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Analysis and Characterization of Mosquito-Repellent Textiles

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Abstract

Trevira CS knitted fabrics are treated with Eucalyptus oil and DEPA (N, N, Diethylphenylaccetamide) and evaluated for mosquito-repellent properties using Cage Test, Indoor Test, Field Test and assessment of fragrance decay. It is observed that Trevira CS fabrics treated with 15-30% Eucalyptus Oil exhibit good mosquito-repellency. Similarly, the fabric treated with 15% N, N-Diethylphenylacetamide (DEPA) exhibits good mosquito-repellency with a higher mean protection time.

Keywords: Mosquito-repellency; Cage test; Indoor test; Field test; Trevira CS

Introduction

Nature has evolved every creature with a significant purpose and everything that exists in this world is not necessarily useful to human beings, some are harmful and even fatal. One such creation is the Mosquito. In English language, the word Mosquito (Span, little fly) dates back to about 1572. The word was adopted to replace the term "biting flies" to prevent confusion with the house fly. Mosquitoes not only cause pain while biting, but also result in a wide range of diseases such as Malaria, chikungunya, etc. In every part of this world, Mosquito bite is considered as a nuisance. The following are some of the statistical data pertaining to the menace caused by Mosquitoes. Worldwide, however, Mosquitoes transmit diseases to more than 700,000,000 people annually and will be responsible for the deaths of 1 out of every 17 people currently alive. Malaria results from infection with a protozoan carried by Mosquitoes and, according to reports from the World Health Organization, causes as many as 3,000,000 deaths annually. It is responsible for yellow fever, dengue, hemorrhagic fever, epidemic polyarthritis, and several forms of encephalitis. Human beings are solely responsible for the proliferation of Mosquitoes by creating stagnant water, which is the primary breeding ground. Hence it becomes imperative to develop some preventive measures to resist these Mosquitoes "Development of Mosquito-Repellent Garments" is a venture to achieve it.

"Necessity is the Mother of Invention", this implies that any novel or innovative initiation is exclusively need based. One of the callous situations that the world faces is infant mortality. This is mainly due to the diseases spread by Mosquitoes. Hence, it is high-time to take definite measures to protect infants from the ordeals caused by Mosquitoes. Mosquitoes are a vector, agent that carry disease-causing viruses and parasites from person to person without catching the disease themselves. Female Mosquitoes suck blood from people and other animals as part of their eating and breeding habits. The female mosquito that bites an infected person and then bites an uninfected person might leave traces of virus or parasite from the infected person's blood. The infected blood is injected through, the "dirty" proboscis into the uninfected person's blood and the disease is thus spread from person to person. In view of the above, it is essential to develop mosquito-repelling items, especially, the garments that repel the Mosquitoes, so that human beings can be protected from the mosquito menace. The current work represents an attempt in this direction. The global warming leads to the distribution of Mosquitoes which have expanded from tropical regions to northern latitudes, and that leads to a spread in sources of viral infection from Mosquitoes. Although some chemical repellents do work, it is always preferable to have a natural alternative. Here are some natural ways to repel Mosquitoes. The most effective natural Mosquito-repellents are essential oils, such as citronella, lemongrass, eucalyptus, peppermint, lavender, tea tree oil, and cedar oil. All of these oils are to be applied topically, not internally. There are many products on the market that are comprised of a combination of these oils and are quite effective. Citronella candles and incense are also common and effective, especially when used in combination with the oils.

Value addition in clothing has changed the global textile scenario. A novel and holistic approach of the 21st Century has been the use of microencapsulation in textile finishing. Creative designers of the 21st Century want to diversify their vision from visual aesthetics to performance value like sense of smell, colour change technology, phase change materials and bactericides. Mosquitoes are members of the family of nematocerid flies. In particular, many species of female Mosquitoes are bloodsucking pests and dangerous vectors of diseases. Over 3,500 species of Mosquitoes have already been identified in various parts of the world. Some Mosquitoes that bite humans are vectors for a number of infectious diseases affecting millions of people per year. According to World Health Organization, dengue fever is the most important arbovirus which infects human in the world. This virus is spread through female Mosquitoes (*Aedes aegypti*) from person to person they also spread other diseases. Eliminating Mosquitoes from the planet may sound extreme. A few scientists and researchers have suggested that complete eradication would not have serious ecological consequences. In practice, however, control measures focus on the small group of Mosquito species which are vectors of human or livestock disease using chemical solutions, coils and mats. The synthetic repellents are used to protect the human being from Mosquitoes by coating them on fabrics and applying to skin.

