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A REVIEW ON MOSQUITO REPELLENT CLOTHING

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Abstract - *The current trend of mosquito protective wears was involved in infusion of insecticides in the textile material. We have come across many protective textile materials which involve providing all sorts of protection from UV protection to germs and thus engineering a fabric to tackle all possible discomfort and harm caused by the environment becoming more needed. Mosquito repellent clothing is involved in protecting the human community from harmful diseases caused by mosquitoes like chikungunya, yellow fever, dengue, malaria, nile west fever etc. This paper reviews the natural plant extracted chemicals, and derived chemicals used for killing insecticides will be incorporated in the fabric by using finishing techniques and the factors involved for achieving prominent efficiency and durability of coating are discussed.*

***Key Words*: Protective textile, Mosquito repellent finish, Natural extracts, microencapsulation, Dip coating.**

1. INTRODUCTION

Mosquito repellent clothing was one of the emerging streams of Personnel protective wearing (PPE) which is equipped for minimizing the exposure to the hazard (any form) which has potential to break the immunizing capacity. This sort of improvement in the existing clothing required an enormous amount of experiment and studies. We are going to disclose previous work done on this topic of mosquito repellent clothing and review them elaborately. Since it is much needed for a wide range of users like children, people who live in the zone more affected by mosquito borne disease, low immune patients (like HIV, cancer patients) military soldiers, wildlife researchers, wildlife photographers (Smith, W.C. 2014).

Mosquitoes are one of the most intense threats for mankind. Major studies show that there more than 3000 species of mosquitoes are in different ecosystems and feeding from varieties of host, their presence and capacity to transmit disease causing agents are immense in the animal kingdom. The parasites and viruses that are vectored by mosquitoes are the reason for the death of thousands of humans every year, where millions are affected and suffer. Moreover this contagion causes a burden in substantial developing countries. Which lack the infrastructure, economical and educational resources necessary to properly control the spread of mosquito borne disease. In general there are two kinds of practice to control the spread of the disease that are destroying the target vector (mosquitoes) which is almost impossible to bring on and another method is a preventive method which has a good response. This measure is enhanced by developing a fabric which has the potential to repel the mosquito (Bhatt S, Gething PW, Brady OJ, Messina JP, Farlow AW, et al.(2013))

The present mosquito protective textile materials which are available in the market where insecticide infused net and curtains. Even this mosquito protective material is more promising than the commonly used method of spraying insecticides in the environment and using lotion creams over the body since they are short lasting in case of periods of protection (Jansen CC, Beebe NW(2010)). The studies begin with coining suitable insecticides for encapsulation on the fabric and also fibre which is suitable for that particular insecticides and investigating the best way of spinning, washing fastness of the fabric, ultraviolet light and ironing using high liquid pressure chamber, performance testing of the fabric, limitations and practical challenges, better way treatment, amount and way of using insecticides by World Health Organisation (WHO) in order to prevent side effects are discussed below with reference of previous milestone works carried out based on mosquito repellent clothing in nook and corner of world.

2. MATERIALS AND METHODS

The material, methods and testing procedure performed by previous researchers are discussed below (J. Griffin of Insect Shield, personal communication, February 17, 2014).

2.1 Materials

a) 100 % cotton i.e., Denim jeans (Grainger, Lake Forest,, IL);
b) 100 % polyester, i.e., lightweight work shirt (Grainger, Lake Forest, IL);
c) 35 % of cotton 65 % of polyester (Human Technologies Corporation, Utica, NY).

One set of each type of clothing was sent to the insect shield for treatment with permethrin. All fabrics used in this study were treated with permethrin at a concentration of 125 µg/cm^2 (J. Griffin of Insect Shield, personal communication, February 17, 2014). Two replicate swatches (5 cm× 5 cm) were cut from each treated and untreated fabric and used for experiments for a total of 192 swatches. Temperature treatments (18°C and 32°C) were based on temperatures during spring (Weather Underground, 2017a) and summer (Weather Underground, 2017b) months in North Carolina.

2.2 Natural Product Based Mosquito Repellent Chemicals

In further studies, the researchers ended up with discovery of mosquito repellent capacity of natural extract which become much needed since this type of naturally extracted chemical components are less allergic then the man made synthesized chemicals. Some of the extracts are eucalyptus oil, rosemary oil, clove oil etc. These essential oils are complex mixtures of volatile organic compounds present in the plants. Monoterpenes, sesquiterpenes, and phenols are the main active compounds produced as result of secondary metabolites in the plant system (Sman MB. Pesticides based on plant essential oils, Pestic Outlook 1999; 10:68-72). Repellent properties of several essential oils appear to be associated with the presence of lower isoprenoids. Monoterpenes such as α-pinene, limonene, terpinolene, citronellol, citronellal, camphor and thymol are common constituents of a number of essential oils that show mosquito repellent activity (J Am Mosq Control Assoc. 2005; 21:80-3)

