Chapter 5

# Vector Diseases Treatment Based on Intermediate Complexion Using Textile Substrates

***Fabricio Maestá Bezerra[1,*]; Taís Larissa Silva[1]; Manuel J Lis[2]***

*[1]Textile Engineering (COENT), Federal University of Technology Parana (UTFPR), Apucarana, Brazil.*

*[2]INTEXTER-UPC, Colon, 15, 08222. Terrassa. Barcelona. Spain.*

[*]**Correspondence to: Fabricio Maestá Bezerra,** *Textile Engineering (COENT), Federal University of Technology Parana (UTFPR), Apucarana, Brazil.*

*Email: manuel-jose.lis@upc.edu*

## 1. Introduction

Insect-borne diseases (Vector diseases) affect millions of people every year, especially in tropical and subtropical countries [1]. The pathogens transmitted by these insects are responsible for most infectious diseases on the planet [2]. Examples of these diseases transmitted to humans include malaria, dengue fever, filariasis, yellow fever, chikungunya, Zika virus, West Nile virus, Japanese encephalitis and others [3-7].

Peila et al. [1], shows that among basic precautions to prevent transmitted diseases are the use of repellents. Repellents are substances that act to inhibit insects, producing a barrier that prevents contact between the vector and human or animal skin [8]. The substances may be from both synthetic and natural origin.

The most efficient insect repellents are DEET (N, N-diethhyl-meta-toluamide) from synthetic origin and citronella essential oil from natural origin [9]. However, there are other products that can also be used as insect repellents from synthetic origin, such as: DEPA (N, N-Diethyl Phenylacetamide), Icaridin, IR3535 and Permethrin and, of natural origin*: Carapa guianesis, Atemisia vulgaris, Ocimim., basilicum, Cinnamomum camphora, Corymbia citriodora, Eucalyptus sp, Cymbopogon, Mentha pulegium*, [10-14].

All those products are the basis of most commercial repellents; however the action of these repellents is of short duration, due to the volatility of the chemical compounds of these products and, therefore they offer an uncontrolled release. The authors [15]have shown that there would be an alternative to control their release based on the complexation of the active principle (the repellent oil). Thus, the repellent will have its prolonged effect and will protect the user longer.



The active principle can be used in repellent products, applied to the skin via spray or can be used on textiles. According to Lis Arias et al. [16] when used in textiles, these products become biofunctional, enabling the delivery of assets for cosmetotextiles applications. Due to its specific response, biofunctional textiles are especially useful when the textile comes into close contact with the skin [17]. Thus, these products can be used as insect repellents, reducing the number of infections caused by these vectors [18].

## 2. Repellent

**(Table 1)** shows the main synthetic compounds and a brief description.

**Table 1**: Synthetic compounds used as vector repellents and its description.

| **Compound** | **Description** |
|---|---|
| DEET | DEET is the most common repellent used in the world and the repellent properties of this product can be attributed to activation of olfactory receptor neurons (ORNs) in mosquito antennae. DEET has a strong repelling action and its use is not recommended during pregnancy and to children [19,20]. |
| DEPA | DEPA was developed from the unavailability of a chemical component for the production of DEET in India. It has low toxicity and is used for various vector species [21]. |
| ICARIDIN | Icaridin or 2-(2-hydroxyethyl)-1-methylpropylstyrene 1-piperidine carboxylate is a volatile oil that is effective in repelling mosquitoes, flies, bees, ticks and fleas. It has a longer lasting action than DEET [22]. |
| IR3535 | IR3535 ou 3-(N-n-butyl-N-acetyl)-aminopropionic acid ethylester, is a natural derivative of amino acid β-alanine, it has no skin contact toxicity making it a repellent that can be applied to children, but it has lower repellency than DEET [23]. |
| PERMETHRIN | It has high toxicity to the environment and no adverse effect on humans. Can be used in feed and food, clothing and still has many applications in agriculture and animal health [20]. |

**Table 2** shows the main essential oils from plants used as insect repellents. These oils have a large number of bioactive compounds, allowing application in various industries [24].