A variety of botanical substances have been evaluated for their repellency against Mosquitoes. Thousands of plants have been tested as potential sources of insect repellents. None of the plant-derived

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chemicals tested to date demonstrate the broad effectiveness and duration of DEET(N,N-Diethyl-meta-toluamide), but a few show repellent activities. Plants whose essential oils have been reported to have repellent activity include citronella, cedar, verbena, pennyroyal, geranium, lavender, pine, cajeput, cinnamon, rosemary, basil, thyme, allspice, garlic, and peppermint. Unlike synthetic insect repellents, plant-derived repellents have been relatively poorly studied. It also causes a behavioural problem and affects, respiratory tract and nervous system. Natural repellents are identified by researchers to control the Mosquitoes. Market for fragrant clothing has also been expanded and due to increase in awareness about health and hygiene, people increasingly want their clothing to be hygienically fresh [1]. To ensure safety and security of people from the future hazards, it is essential to develop the technology for our protection [2].

A Mosquito repellent textile is one such product that has come out recently to protect the human beings from the bite of Mosquitoes promising safety from the diseases like malarial fever. Thorough research and development has facilitated the applicability of certain chemicals of the textile products, which sustain this character for a reasonable period [3]. Basically mosquito-repelling textiles are the ones, which exhibit a character of repelling Mosquitoes. This feature is developed as a need in the sense of protection from the Mosquitoes in which the textile material is given an anti-Mosquito finish. There are various kinds of Mosquitoes, each of which has a different habitat, behaviour and preferred source of blood. About ten of these species are so numerous and such vicious biters of man and animal, that an organized Mosquito control is necessary because Mosquitoes are not only a nuisance as biting insects, but are also involved periodically in transmitting disease to humans and animals [4]. The repellent properties of plants to Mosquitoes and other pest insects have been well known before the advent of synthetic chemicals. However, the most commonly used insect repellents are synthetic chemicals that mostly have contained DEET (N, Ndiethyl-3-methylbenzamide) in their formulations. Although DEET is an effective repellent against a broad spectrum of insects, however, there are disadvantages associated with the use of DEET, which stem principally from its activity as a solvent of paints, varnishes, and some plastic and synthetic fabrics. There have also been concerns over the toxicity of DEET [5].

Uniqueness of microencapsulation is the smallest of coated particles and it provides a means of packaging, separating and storing materials on a microscopic scale for later release under controlled conditions [6]. The properties of microcapsules, size, shape, wall material, active substance release mechanism, have to be adapted to the requirements of textile processing methods and use of final products [7]. Some of the herbal compounds obtained from plants are well known from time immemorial as antibacterial and antifungal products. These plants and tree products are applied directly on skin or wounds as paste or decoction either for skin care or wound healing [8]. Apart from dyeing these medicinal products possess distinct odour for identification. These plant products are nonirritant to skin and non-toxic. Many of these materials are skin care products. The stem, bark, leaf, root and tuber of the plants and trees can be used for special application. Lemongrass is a medicinal plant whose leaves are widely used for many applications [9]. Lemongrass is commonly known as "East Indian Lemongrass" is a perennial and multi cut aromatic grass. The prefix 'lemon' owes to its typical lemon like odour, which is mainly due to the presence of citral, a cyclic monoterpene. Lemongrass is the source of Lemongrass oil, a good source of natural citral, which is used as a basic raw material for synthesis of ß-ionone used for synthesis of a number of useful aromatic compounds and Vitamin-A. Lemongrass oil is thus used as a main substitute for 'Cod liver oil' [10].

Recently, several new commercially developed Mosquito control devices have become available to control Mosquitoes and other biting arthropods. These products claim that they can significantly reduce or even eliminate the number of Mosquitoes and other biting arthropods present by effectively trapping or repelling them from residential properties. In another study, a lethal ovitrap designed and developed to kill dengue vectors via an impregnated insecticide-treated ovistrip has been evaluated in Rio de Janeiro, Brazil, and has shown to be effective in reducing *Aedes aegypti* (L.) populations in and around homes [11].