2.3 Methods:

Fabric treated method

The treating process involved in infusing the potential chemical of calculated proportion in order to achieve the desired outcome and this way of treatment decides the durability and performance of the purpose (I. Soljacic: Textile Coating, Tekstil 42 (12) 673-686 (1993.)), The methods of treating the fabrics is discussed below,

Dip coating

The method of dip technique of coating is a powder coating process which includes immersing or dipping, a substrate into a solution of coating material at an imperturbable speed (Ceratti DR, Louis B, Paquez X, Faustini M, Grosso D (2015)) It is a technical process used to fabricate large quantities of coated fabrics or prophylactics in conjunction with specialized coatings in the biomedical field. Diverse chemical and nanomaterial engineering research processes are used in academic research to study the use of dip coating to produce thin film coatings. The dip coating technique can bring a uniform, high-grade film even on bulky, and complex shapes.

The antecedent application of dip coating is presumed to have been in candle fabrication. Similar to candle making, modern-day substrate dip coating involves repeating the process, until the coated material is built up, therefore ending in a relatively thick final object. Dip coating can be performed as a continuous roll-to-roll process for malleable laminar substrates like fabrics. Conversely, 3D objects can effortlessly be inserted and removed from a coating bath and objects like prophylactics are dipped into the coating. The dip coating process involves five stages:

- Immersion
- Start-up
- Deposition
- Drainage
- Evaporation

Once the dip coating process is complete, the final product may incorporate both the substrate and the coating or the coating can be peeled off so that the object consists only of the dried or solidified coating (as with prophylactics). Academic research projects study reveals that certain nanoparticles are used as coating materials through dip coating finishes. The applications consist of multi-layer sensor coatings, implant functionalization, hydro-gels, Sol-Gel nanoparticle coatings, self-assembled monolayers, and layer-by-layer nanoparticle assemblies (Sina Ebnesajjad PhD, Arthur H. Landrock, in Adhesives Technology Handbook (Third Edition), 2015).

The following dipping techniques are used for the application of fabric such as,

(I) **Factory dipped clothing** (FDC) in which permethrin polymer coated over the surface by dipping the fabric in permethrin polymer (0.52 % permethrin as mobile ingredient).

(II) **Home dipped clothing** (HDC) in which without any preprocess the fabric is dipped in 0.50 % permethrin as a working ingredient.
Alternate methods of incorporation of natural extract applied on the fabric such as,

(III) **Microencapsulation** is the process in which tiny particles are just coated with polymeric material to produce capsules from microns to millimeters in size.

(IV) **Direct coating** is a process, where polymeric material is put on the surface of the fabric.

(V) **Spraying Technique**

Spraying is a painting technique that engages a spraying device, usually paired with compressed air, to air-spray a workpiece with a choice of coating. Coatings can be peculiar between paint, ink, varnish, and other materials. Airbrushes and spray guns are the two important devices used for industrial spraying. They are distinguishable by their sizes and patterns produced on the fabrics. While airbrushes are hand-held, they are typically applied to projects that require a greater amount of detail such as fine art, small nails, or photo retouching (Gross D (2014)). The equipment used with spray guns is generally quite large. Spray guns are typically well suited for covering the large surfaces with an even liquid coat on the fabrics. Their interchangeable heads allow users to spray different patterns and they can be either automated or handheld. Also there is an idea of incorporating the permethrin as a dope (solution) on the initial stage of polyester monofilament manufacturing process by melt spinning of polymer. In this method only 20g/kg of fibre is used in case of increasing contraction where the structure, property, nature, and spinnability are altered to more and decreasing the concentration reduces the practical validity of insecticides which affect the purpose of adding insecticides. In conjunction with this polyester monofilament a net was prepared which has protection against mosquito for about 20 washes.

Method of Testing

In uniform the swatches of dimension 5*5 cm were subjected to almost all form of assessment and three kinds of sample were subjected (i.e. fresh (untreated), treated and washed) into the washing fastness test, light fastness test and also in mosquito mortality experiment and chemical used was permethrin according to United State Environmental protection Agency, the only insect repellant currently used for factory treatment of clothing and it is extracted from chrysanthemum flowers (W.H.O. (2009) Guidelines for efficacy testing of mosquito repellents).

3. Experiments

The following works were the clothing evaluation summary which involves in the evaluating and justifying the standard of the performance and durability of the mosquito repellent clothing (PLOS Neglected Tropical Diseases| DOI:10.1371/journal.pntd.0004109, October 6, 2015).

