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Comparative Study of Natural Antimicrobial Agent *vs.* Industrial Antimicrobial Agent

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Abstract

Recent market survey has quite convincingly shown that the apparel consumers all over the world have become more aware about hygiene and potentially harmful effects of microorganism and hence demand for antimicrobial finished clothing is increasing. The antimicrobial property of fabric is being considered to be an important and inevitable parameter for garments which are in direct contact with human body. Textile made up of natural fiber in contact with human body offer an ideal environment for microbial growth. Many commercial products are currently available in the market with different trade names are synthetic based and may not be ecofriendly. In this work ecofriendly natural antimicrobial finish has been prepared from plant extract for textile application. Herbal extract from neem, tulsi and aloe Vera have been applied individually and in combination on cotton and polyester fabric by method of application. All treatment has shown good antimicrobial activity for agar plate test. Amongst all neem gives good result. No significant changes in physical properties of treated sample observed.

Keywords: Antimicrobial ecofriendly •Antimicrobial agent • Micro-organisms • Textile

Introduction

The inherent properties of the textile fibers provide room for the growth of micro-organisms. Besides, the structure of the substrates and the chemical processes may induce the growth of microbes. Humid and warm environment still aggravate the problem. Infestation by microbes cause cross infection by pathogens and develop odour where the fabric is worn next to skin. In addition, the staining and loss of the performance properties of textile substrates are the results of microbial attack. Basically, with a view to protect the wearer and the textile substrate itself antimicrobial finish is applied to the textile materials.

Antimicrobial textile products continue to increase in popularities demand for fresh smelling, skin friendly, and high performance fabrics. Modern performance fabrics are required in much specialist application, sports textile is one example. This need to exhibit high degrees of performance in terms of longevity and durability by imparting antimicrobial properties to the fabrics. These properties can be improved as well as increase the comforts as hygiene factor making them more pleasant to wear. Odour can be neutralized and skin problems caused by microbial growth reduced thus emphasizing the 'hygienic' nature of the treated product. Microbes are the tiniest creatures no seen by the naked eye. They include a variety of micro-organisms like Bacteria, Fungi, Algae and viruses. Bacteria are unicellular organisms which grow very rapidly under warmth and moisture. Further, Sub divisions in the bacteria family are Gram positive (Staphylococcus aureus), Gram negative (E-coli), spore bearing or non-spore bearing type. Some specific types of bacteria are pathogenic and cause cross infection. Fungi, molds or mildew are complex organisms with slow growth rate. They stain the fabric and deteriorate the performance properties of the fabrics. Growing awareness towards health and hygiene has increased the demand of bioactive textiles. A durable finish is potentially effective means of controlling micro-organism on to textiles. In last few decades, wide varieties of antimicrobial agents have been used for the protection of textile as well as wearer. The major class of antimicrobial agents for textiles includes triclosan, metal and their salts, organometallics, phenols, quaternary ammonium compounds and organosilicons. One prime consideration related to the end use and function of an antimicrobial finish on textiles is the low toxicity of the finishing agent and such chemical finishes applied to textiles should meet environmental and low toxicity criteria. The use of natural antimicrobial agents on textiles dates back to antiquity, when the ancient Egyptians used spices and herbs to preserve mummy wraps. Neem and tulsi are the richest source of antimicrobial compounds [1].

Object of Antimicrobial finishes

Antimicrobial treatment for textile material is necessary to fulfill the following objectives:

-To avoid cross infection by pathogenic micro organisms

-To control the infestation by microbes

-To arrest metabolism in microbes in order to reduce the formation odor; and

-To safeguard the textile products from staining, discoloration and quality deterioration [2].

Necessity of antimicrobial finishes

Antimicrobial treatment for textile material is necessary to fulfill the following objectives.