Experimental Procedure

The detailed experimental procedure involved in carrying out this work is described below.

Materials

In the present work, Cotton and Trevira knitted fabrics are produced separately from 30 Ne Cotton and 30 Ne Trevira ring-spun yarns on a 16″diameter Knitting Machine (PMW make) using a 24-gauge cylinder with 1200 needles and a positive feeder, are used as basic textile material for experimentation. The natural Mosquito-repelling agent, namely Eucalyptus Oil (EC) and a synthetically developed mosquito-repelling reagent namely, N, N-Diethylphenylacetamide (DEPA) of technical grade are used for imparting on the basic fabrics chosen for study.

Pre-treatment of fabrics

Pre-treatment of cotton fabric: The Cotton fabric is scoured with NaOH, bleached with H_2O_2, and dyed with Reactive Red H8B dye to render it attractive to the Mosquitoes. The recipe for scouring, bleaching and dyeing is given below.

Recipe for scouring

- Sodium Hydroxide (NaOH) - 4% owm
- Wetting Agent - 0.5% owm
- M:L Ratio - 1:20
- Temperature - 90 to 100°C
- Duration - 1 hour.

Recipe for bleaching

- Hydrogen Peroxide - 2% owm
- M:L Ratio - 1:20
- Temperature - 85°C
- Duration - 1.5 hour.

Recipe for dyeing

- Reactive Dye (Red H8B) - 0.5% owm
- Sodium Carbonate (Na_2CO_3) - 4.0 gpl
- Sodium Chloride (NaCl) - 40.0 gpl
- M:L Ratio - 1:20
- Temperature - 80°C
- Duration - 1 hour.

Pre-treatment of Trevira fabric: The Trevira fabric is plain washed

and dyed with Disperse Red dye using the recipe given below:

Disperse Red Dye	-	0.5% owm
Carrier	-	10% owm
Acetic Acid (CH_3COOH)	-	1.0 gpl
M:L Ratio	-	1:20
Temperature	-	100°C
Duration	-	1.5 hour.

Mosquito-repellent treatment

a) *Mosquito-repellent treatment with Eucalyptus oil*: The pre-treated Cotton and Trevira knitted fabrics are separately given finishing treatment in a padding mangle with Eucalyptus Oil and an acrylic based binder using the recipe given below. The finished samples are dried naturally inside the laboratory.

Trial 1

- Eucalyptus Oil - 15% owm
- Binder - 2% owm
- Soap - 2% owm
- M:L Ratio - 1:5.

Trial 2

- Eucalyptus Oil - 30% owm
- Binder - 4% owm
- Soap - 4% owm
- M:L Ratio - 1:5.

b) *Mosquito-repellent treatment with DEPA*: The pre-treated Cotton and Trevira knitted fabrics are separately given finishing treatment in a padding mangle with DEPA, an acrylic based binder and fixer, using the recipe given below.

- N,N- Diethylphneylacetamide (DEPA) - 15%
- Binder (Acrylic Copolymer based) - 30%
- Fixer (Melamine Formaldehyde Trimethylamine) - 6%
- Emulsifier - 3%
- Glacial Acetic - 1%

Dried at a temperature of 80°C for 3 minutes and Cured at a temperature of 130-150°C for 2 minutes.

Testing and evaluation

Fabric constructional particulars: The important fabric constructional particulars such as courses per inch (CPI), wales per inch (WPI), thickness, areal density (GSM), loop length, and tightness factor are measured both in gray and finished states for both Cotton and Trevira samples.

Mosquito-repellency: The field test is the most meaningful evidence in testing the efficacy of mosquito-repellent-treated textiles. Field studies are the ultimate verification of the performance of the garment developed. The most realistic conditions deliver the most meaningful results. The field test is carried out in areas where Mosquitoes are available in abundance. The following are the steps involved in carrying out this test as (Express textile web page):

- The field test is carried out in the Bannari Amman educational institute, where Mosquitoes are available in abundance (Figure 1);
- The test is started by dusk (around 6 pm) with the required samples;
- All parts of the body other than fore-arms are covered to avoid undesired mosquito bites;
- Wrap the control sample is wrapped over the left fore-arm and the mosquito-repellent-treated textile on the right fore-arm as shown in Figure 2;
- Both the hands with the treated and untreated samples are exposed to the area of mosquito availability for a time-period of 3 minutes. Using the digital camera the observations are captured and the rate, number and frequency of the Mosquitoes approaching are recorded manually;
- The above procedure is repeated for every treated sample.