Review on Washing Fastness and Exposure to Light and Temperature

The experiment done on the washing fastness shows that the fabric coated with permethrin when subjected to analyze their ability to withstand exposure to the light and temperature are prepared by soaking them for 10 min in container of 250 ml cold tap water and 1 ml of all free and clear detergent and the rinsed in the cold tap water for 15 sec. This process was carried out twice and the swathes were air dried in incubator overnight in 18 °C and then subjected to various number of washes and also exposed to 72hr light, 288hr light, 864hr light (hr light is just a variety of bulb made for experimental purpose). The fabric samples are segregated into groups such as zero wash and no exposure to light and temperature were kept in the incubator of vacuum. The result found that to some extent it gives better than all the three parameters has its own limitation like 18 washes, 3 min exposure to 100% light and 32°C temp it become ideal method of testing for this type of coated textile material (Sukumaran, D., Sharma, A.K., Wasu, Y.H., Pandey, P., & Tyagi, V. (2014))

Review on Mosquito Mortality Experiment

An remarkable and most need experiment on the mosquito mortality or knockdown were conducted for the fabric by using Ae.albopictus an species of mosquito which originated from New Orleans, Louisiana. This colony had no history of insecticide exposure, mosquitoes were reared under standard conditions (this particular work was done by Richards, Anderson & Alto, 2012) and eggs were hatched in plastic rearing pans (12cm*8cm*5cm) with 1.0 L of tap water and 200 mg larval food (1:2 mixture of brewer's yeast and liver powder) Larvae were fed every other day for approximately 4days. The initial growing stage Pupae were transferred to 25 ml plastic cups containing 20 ml water and adults were allowed to emerge in square cages (33 cm) and provided 20% sucrose for each group and replicate of fabric samples approximately 12 female mosquitoes were transferred via mechanical aspirator to clear plastic cones (65 mm length * 15 mm stem diameter) and placed over each fabric swatch and held for 3min to approximate the World Health Organization Pesticides Evaluation Scheme (WHOPES) (world health organization, 2013).

After the fabric exposure period, mosquitoes from the replicate were aspirated from funnels and transferred to separate 0.5L cardboard cages with mesh screening on top; they were provided with sucrose. Mosquitoes were held in an incubator at 28°C for the duration of the experiment. The extent to which mosquitoes were knocked down (i.e. lying on back or side and unable to fly) was assessed and recorded. From the test results, it is found that the home dipping and factory dipping method has better durability than microencapsulation.

4. ISSUES AND CHALLENGES

Limitation and consideration for the further studies and research work in this stream of mosquito protective textile clothing are as follows. The necessary of advancement in the research work begins with coining of appreciate chemical with the effective mosquito repellency and their affinity to infuse with the textile material and an comparative study has to be conducted with permethrin in all stage then their durability of the coating and encapsulation has to be advanced since failure in this property has the possibility to degrade efficiency by period of time and environment, which can be achieved by microencapsulation over direct way of coating in order to enhance this the suitable wall material has to be coined where the material used were starch, gum acacia, sodium alginate and other method is inclusion forming compounds like α-cyclodextrin can be utilized to entrap the aromatic fragrance compound. They can be fixed on the textile material by way of chemical bonding using cross linking agents. It is reported that thyme oil, cypress oil and grapefruit oils are in combination of 2:1:1 and microencapsulating them using sodium alginate as a wall material are the best method for mosquito repellency. Hence their performance has to be enriched in the way that they are free from allergy, durable and economical in production.

5. SUGGESTION FOR FURTHER DEVELOPMENT

The studies extend the relationship between the chemical used and method of incorporating that substituent into the fabric (I. Soljacic: Textile Coating, Tekstil 42 (12) 673-686 (1993.). The incorporating style and fibre subject to the study (cotton, polyester, cotton polyester blends).This can be extended to more number of fibre in order to get best performance and to overthrow the limitation and challenges that were faced using this limited number of techniques of coating and quite lesser variety of fibre by using some artificial fibre like Aramid (p-aramid, m-aramid) which has obvious strength wide use, Polyethylene sulphide fibre (PPS) is a crystalline thermoplastic fibre, high heat and chemical resistance, Ultra high tenacity Polyethylene fiber, Polyether ketone fibers (PEEK), Novoloid (cured phenol-aldehyde) fibers, PBO (p-phenylene-2,6-

benzobisoxazole) (Tasneem Sabir, in High-Performance Apparel, 2018). The suggested fibres have been largely used in protective textiles for the past few years. The study could be enhanced to a larger extent with help of these fibers can be a better optional one and can fulfill the needs.

6. CONCLUSION

In this review, we tried to give an overall outlook of all the research work, studies, journals and experiments which have been done in the past history in the form of mosquito repellent clothing and their remarkable achievement and drawbacks which has to be considered for further improvement and experiments. The tests and studies can conclude that both microencapsulation and home dipping has combined together with better durability and performance than any other method of coating and permethrin is proved to be the best natural extracts used for mosquito repellency application. Future research must be in the direction of engineering a more durable method of entrapping the insecticides in the fabric and coining insecticide for unallergic situations.

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