**Table 2**: Natural compounds used as vector repellents and their description.

| **Compound** | **Description** |
|---|---|
| Andiroba | Andiroba oil is known for its insecticidal and medicinal uses as an anti-rheumatic, analgesic, anti-inflammatory and healing agent. Also, it is used in soaps, candles and cosmetics due to its insect repellent power. The compounds responsible for this effect are tetranortriterpenoids, limonoids or meliacins [25,26]. |
| Citronella | Citronella oil is composed of citronellol, geraniol, limonene, methyl isoeugenol, among other compounds. This oil has been used as an insect repellent, also in aromatherapy, in deodorants, showing health benefits [27]. Citronella oil still has several biological effects, including: antifungal, antibacterial, antioxidant and insect repellent activities [24,28,and 29]. |
| Lemon eucalyptus | The main element is 1,8-cineole (cineole or eucalyptol), oil used in various areas, including perfumery, pharmaceuticals and nutraceuticals. Lemon eucalyptus is the only CDC approved herbal repellent for use in endemic malaria [30,31]. |

Due to the properties of repellent agents, they can be applied to textile articles further extending their action. These applications are possible by textile finishing processes.

## 3. Textile Finishing

Textile finishing processes consist of a series of operations applied to fabrics in order to improve their properties. These processes can occur in three ways: physical, chemical and biological, as shown in **(Figure 1).**

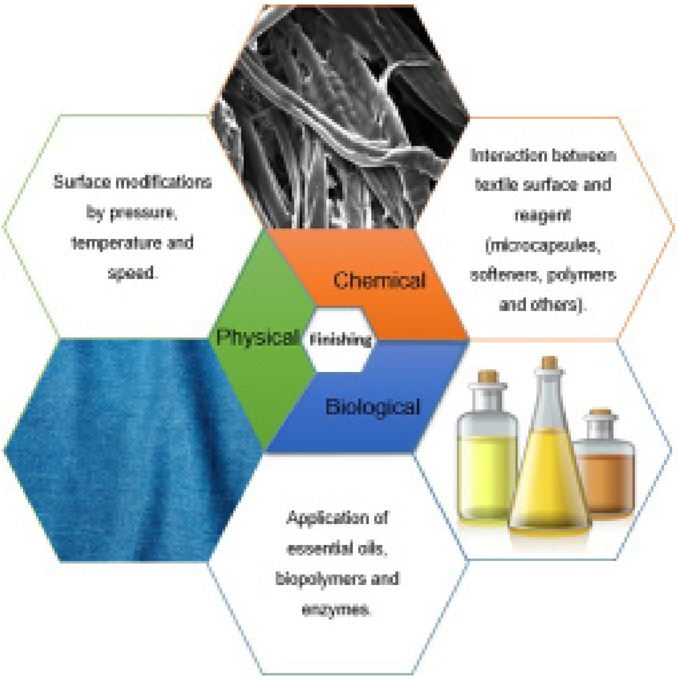


**Figure 1***:* Textile finishing classification.

The techniques used for finishing will depend, basically, on the structure and type of fiber (natural or chemical) that will be used [32]. Some of the desired properties are acquired with functional finishes, such as: bactericidal properties [33] drug release [34] and gas adsorption [35]. For these properties to have a function on the skin, it is necessary that agents be applied on the tissue surface, make the bioactive complexation and release into the skin, bringing benefits to the user [36].

Thus, the effect of the active ingredient will be prolonged due to the protection provided by the complexing agent. In the development of new properties for the fabric, one of the factors that must be considered is the finish durability; it means the prolongation of the effect is essential for the commercialization of the textile article.

There are several protection methods. Table 3 shows some techniques of protection of active ingredients used as repellent agents.

**Table 3**: Techniques for the protection of active ingredients used for insect repellency.

| TECHNIQUE | ACTIVE PRINCIPLE | REFERENCE |
|---|---|---|
| Cyclodextrin | Citronella | [15] |
| Microcapsule | Eucalyptus | [37] |
| Micro/Nanoemulsion | Andiroba | [38] |
| Liposome | DEET | [39] |
| Hydrogel | IR3535 | [40] |
| Solid Lipid Micro/nanoparticle | DEET | [41] |

**Figure 2** shows gelatin and gum arabic microcapsules as wall materials and citronella essential oil as active ingredient [42].