Assessment of fragrance decay: In this test, the fragrance of Cotton and Trevira samples treated with Eucalyptus Oil of 15% and 30% (B, C, E & F), respectively are subjectively assessed. The observations are taken once in a week for a period of 35 days. The steps involved in this observation are as follows:

- Each sample is placed every week at a constant place on a table in the corridor of the hostel. The observer will walk from a certain distance, say 25 feet away from the sample, with the sense for smell of the Eucalyptus Oil.
- Once the observer smells the fragrance, he stops moving and the distance is measured. The same method of the fragrance is repeatedly carried out for 5 weeks.

Figure 1: A view of area for field test.

Figure 2: Demonstration of field test.

➢ A graph showing the decay of fragrance as a function of time is plot for analysis and reference.

Cage, cone and indoor tests: Around 8 samples of knitted fabrics impregnated with repellents (DEPA and Eucalyptus Oil) have been evaluated in the laboratory for protection from *Aedes aegypti* mosquito bites. Samples are coded as 'A' for Control (Untreated), and other fabric samples are treated and coded as 'B, C, D, E, F, G'. The evaluation of DEPA impregnated fabrics has been carried out in the laboratory as follows:

a) Test insects: *Aedes aegypti* females (major vetor of dengue and chikungunya in India), which were 4-5 days old drawn from the stock colony maintained in the laboratory at 27 ± 2°C and 70 ± 5% RH;

b) Test chamber: Wooden test chamber of size 750 mm × 650 mm × 650 mm (Figure 3).

Evaluation procedure: *Aedes aegypti* of about 200 in number are released in the test chamber. The repellent impregnated knitted fabrics are cut and stitched as hand glove of the size of the fist and used for evaluation. Before evaluating the fabric samples, a hand (without any application) repellent was inserted in to the test chamber containing female mosquito for ensuring that the Mosquitoes are hungry enough to take blood meal. The control fabric sample 'A' is first tested. The remaining samples B, C, D, E, F, and G are subsequently tested separately. For evaluation purpose, the impregnated fabrics worn on hand are exposed to mosquito at every 30 minutes interval for a period of 5 minutes and recording the mosquito bites. The exposure of fabrics was replied twice. The protection time of impregnated fabrics is determined on the basis of five mosquito bites/pierces received in 5 minute exposure period and thereafter the evaluation is terminated.

Figure 3: Test chamber.

Results and Discussion

The characteristics of the mosquito-repellent treated fabrics are analysed and discussed as follows.

Constructional particulars of fabrics

The constructional particulars of all the fabric samples are given in Table 1.

Field test observations

The results of the field test of the treated samples evaluated against the control sample are given in Table 2 for comparison and discussion. It can be seen that no Mosquitoes are attracted to the Cotton fabric treated with 30% Eucalyptus Oil as against the untreated sample (Control sample), which attracted at least one mosquito per minute. This proves that the fragrance of the Eucalyptus Oil has got good mosquito repellency.

Assessment of fragrance decay

It can be seen from Figures 4 and 5 that the fragrance of the Eucalyptus Oil treated fabrics decreases as indicated by the reduction in distance upto which the fragrance is emanated by the sample for a function of time. This indicates that the mosquito-repellency of these samples decreases as a function of time. This represents the limitation of natural fragrant Eucalyptus Oil.

Cage, cone and indoor tests

The mean protection time (MPT) of fabrics impregnated with repellents against *Aedes aegypti* Mosquitoes is shown in Figure 6.

The results given in Table 3 show that the untreated control sample 'A' could not provide protection against mosquito bites. The fabrics coded with B, C, D and F are found to provide protection, mosquito bites for more than 6 hours, whereas in the case of other two samples viz., E and G the protection time is found to be only 1.0 hour and 1.5 hours respectively.