-To control micro-organisms

-To avoid cross infection by pathogenic micro organisms

-To control the infestation by microbes

-To arrest metabolism in microbes in order to reduce the formation odour

-To safeguard the textile products from staining, discoloration and quality reduction

Requirements for Antimicrobial finish

Textile material in particular, the garments are more susceptible to wear and tear. It is important to take into account the impact of stress strain, Thermal and mechanical effect on the finished substrates.

Durability to washing, dry cleaning and hot pressing.

Selective activity to undesirable microorganisms.

Should not produce harmful effect to the manufacturer, user and the environment.

Compatible with the chemical process.

Easy method of application.

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No deterioration of the fabric quality.

Resistance to body fluids.

Antimicrobial finishing methodologies

The antimicrobial agents can be applied to the textile substrates by exhaust. Pad-dry-cure. Coating. Spray and foam techniques. The substances can also be applied by directly adding into the fiber spinning dope. It is claimed that the commercial agents can be applied online during the dyeing and finishing operations. Various methods for improving the durability of the finish include:

Insolublisation of the active substances in/on the fiber

Treating the fiber with resin. Condensates or cross linking agents

Micro encapsulation of the antimicrobial agents with the fiber matrix

Coating the fiber surface

Chemical modification of the fiber by covalent bond formation

Use of graft polymers, homo polymers and/or copolymerization on to the fiber

The activity which affects the bacteria is known as antibacterial and that of fungi is antimitotic. The antimicrobial substances function in different ways. In the conventional leaching type of finish, the species diffuse and poison the microbes to kill. This type of finish shows poor durability and may cause health problems. The non-leaching type or bio-static finish shows good durability and may not provoke any health problems. A large number of textiles with antimicrobial finish function by diffusion type. The rate of diffusion has a direct effect on the effectiveness of the finish. For example, in the ion exchange process, the release of the active substances is at a slower rate compared to direct diffusion ad hence, has a weaker effect. Similarly, in the case of antimicrobial modifications where the active substances are not released from the fiber surface and so less effective. They are active only when they come in contact with micro-organisms. These so called new technologies have been developed by considering the medical, toxicological and ecological principles. The antimicrobial textiles can be classified into two categories, namely. Passive and active based on their activity against micro-organisms. Passive materials do not contain any active substances but their surface structure (Lotus effect) produces negative effect on the living conditions of micro-organisms (Anti-adhesive effect). Materials containing active antimicrobial substances act upon either in or on the cell.

Materials with active finishes contain specific active antimicrobial substances, which act upon micro-organisms either on the cell. During the metabolism or within the core substance (genome). However, due to the very specific nature of their effect. It is important to make a clear distinction between antibiotics and other active substances which have abroad range of uses.

Quaternary ammonium compounds, biguanides. Amines and glucoprotmine show poly cationic, porous and absorbent properties. Fibers finished with these substances bind microorganisms to their cell membrane and disrupt the lipo polysaccharide structure resulting in the breakdown of the cell.

Natural herbal products can be used for antimicrobial finishes since; there is a tremendous source of medicinal plants with antimicrobial composition to be the effective candidates in bringing out herbal textiles.

Antimicrobial agents

Neem

The word neem is derived from Sanskrit nimba which means 'bestowed of good health. It has also known as ravisambha —sun ray like effect in providing health. The neem tree has been venerated through the ages in the Indian countryside as it provided hope in any situation and the faith in the miraculous healing power of this amazing tree led patients with incurable diseases to adopt neem as way to life. The use neem leaves in pest control has been known since ancient times. But recently it has been studied scientifically reported that it contains different chemical which have insect repellent, insecticide, antifeedant, nematicides and antimicrobial properties [1].

Neem contains a very important constituent namely "NIMBUS" (C12H3609). This compound has the property to act against bacteria. Neem is one of the very few trees known in Indian sub-continent. This tree belongs to meliceae family, and grows rapidly in the tropic and semi tropic climate. It is also observed that this tree could survive in very dry and arid condition.