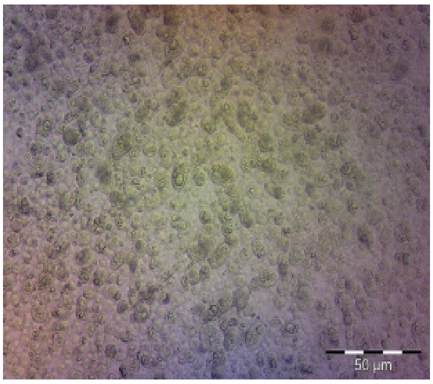


**Figure 2**: Citronella insect repellent microcapsules.

On the other hand, after the process of inclusion or microencapsulation, it is necessary to release the trapped active principle, at a desired rate. Costa and Lobo [43] point out that the release of those encapsulated substances generally follows, basically, three mechanisms: diffusion, activation release and polymeric breakdown / erosion. The control of these mechanisms, can cause the effect of prolongation of active principle to occur, providing greater durability of the final and desired effect. Figure 3 shows in general the production steps of a functional textile article.

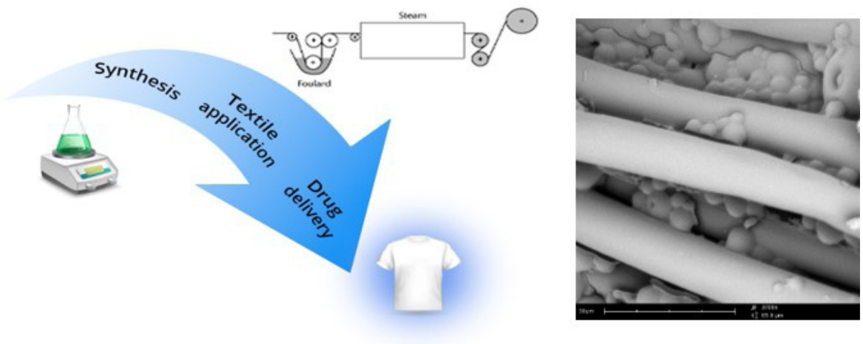


**Figure 3**: Application of active ingredients on textile substrates.

Regardless of the complexation or inmobilization, technique used, the release of the active principle (natural or synthetic) will be responsible for the repellency. Islam et al. [44] shows that the mechanism of action of repellents is related to the formation of a vapor layer on the skin with an unbearable odor to the insect that deflects the path, preventing contact with the host. Thus when the active principle is released from the tissue it will form a layer on the skin causing the insect direction change, avoiding its contact on the user who uses the textile.

Thus, in this system it is important to relate the type of fiber with the compound to be impregnated in the fabric. Both must have interaction to make the finish effective. **Figure 4** shows the main characteristics that a fabric must have to be a repellent biofunctional article.

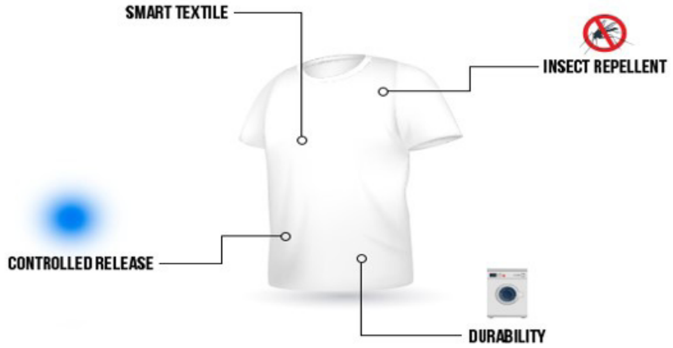


**Figure 4**: Characteristics of an insect repellent textile article.

The repellent textile product, as suggested by Tavares et al. [20]), to be accepted in the market of repellents, mustaccomplish, as main characteristics:

- Repel the largest number of insect species;
- Nontoxic;
- Do not irritate the skin;
- Odorless to humans and an unbearable odor to mosquitoes;
- Water resistance (washing);
- Good resistance to friction and abrasion;
- Low cost.

### 4. Repellence Activity Tests

There are several methods that can be used for to check the efficiency of the system formed with repellents. Generally, the majority of these methods, need the intervention of human beings, and therefore, they are submitted to some severe regulations, **(Figure 5).**

**Figure 5*:*** The human landing catch (HLC) method for measuring the efficacy of topical repellents under field conditions. Mosquitoes alighting on the treated and exposed lower leg were aspirated by a mouth aspirator and kept in Falcon tubes for species identification in the laboratory. Apart from the treated area the whole body was fully protected by a jump suit, a bee keeper's hat and latex gloves through which mosquitoes cannot bite [45].