Sl. No.	Sample Description	Sample Code	CPI	WPI	GSM	Thickness (mm)	Loop Length (mm)	Tightness Factor
1	Cotton untreated	A	50	40	152	0.48	1.89	0.34
2	Cotton treated with 15% EC	B	49	37	170	0.52	2.19	0.49
3	Cotton treated with 30% EC	C	50	39	174	0.52	2.15	0.48
4	Cotton treated with 15% DEPA	D	46	37	176	0.45	2.24	0.5
5	Trevira treated with 15% EC	E	56	44	175	0.44	1.39	0.31
6	Trevira treated with 30% EC	F	55	45	179	0.44	1.4	0.31
7	Trevira treated with 15% DEPA	G	56	47	217	0.5	1.36	0.3

A: Control sample; EC: Eucalyptus oil; DEPA: N,N-Diethylphenylacetamide.

The fabric constructional variation in the samples of untreated, treated with 15% and 30% Eucalyptus oil and DEPA (N,N-Diethyphenylacetamide).

Table 1: Constructional particulars of fabrics.

Sl.No.	Description	Control sample (A)	Cotton treated with 15% EC (B)	Cotton treated with 30% EC (C)
1	No. of mosquitoes	3-4	1	-
2	Time of observation (min)	3	3	3
3	No. of mosquitoes/min	1	-	-

Table 2: Observations of field test.

S. No.	Sample code and name	Sample description	Mean protection time (MPT)
1	A (Untreated - controlled sample)	Knitted cotton fabric untreated	5 minutes
2	B (Impregnated with eucalyptus oil)	Knitted cotton fabric treated with 15% EC	More than 6.0 Hours
3	C (Impregnated with eucalyptus oil I)	Knitted cotton fabric treated with 30% EC	More than 6.0 Hours
4	D (Impregnated with repellent DEPA)	Knitted cotton fabric treated with 15% DEPA	More than 6.0 Hours
5	E (Impregnated with eucalyptus oil)	Knitted polyester fabric treated with 15% EC	1.0 Hour
6	F (Impregnated with eucalyptus oil)	Knitted polyester fabric treated with 30% EC	More than 6.0 Hours
7	G (Impregnated with DEPA)	Knitted polyester fabric treated with 15% DEPA	1.5 Hours

EC: Eucalyptus Oil; DEPA: N,N-Diethylphenylacetamide.

Table 3: Mean protection time of fabrics impregnated with repellent against *Aedes aegypti* mosquitoes.

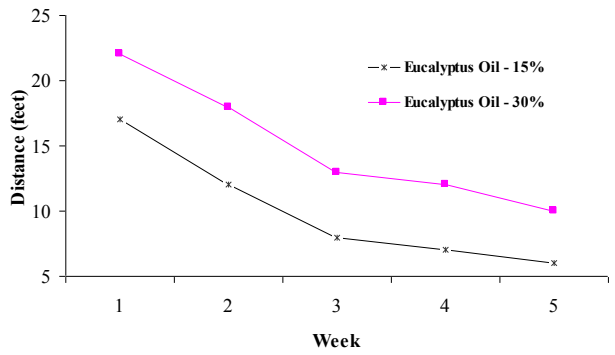

Figure 4: Fragrance decay in cotton treated samples.

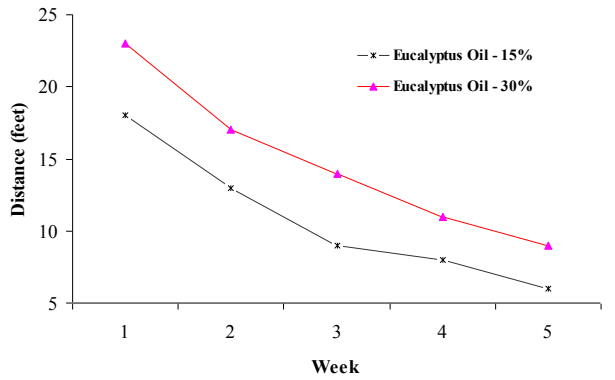

Figure 5: Fragrance decay in Trevira CS treated samples.