All parts neem plant such as leaves, bark, flowers, Fruit and root have advantage in medical treatment and industrial products. The bark extract is also used as tonic, nausea, vomiting and skin diseases. Its leaves can be used as drug for diabetes, eczema and reduce fever. Neem seed is part of neem tree which has high concentration of oil [4].

Tulsi

Tulsi is herbaceous, much brachedannual plant found throughout India. All parts of Tulsi are used in medicine, specially fresh and dried leaves. The leaves are green in color with aromatic flavor and slightly pungent test. The leaves of tulsi yield and essential oil, ursolic acid, volatile oil etc

Antimicrobial effects - Essential oil of Tulsi have antibacterial, antifungal and antiviral properties. It inhibits the growth of *E coli, B.anthracis, M. tuberculosis*, etc. Its antitubercular activity is one tenth the potency of streptomycin and one - fourth that of isoniazid.

Antimalarial effects - Essential oil of Tulsi has been reported to possess 100% lavividal activity against the culex mosquitoes. Its extracts have marked insecticidal against mosquitoes. Its repellent action lasts for about two hours.

Antiallergic effect - Essential oil of tulsi was found to have antiallergic properties.

Anti' tress effect - Extract from the plant been found to reduce stress.

Other effects - The leaves in form of a paste are used in parasitical diseases of the skin and also applied to the finger and toe of nails during fever when the limbs are cold. The juice of the leaves is given in catarrh and bronchitis in children [3].

Aloe vera

Aloe vera is actually a common plant in many homes. Aloe (Aloe vera) is an important and traditional medicinal plant belonging to the family Liliaceous. An evergreen perennial growing to 0.8m by 1m at a slow rate. It is hardy to zone [5]. It is in leaf all year, in flower from May to June It is indigenous to Africa and Mediterranean countries. It is reported to grow wild on islands of Cyprus, Malta, Sicily, Carary cape, Cape Verde and arid tracts of India. This is a hardy perennial tropical plant that can be cultivated in drought areas. But its potential is yet to be exploited. Aloe, despite being identified as 'a new plant resource with the most promising prospects in the world', remains a disregarded plant. It is scattered in the wild, along the coast of southern India. China, U.S.A., Mexico, Australia and some of the Latin American countries are the major producers and exporters of aloe products. These countries are exploiting the plant potential with the growing cosmetic and neutraceutical market. Aloe can substitute synthetic ingredient used in cosmetic industry very competitively and is finding increasing use in the ever growing consumer product segment.

Aloe contains mixture glycosides collectively called 'aloin', which is the active constituent of the drug. Aloin and its gel are used as skin tonic, have cooling effect and moisturizing agent and so it is used in preparation of creams, lotions, shampoos and allied products. It is also used in gerontology and rejuvenation of aging skin.

The aloin is extensively used as active ingredient in laxative and anti-obesity preparations. The products prepared from aloe leaves have multiple properties such as emollient, purgative, antibacterial, anti-oxidant, anti-fungal, antiseptic and cosmetic. The Food and Drug Administration of the UAS has approved the developmental study of aloe Vera in the treatment of cancer and AIDS. Traditionally, aloe is extensively used in treating urine related problems, pimples, ulcers, etc [5].

Antimicrobial Activity Test

There are various methods to demonstrate the efficacy of an antimicrobial activity. Tests normally conducted are

Agar diffusion test (Table 1).

Material and Methods

Antimicrobial agents are used

1. Neem leaves
2. Tulsi
3. Aloe Vera
4. Neem + Tulsi + Aloe Vera
5. Industrial antimicrobial agent (Parma lose)
6. Bleached cotton fabric

Chemical and auxiliaries

1. PVOH-polyvinyl alcohol(L.R Grade)
2. Glyoxal(L.R Grade)
3. $MgC1_2$ (L.R Grade)
4. PE emulsion

Extraction of antimicrobial agent from material by boiling method

Neem extraction

Fine powder of neem leaves purchased from local market. Water extraction method is used for extraction of neem. The neem powder was treated

With water at 65 oc with MLR 1:10 for 8 hrs. This mixture is allowed to settle for 24 hrs and the extraction is separated by simple filtration method.