A method used for the evaluation of mosquito behavior while searching for a host is suggested by Ribeiro et al., [46]. The system consists of two acrylic boxes (25 cm × 21 cm × 60 cm), one corresponding to the control and other to the test. Each box is divided into two equal chambers (A and B). In chamber B a anesthetized and immobilized Rattus norvegicus (Wister lineage) is introduced as a blood-feeding bait. In chamber A, 100 A. stephensi (not fed, 3 to 5 days old) are released, allowing passage from one chamber to another. Therefore, four tests are performed on treated and untreated tissues. Each sample must be 25 x 21 cm and stay in the boxes for 60 minutes. Thus the records of the number of mosquitoes passing from chamber A to chamber B are done. At the end of the test, the number of live mosquitoes is counted. And one can calculate the blood feeding reduction index (BFI):

$$BFI = 100 - \frac{treated \times 100}{control}$$

Where the term ***treated*** represents the proportion of fed females captured in the test tunnel and the control represents the proportion of fed females captured in the control tunnel.

Another way to evaluate repellency in textile articles is proposed by Zhang et al. [28], Cao et al. [47] and Shiomura et al. [48]. In this case, adult insects about 2 weeks old are used. Solutions with different concentrations of the active ingredient to be tested are prepared and applied to 6 cm diameter filter paper, half of the paper is applied to the active principle solution (150 μL) and the other half to the solution without the principle active (150 μL), only the solvent. The solvent is then evaporated and the paper is placed in a petri dish. Insects are placed on the paper surface and counted after 2 and 4h. The repelling percentage (RP) is calculated by following the equation:

$$RP(\%) = \left[\frac{(N_c - N_t)}{(N_c + N_t)}\right]$$

Where $N_c$ is the number of insects present on half of paper with no active ingredient and $N_t$ is the number of insects present on half of treated paper.

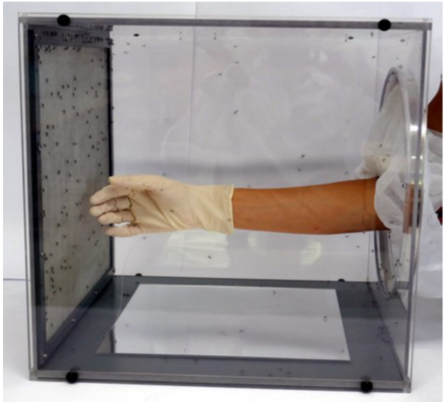

**Figure 6**: The arm-in-cage (AIC) test for measuring the efficacy of topical mosquito repellents under laboratoryconditions [45].

Specos et al. [49] perform the repellency test using gloves (treated and untreated tissue) in boxes containing insects (arm in cage, AIC, **Figure 6**). In this Process the treated and untreated gloves are hung outdoors during the test period. Repellent activity is assessed by inserting a human hand and gloved arm into a chamber (50 x 50 x 50 cm) within 1 minute. In the test chamber there are approximately 200 female insects, and the contact number is counted.

## 5. **Conclusion**

Vectors are responsible for the transmission of various diseases worldwide, mainly in tropical and subtropical countries. The use of repellents, natural or synthetic, is an alternative to prevent the spread of diseases such as dengue, yellow fever, malaria, Zika virus and others.

However, applying some repellents on the skin may cause allergies and short protection due to the volatility of these products. Thus the protection of the active agent and its controlled release can increase the protective effect against these vectors, as well as reduce the unwanted effects on the user's skin.

For better protection these encapsulated or complex repellents can be applied to textiles, clothing, curtains, rugs and other products. These products are called textile finishes and can help with mosquitoes and the diseases caused by them. Textile articles create repellent barriers by keeping mosquitoes away from their wearer. Thus, textiles can be used in various forms for the purpose of repelling.

## 6. References

1. PEILA, R.; SCORDINO, P.; SHANKO, D.B.; CALDERA, F.; TROTTA, F.; FERRI, A. Synthesis and characterization of β-cyclodextrin nanosponges for N,N-diethyl-meta-toluamide complexation and their application on polyester fabrics. Reactive and Functional Polymers, 119, 87-94, 2017.

2. SIBANDA, M.; FOCKE, W.; BRAACK, L.; LEUTERITZ, A.; BRÜNING, H.; AN TRAN, N.H.; WIECZOREK, F.;TRÜMPER, W. Bicomponent fibers for controlled release of volatile mosquito repellents. Materials Science & Engineering C, 91, 754-761, 2018.

