are durable to laundering. The finished fabric

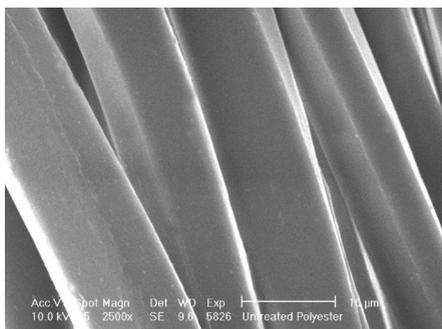


Fig 5 - Untreated polyester does not exhibit any odour.

Application

Pad-dry method, using laboratory pneumatic padding mangle (70% pickup) and laboratory mini-stenter.

Recipe

For 100% Cotton: *Repello MSQ* (100 g/l) and *Saraprint AC* (10 g/l)
 For 100% Polyester: *Saraguard MOSQ* (120 g/l)

Evaluation

Mosquito repellency was evaluated using modified WHO/CTD/WHO/PES/IC/96.1 method. Laboratory reared stains of Culex species of mosquitoes were released in an Excito repellency chamber containing finished and unfinished fabrics, to observe changes in their behaviour in the form of moving away from treated fabric to untreated fabric. The observations were recorded after 10 minutes and after 1/2 hour.

Durability Study

According to AATCC 135

SEM Analysis

The fabrics were further taken for analysis using Scanning Electron Microscope (Philips XL-30) to actually verify the presence of microcapsules. The SEM machine was operated at 10KV, with a specimen tilt of 45°.

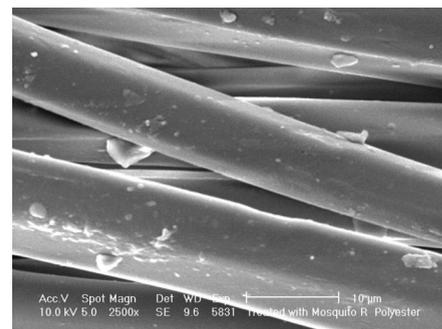


Fig. 6: Polyester treated with mosquito repellent microcapsules

The results for cotton are depicted in Table 2 and for polyester in Table 3 and Figures 5 and 6.

Cotton Fabric

The results obtained clearly indicate 100% repellency, which is equivalent to the percent protection imparted by 100% cotton fabric finished with Repello-MSQ (100 g/l) and Saraprint-AC (10 g/l). Finished fabric, even after 10 washes, showed 100% repellency.

Polyester Fabric

The results obtained clearly indicate 100% repellency, which is equivalent to the percent protection imparted by 100% polyester fabric finished with Saraguard-MOSQ (120 g/l). Finished fabric, even after 10 washes, showed 100% repellency.

The presence of the microcapsules was further proved by the SEM studies carried out on treated (Fig. 6) and untreated (Fig. 5) polyester. The treated fabric, when viewed under a scanning electron microscope, clearly showed the presence of the microcapsules bonded to the fibre surface.

Conclusion

We at Sarex have been able to develop our own durable finish, using a home-grown microencapsulation technique. As a result it can be offered at less than 50% of the current cost of other microencapsulation. ID

Sample Identification	No. of Mosquitoes released in Treated chamber	No. of Mosquitoes on Treated Fabric	No. of Mosquitoes migrating to Untreated side	No. of Mosquitoes showing mobility	Percentage Repellency
Cotton Fabric Finished with 100gpl Repello MSQ and Saraprint AC - Initial (Initial)	10	0; 2dead	8(6 dead)	0	100
Cotton Fabric Finished with 100gpl Repello MSQ and Saraprint AC - Initial (Half an hour)	10	0; 2dead	8(6 dead)	0	100
Cotton Fabric Finished with 100gpl Repello MSQ and Saraprint AC - After 10 washes (Initial)	10	0; 2 unable to move	8(1 unable to move)	0	100
Cotton Fabric Finished with 100gpl Repello MSQ and Saraprint AC - After 10 washes (Half an hour)	10	0; 2 unable to move	8(2 unable to move)	0	100
Repello - MSQ (Saraprint AC)-100 gpl on Cotton fabric - "0" wash has shown 100% Mosquito repellency; Repello - MSQ (Saraprint AC)-100 gpl on Cotton fabric -after "10" wash has shown 100% Mosquito repellency.					

Table 2: Results of modified WHO/CTD/WHO PES/IC/96.1 test for cotton

Sample Identification	No. of Mosquitoes released in Treated chamber	No. of Mosquitoes on Treated Fabric	No. of Mosquitoes migrating to Untreated side	No. of Mosquitoes showing mobility	Percentage Repellency
Saraguard - MOSQ - 120 gpl - "0" wash (Initial)	10	0	9	1	90
Saraguard - MOSQ - 120 gpl - "0" wash (Half an hour)	10	0,1 dead	8	0	100
Saraguard - MOSQ - 120 gpl -after "10" wash (Initial)	10	0	9	1	90
Saraguard - MOSQ - 120 gpl -after "10" wash (Half an hour)	10	0,3 dead	7	0	100

Table 3: Results of modified WHO/CTD/WHO PES/IC/96.1 test for polyester