Tulsi extraction

Fine powder of Tulsi leaves purchased from local market. Water extraction method is used for extraction of neem. The neem powder was treated with water at 65 oc with MLR 1:10 for 8 hrs. This mixture is allowed to keep for 24 hrs and the extraction is separated by simple filtration

Aloe Vera extraction

The leaves are cut transversally then the green outer portion that contains aloin is removed, leaving the gel that remains in the leaf. The gel remains thick, but after a few minutes, an enzymatic reaction causes it to become liquid and freely run out. Because bacteria can thrive on this raw liquid, ascorbic acid (vitamin C) and sodium benzoate are added as preservatives. Sodium benzoate is effective in very low quantities, and is therefore perhaps the best and safest method for preserving aloe vera juice

Application methods

Finish Application

The antimicrobial agent can be applied to textile substrate by pad-dry-cure, coating, spray technique, and foam technique. Here extracts of the herbs was directly applied on textile substrate by pad-dry-cure method. For this different concentration of antimicrobial agent 2.5g/l, to 15g/l and curing condition (150˚C for 3 min) were used. Padding was in a pneumatic padding mangle. With the 60% expression O.w.f after that air drying was carried out and sample was cured (Table 2 and 3).

Application of antimicrobial material on socks

For performance evaluation the natural antimicrobial agents as well as industrial antimicrobial agent both were applied on knitted socks. For this exhaust method was used the optimized concentration of antimicrobial agents were taken and applied on socks at 60°C the time of treatment was 30 mins.

After application upto 9 washing cycles regular laundering of socks was done to check the fastness of antimicrobial agent. Details of the same are mentioned in table 3.

Table 1. Antimicrobial activity test.

SII 195920 - 1992	Textile fabrics: Determination of the antibacterial activity: agar diffusion plate test	Agar diffusion test
SII 195121- 1992	Textile fabrics: Determination of the antimitotic activity: agar diffusion plate test	
AATCC 30-1993	Antifungal activity, assessment of textile materials: mildew and rot resistance of textile materials	
AATCC 90-1982	Antibacterial activity of fabrics , detection of agar plate method	
JIS L 1902-1998	Testing method for antibacterial of textiles	

Table 2. Optimization of mix (neem, tulsi, aloe Vera) extract on concentration basis.

Concentration in(g/l	Glyoxal (g/l)	PVOH (g/l	MgC12 (g/l)	PE emulsion (g/l)	Curing condition
2.5	25	2.5	1.5	6.25	150˚C for 3 min
5	25	2.5	1.5	6.25	150˚C for 3 min
7.5	25	2.5	1.5	6.25	150˚C for 3 min
10	25	2.5	1.5	6.25	150˚C for 3 min
12.5	25	2.5	1.5	6.25	150˚C for 3 min
15	25	2.5	1.5	6.25	150˚C for 3 min

Table 3. Optimisation of industrial Antimicrobial agent (neem, tulsi, aleovera) extract on concentration basis.

Concentration in(g/l	Glyoxal (g/l)	PVOH (g/l	MgC12 (g/l)	PE emulsion (g/l)	Curing condition
2.5	25	2.5	1.5	6.25	150˚C for 3 min
5	25	2.5	1.5	6.25	150˚C for 3 min
7.5	25	2.5	1.5	6.25	150˚C for 3 min
10	25	2.5	1.5	6.25	150˚C for 3 min
12.5	25	2.5	1.5	6.25	150˚C for 3 min
15	25	2.5	1.5	6.25	150˚C for 3 min

Table 4. Comparative result of Natural antimicrobial agent and Industrial antimicrobial agent.