3. FRANCES, S.P.; WIRTZ, R.A. Repellents: past, present, and future. J. Am. Mosq. Control Assoc. 21, 1–3, and 2005.

4. SARWAR, M. Insect vectors involving in mechanical transmission of human pathogens for serious diseases. Int. Bioinf. Biomed. Eng., 1, 300-306, 2015.

5. PLACE, L.W.; GULCIUS-LAGOY, S.M.; LIM, J.S. Preparation and characterization of PHMB-based multifunctional microcapsules. Colloids and Surfaces A, 530, 76-84, 2017.

6. ALFHILI, M.A.; NKANY, M.B.; WEIDNER, D.A.; LEE, M. Stimulation of eryptosis by broad-spectrum insect repellent N,N-Diethyl-3-methylbenzamide (DEET). Toxicology and Applied Pharmacology, 370, 36-43, 2019.

7. FÉAT, A.; FEDERLE, W.; KAMPERMAN, M.; GUCHT. V. Coatings preventing insect adhesion: An overview. Progress in Organic Coatings, 134, 349-359, 2019.

8. LEGEAY, S.; CLERE, N.; APAIRE-MARCHAIS, V.; FAURE, S.; LAPIED, B. Unsual modes of action of the repellent DEET in insects highlight some human side effects. European Journal of Pharmacology, 825, 92-98, 2018.

9. PASCUAL-VILLALBOS, M.J.; CANTÓ-TEJERO, M.; VALLEJO, R.; GUIRAO, P.; RODRÍGUEZ-ROJO, S.; COCERO, M.J. Use of nanoemulsions of plant essential oils as aphid

Repellents. Industrial Crops & Products, 110, 45-47, 2017.

10. NAUCKE, T.J.; LORENTZ, S.; GRÜNEWALD, H. Laboratory testing of insect repellents IR3535 and DEET against Phlebotomus mascittii and P. duboscqui (Diptera: Psychodiddae). International Journal of Medical Microbiology, 296, 230-232, 2006

11. SOONWERA, M.; PHASOMKUSOLSIL. Efficacy of Thai Herbal essential oils as green repellent against mosquito vectors. Acta Tropica, 142, 127-130, 2015.

12. ROY, D.N.; GOSWAMI, R.; PAL, A. The insect repellents: A silente environmental chemical toxicant to the health. Environmental Toxicology and Pharmacology, 50, 91-102, 2017.

13. MUÑOZ, V.; BUFFA, F.; MOLINARI, F.; HERMIDA, L.G.; GARCÍA, J.J.; ABRAHAM, G.A. Electrospun ethylcellulose-based nanofibrous mats with insect-repellent activity. Materials Letters, 253, 289-292, 2019.

14. JOSEPH, W.V. Repellent effects of insecticides on Stephanitis pyrioides Scott (Hemiptera: Tingidae) under laboratory conditions. Crop Protection, 127, 104985, 2020

15. BEZERRA, F.M.; CARMONA, O.G.;CARMONA, C.G.; PLATH, A.M.S.; LIS, M. Biofunctional wool using β-cyclodextrins as vehiculizer of citronella oil. Process Biochemistry 77, p. 151-158, 2019.

16. ARIAS, M. J.L.; CODERCH, L.; MARTÍ, M.; ALONSO, C.; CARMONA, O.G.; CARMONA, C.G.; MAESTA, F. Vehiculation of active principles as a way to create smart and biofunctional textiles. Materials, 11, 2152, 2018.

17. RUBIO, Laia et al. Skin Delivery of Caffeine Contained in Biofunctional Textiles. Textile Research Journal, [s.l.], v. 80, n. 12, p.1214-1221, 28 Jan. 2010. SAGE Publications.

18. VAN LANGENHOVE, L.; PAUL, R. Insect repellent finishes for textiles, functional finishes Tex: Improving comfort, performance and protection. Elsevier Inc., 2014, 333-360.

19. LEAL, W.S. The enigmatic reception of DEET – the gold standard of insect repellents. Curr. Opin. Insect. Sci., 6, 93-98, 2014.

20. TAVARES, M.; SILVA, M.R.M.; SIQUEIRA, L.B.O.; RODRIGUES, R.A.S.; ALMEIDA, L.B.; SANTOS, E.P.; RICCI-JÚNIOR, E. Trends in insect repellent formulations: A review. International Journal of Pharmaceutics, 539, 190-2019, 2018

21. KALYANASUNDARAM, M. A preliminary report on the synthesis and testing of

mosquito repellent. Ind. J. Med. Res., 76, 190-195, 1982.