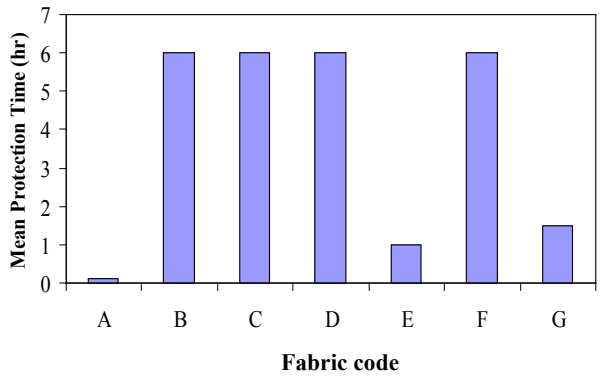

Figure 6: Mean protection time (MPT) of fabrics impregnated with repellents against *Aedes aegypti* Mosquitoes.

Conclusions

The following conclusions are drawn from the present work: The Cotton and Trevira fabrics treated with 15% and 30% Eucalyptus Oil exhibit good mosquito repellency as observed from the field test. It is the fragrance of the Eucalyptus Oil that is responsible in repelling the Mosquitoes.

The fragrance of the Eucalyptus Oil treated fabrics decreases as indicated by the reduction in distance upto which the fragrance is emanated by the samples. This indicates that the mosquito-repellency of these samples decreases as a function of time. The mosquito-repellency of Eucalyptus Oil treated fabrics can be improved by using an enhanced binder or fixer in optimized quantities.

The fabric samples coded as B, C, D, E, F and G impregnated with repellents (DEPA and Eucalyptus) showed different periods of mean protection time (MPT) from the bites of *Aedes aegyti* Mosquitoes. Based on the efficacy of the repellents, it may be concluded that the sample coded as 'D' is the most effective followed by sample 'C', sample 'B' and sample 'F'. Garments finished with mosquito-repellents are more desirable and comfortable means to avoid Mosquitoes than other methods to such as applying lotions, sprays, etc. The mosquito-repellant textiles can also be used for production of apparel, T-shirts and also home textiles. In the mosquito prone areas, these textiles can be extensively used in the form of wall coverings and tents. Apart from these applications, these textile materials can also be used for manufacturing bags used for storing eatables, textiles, perishable goods and all other goods prone to damage by insects.

References

1. Karolia A, Mendapara S (2005) Application of antimicrobial and fragrance finish in combination by microencapsulation on cotton fabric. Journal of the Textile Association, pp:155-159.
2. Kumaravel S, Lakshmikantha CB, Ponmurugan P (2009) Mosquito repellent fabric – A comprehensive view. Textile Review, pp: 26-29.
3. Pani BD (2008) 'New microbial insectide -a discovery by accident. Magazine Invention Intelligence: 26-28. 3
4. Gulrajani ML, Agarwal A, Lohia C (2007) Preparation of mosquito repellent fabrics. Asian Dyer: 53-55.
5. Oshaghi MA, Ghalandari R, Vatandoost H, Shayeghi M, Kamali MN, et al (2003) Repellent effect of extracts and essential oils of Citrus limon (Rutaceae) and Melissa officinalis (Labiatae) against main malaria vector, Anopheles stephensi (Diptera: Culicidae). Iranian J Publ Health 32: 47-52.
6. Thilagavathi G, Bala SK (2007) Micro encapsulation of herbal extracts for microbial resistance in healthcare textiles. Indian Journal of Fibre and Textile Research 3: 351-354.
7. Voncina B, Kreft O, Kokol V, Chen WT (2009) Encapsulation of Rosemary oil in ethyl cellulose microcapsules. Textile and Polymer Journal 1: 13-19.
8. Sayed U, Jawale LS (2006) Application of herbs on fabrics. Supplement to Colourage 4: 129-133.

9. Premalatha R, Nagarajan L (2007) Herbal finishing on woven fabrics. National Conference on ACTPAQ: 88-92.

10. Hebbalkar DS, Hebbalkar GD, Sharma RN, Joshi VS, Bhat VS (1992) Mosquito repellent activity of oils from Vitex negundo Linn. Leaves. Indian Journal of Medical Research 95: 200-203.

11. Perich MJ, Kardec A, Braga IA, Portal IF, Burge R, et al. (2003) Field Evaluation of a Lethal Ovitrap Against Dengue Vectors in Brazil'. The Royal Entomological Society, Medical and Veterinary Entomology 17: 205-210.