Sr.no	concentration	Neem		Tulsi		Mix (Neem+Tulsi+Alovera)		Industrial antimicrobial agent	
		ZOI Mm(gm+ve	ZOI Mm(g-ve	ZOI Mm(gm+ve	ZOI Mm(g-ve	ZOI Mm(gm+ve	ZOI Mm(gm-ve	ZOI Mm(gm+ve	ZOI Mm(g-ve
1	2.5	25	24	25	18	22	19	23	19
2	5	28	27	28	21	26	20	27	22
3	7.5	31	29	31	24	29	22	30	26
4	10	33	32	34	27	32	27	33	28
5	12.5	36	34	36	29	35	29	36	31
6	15	36	34	36	29	35	29	36	31

Table 5. Performance evaluations of antimicrobial agents on socks.

Sr no.	Antimicrobial agent	Concentration(g/l)	No.of washes	ZOI (gm+ve)	ZOI (gm-ve)
1	neem	12.5	9	2.1	2.2
2	tulsi	12.5	6	1.5	-
3	Mix(neem +tulsi +alovera)	12.5	9	2	-
4	Industrial antimicrobial agent	12.5	9	1.5	-

Testing of antimicrobial activity

Agar diffusion test

Antimicrobial assessment

Microbes are living organism and like any living organism will take extreme measures to survive. The ability microorganism to adapt to potential toxicants has been recognized in the medical community for years. The exposure of microbes to a lethal dose of an antimicrobial can cause mutation of their genetic material allowing for resistance that is then replicated through the reproductive process creating generation of microorganism that are no longer affected by the chemistry.

The outermost edge of the zone of inhibition is where the sub lethal dose can be found. This is where resistant microbes are found that have been produced by leaching antimicrobial this is demonstrated in the following procedure. Where microbes was taken from the outer edge of the zone of inhibition of a common leaching.

Antimicrobial from treated carpet fiber and used to inoculate a new test plate. The second plate test shows the adapted microorganism growing within the zone of inhibition. The adapted organism is taken from second plate and used to inoculate of third plate. The microorganism used to inoculate this plate is fully adapted to the leaching antimicrobial and has over grown the fabric [6]. Optimization of Industrial antimicrobial agent on the concentration basis

Result and Discussion

Antimicrobial activity of samples

The antimicrobial activity of material can be studied by qualitative as well as quantitative test methods. Here to study antimicrobial activity of treated samples we carried out quantitative test. For this followed AATCC 147 test method i.e. Agar diffusion test. It has found that qualitative test is good for testing main agent or the treated fabric provided antibacterial agent used are capable of leaching out.

Antibacterial activity of treated fabrics using qualitative method is given in following tables in table 2

The result from the above method clearly shows that treated fabric is having good antibacterial properties to gram positive micro-organism and negative microorganism. The treated fabric does not allow the growth of bacteria under test specimens (Table 4 and 5).

As shown in table 4 it is clear that in case of poly/viscose and cotton socks the results are good for Neem and Tulsi comparing to aloe-Vera. While combination of three antimicrobials shows excellent results

Conclusion

Application of herbal extract such as Neem, Tulsi& Aloe-Vera on cellulose has been done successfully by using simple process pad dry cure method. It is found that they exhibit potential for antimicrobial activity against Gram positive microorganism. There is no bacterial growth found in case of treated fabric.

From present study following conclusion are derived

• Natural antimicrobial agent used neem, tulsi, aloe Vera have been effective on cotton fabric.

• These natural antimicrobial agents provide excellent protection when used in combination.

• Neem show more microbial resistance than tulsi.

• Neem gives good result in combination such as Neem + Tulsi and Neem + Aloe Vera etc.

• Cost of finishing by using industrial antimicrobial agent is more than cost of finishing by using natural antimicrobial agent.

• By using industrial agents in finishing, The Zone of inhibition positive and negative both are slightly more or equal to the natural antimicrobial agent.

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