22. HASLER, T.; FEHR, T.; HELD, U.; SCHLAGENHAUF. Use of repellents by travellers: A randomised, quantitative analysis of applied dosage and an evaluation of knowledge, Attitudes and Practices (KAP). Travel Medicine and infectious Disease, 28, 27-33, 2019.

23. BROSCHARD, T.H.; BOHLMANN, A.M.; KONIETZNY, S.; SCHAUER, U.M.D.;

DEKANT, W. Biotransformation and toxicokinetics of the insect repelente IR3535 in male and female human subjects after dermal exposure. Toxicology Letters, 218, 246-254, 2013.

24. JIA, B.; XU, L.; GUAN, W.; LIN, Q.; BRENNAN, C.; YAN, R. ZHAO, H. Effect of citronella essential oil fumigation on sprout suppression and quality of potato tubers during storage. Food Chemistry, 284, 254-258, 2019.

25. SENHORINI, G.A.; ZAWADZKI, S.F.; FARAGO, P.V.; ZANIN, S.M.W.; MARQUES, F.A. Microparticles of poly(hydroxybutyrate-co-hydroxyvalerate) loaded with andiroba oil: Preparation and characterization. Materials Science and Engineering C, 32, 1121-1126, 2012.

26. NOVELLO, Z.; SCAPINELLO, J.; DAL MAGRO, J.; ZIN, G.; DI LUCCIO, M.; TRES, M.V.; OLIVEIRA, J.V. Extraction, chemical characterization and antioxidant activity of andiroba seeds oil obtained from pressurized n-butane. Industrial Crops and Products, 76, 697-701, 2015.

27. YINGNGAM, B.; KACHA, W.; RUNGSEEVIJITPRAPA, W.; SUDTA, P.; PRASITPURIPRECHA, S.; BRANTNER, A. Response surface optimization of spray-dried citronela oil microcapsules with reduced volatility and irritation for cosmetic textile uses. Powder Technology, 355, 373-385, 2019

28. ZHANG, J.S.; ZHAO, N.N.; LIU, Q.Z.; LIU, Z.L.; DU, S.S.; ZHOU, L.G.; DENG, Z.W. Repellent constituents of essential oil of Cymbopogon distans aerial parts against tow stored-product insects. Journal of Agri. Food Chem., 59, 9910-9915, 2011.

29. CUNHA, B.G.; DUQUE, C.; CAIAFFA, K.S.; MASSUNARI, L.; CATANOZE, I.A.; SANTOS, D.M.; OLIVEIRA, S.H.P.; GUIOTTI, A.M. Cytotoxicity and antimicrobial effects of citronella oil (Cybopogon nardus) and commercial mouthwashes on S. aureus and C. albicans biofilms in prosthetic materials. Archives of Oral Biology, 109, 104577, 2020.

30. MAIA, M.F.; MOORE, S.J. Plant-based insect repellents: a review of their efficacy, development and testing. Malaria Journal, 10, S11, 2011.

31. SALEHI, B.; SHARIGI-RAD, J.; QUISPE, C.; LLAIQUE, H.; VILLALOBOS, M.; SMERIGLIO, A.; TROMBETTA, D.; EZZAT, S.M.; SALEM, M.A.; ZAYED, A.; CASTILLO, C.M.S.; YAZDI, S.E.; SEN, S.; ACHARYA, K.; SHARAPOV, F.; MARTINS, N. Insights into Eucalyptus genus chemical constituents, biological activities and health-promoting effects. Trend in Food Science & Technology, 91, 609-624, 2019.

32. SCHINDLER, W. D.; HAUSER, P. J., Chemical finishing of textiles. Cambridge, 2004

33. ABBASI, A. R.; AKHBARI, K.; MORSALI, A., Dense coating of surface mounted CuBTC Metal-Organic Framework nanostructures on silk fibers, prepared by layer-by-layer method under ultrasound irradiation with antibacterial activity. Ultrasonics Sonochemistry, p. 846-852, 2011

34. TAVRA, C. O.; MARSHALL, R. J.; BAXTER, E. F.; LÁZARO, I. A.; TAO, A.; CHEETHAM, A. K.; FORGAN, R. S.; JIMENEZ, D.F., Drug delivery controlled release from biocompatible metal-organic frameworks using amosphization.

Journal of Materials Chemistry B, 2016

35. ETHIRAJ, J.; BONINO, F.; LAMBERTI, C.; BORDIGA, S., H2S interaction with HKUST-1 and ZIF-8 MOFs: A multitechnique study. Microporous and Mesoporous Materials, 2015.

36. ALONSO, C. et al. Skin penetration and antioxidant effect of cosmeto-textiles with gallic acid. Journal of Photochemistry And Photobiology B: Biology, [s.l.], v. 156, p.50-55, mar. 2016. Elsevier BV.

37. CHANG, C.P.; DOBASHI, T. Preparation of alginate complex capsules containing eucalyptus essential oil and its controlled release. Colloids Surfaces B Biointerface, 32, 257-262, 2003

38. MILHOMEM-PAIXÃO, S.S.R.; FASCINELI, M.L.; MUEHLMANN, L.A.; MELO, K.M.; SALGADO, H.L.C.; JOANITTI, G.A.; PIECZARKA, J.C.; AZEVEDO, R.B.; SANTOS, A.S.; GRISOLIA, C.K. Andiroba oil (Carapa guianensis Aublet) nanoemulsion: development and assessment of cytotoxicity, genotoxicity, and hematotoxicity. Journal of Nanomaterial, 2017.

39. SAWYER. Ultra 30 CRIR (Controlled Release Insect Repellent). Extended release insect repellent. Available on: https://sawyer.com/products/ultra-30-liposome-controlled-release/.

40. PINTO, I.C.; CERQUEIRA-COUTINHO, C.S.; SANTOS, E.P.; CARMO, F.A.; RICCI-JUNIOR, E. Development and characterization of repellent formulations based on nanostructured hydrogels. Drug Delivery Ind. Pharm. 43, 67-73, and 2017.

41. KARR, J.I.; SPEAKER, T.J. KASTING, G.B. A novel encapsulation of N,N-diethyl-3-methylbenzamide (DEET) favorably modifies skin absorption while maintaining effective evaporation rates. Journal of Controlled Release, 160, 502-508, 2012.

42. BEZERRA, F.M.; LIS, M.; CARMONA, O.G.; CARMONA, C.G.; MOISÉS, M.P.; ZANIN, G. M.; MORAES, F.F. Assessment of the delivery of citronela oil from microcapsules supported on wool fabrics. Powder Technology, 343, 775-782, 2019.

43. COSTA, P.; LOBO, J. M. S. Modeling and comparison of dissolution profiles. European Journal of Pharmaceutical Sciences, v. 13, p. 123-133, 2001.

44. ISLAM, J.; ZAMAN, K.; DUARAH, S.; RAJU, P.S.; CHATTOPADHYAY, P. Mosquito repellents: An insight into the chronological perspectives and novel discoveries. Acta Trop., 167, 216-230, 2017.

45. Barbara Colucci - Pie Müller. Evaluation of standard field and laboratory methods to compare protection times of the topical repellents PMD and DEET. Nature Scientific Reports, 8, 12578, 2018.

46. RIBEIRO, A.D.; MARQUES, J.; FORTE, M.; CORREIRA, F.C.; PARPOT, P.; OLIVEIR, C.; PEREIRA, A.I.; ANDRADE, L.; AZENHA, C.; MENDES, A.; ALVES, G.M.; SOUSA, C.A.; TAVARES, C.J. Microencapsulation of citronella oil for solar-activated controlled release as an insect repellent. Applied Materials Today, 5, 90-97, 2016

47. CAO, J.; GUO, S.; WANG, Y.; PANG, X.; GENG, Z.; DU, S. Toxicity and repellency of essential oil from Evodia lenticellata Huang and its major monoterpenes against three sored-product insects. Ecotoxicology and Environmental Safety, 160, 342-348, 2018

48. SHIMOMURA, K.; OIKAWA, H.; KAYUKAWA, T.; ASAMIZU, S.; SUZUKI, N.; YAJIMA, S.; TOMIZAWA, M. Repellency activity of vanillyl butyl ether is mediated by transient receptor potential vanilloid channels in the red flour beetle, Tribolium castaneum (Herbst). Journal of Asia-Pacific Entomology, 22, 916-920, 2019.

49. SPECOS, M.M. Miró et al. Microencapsulated citronella oil for mosquito repellent finishing of cotton textiles. Transactions Of The Royal Society Of Tropical Medicine And Hygiene, [s.l.], v. 104, n. 10, p.653-658, out. 2010. Oxford University Press (OUP).