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Research Paper

Antimicrobial Activity of Textiles from Different Natural Resources

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Abstract
The inclusive attention on this article comprises the plant based natural resources and supplementary bioactive natural extract which have applied on textiles coating as an antimicrobial textile finish has gained substantial properties in new era. In the development of modern science, the peoples are more conscious than previous. The researchers are trying to develop hygienic and comfort properties of textiles in order to prevent the infection from any microbes as well as protect the environment. In all over the world especially in the Indian subcontinent, the resources of natural antimicrobial products are available for producing ecofriendly textiles. There are also many chemical ingredients which have used on textiles as an antimicrobial finish that are unhygienic and toxic for environmental concerns. The natural antimicrobial plant like Aloe vera and turmeric consists of many components that are mostly effective on textiles. Those types of plant contains antioxidant, antimicrobial, antifungal and many more potential elements that increase the zone of inhibition of the fabric against microbes as well as producing antimicrobial resistance fabric. Numerous natural antimicrobial ingredients found from plants which is reveals strong antimicrobial properties. There are different applications methods for coating on textiles like pad dry cure, plasma, sol-gel, microencapsulation and others which have applied on textile substrate for the modification of its functional characteristicto increase the absorbency with a view to enhancing the antimicrobial property of textiles for the betterment of curative products and wound healing. Thus, the coating of natural antimicrobial and bioactive plant extract on to cotton and other fabrics are to develop a technology for the producing of medical textiles. In recent study, Pomegranate rind, tulsi and subsequent natural antimicrobial extract applied on cotton and other different fabrics like polyester, wool were found to be sustainable and excellent results as an antimicrobial treatment using as a proper finishing agent to protect the fiber from any bacteria. In this review focus the widely use of natural antimicrobial finish on textiles which analysis the mechanism, how to kill the bacteria on fabric surface to prevent from infection and its different functional methods.

Keywords: Moringa,Seaweed ,Termaric, Tulsi, Nano particles, antimicrobial textiles, ecofriendly.
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I. INTRODUCTION

Antimicrobial textiles with improved functionality find a variety of applications such ashealth and hygiene products specially the garments worn close to the body and severalmedical applications such as infection control and barrier materials etc. In the last fewdecades, with the increase in new antimicrobial fiber technologies and the growingawareness about cleaner surroundings and healthy lifestyle, a range of textile productsbased on synthetic antimicrobial agents such as triclosan, metal and their salts,organometallics, phenols, quaternary ammonium compounds etc. have been developed andquite a few are also available commercially **(1. Purwar and Joshi, 2004)**

Cellulose fibres have found a broad application in medical textile field owing to the unique characteristic, such as high moisture and liquids' adsorption, low impurity content, antistatic behaviour, and good mechanical properties. However, cellulose fibres provide an excellent surface for microorganisms' growth.

Due to their molecular structure and a large active surface area, cellulose fibres, may be an ideal matrix for the design of bioactive, biocompatible, and intelligent materials **(2. Stashak et al. 2004, 3.Belyaev, 2000).**

The use of natural products such as chitosan and natural dyes for antimicrobial finishing of textile materials has been widely reported. Other natural herbal products, such as Aloe Vera, tea tree oil, Eucalyptus oil and tulsi leaf (Ocimumbasilicum) extracts, can also be used for this purpose. There is a vast source of medicinal plants with active antimicrobial ingredients. Although, there are many natural products rich in antimicrobial agents, the study on their use in textiles is very limited and not well documented **(4. Rajendran, 2012).**

The synthetic antimicrobial agents are effective against a range of microbes and give a durable effect on textiles but they possess limitations in use such as associated side effects, action on nontarget microorganisms and water pollution. Therefore, there is still a great demand for antimicrobial textiles based on eco-friendly agents which not only helps to reduce effectively the ill effects associated due to microbial growth on textile material but also comply with the statutory requirements imposed by regulating agencies **(5. Gao and Cranston, 2008)**

Natural fibers are more easily affected due to evolution. The most problematic microorganisms are fungi and bacteria. Fungi induce a variety of problems to textiles including discoloration, colored stains, and fiber damage (eg, loss of elasticity and strength). The bacteria themselves do not directly damage the fibers but deteriorate the fibers, creating unpleasant odors as well as a slick and slimy feeling. Animal hair is more likely to suffer from bacterial attack than cellulosic fibers, while cotton is more likely to be attacked by fungi than animal hair. The growth of some types of bacteria or fungi on textiles also threatens the health of the wearer **(6. Schindler and Hauser, 2004; 7.Guptaa and Bhaumik, 2007).**

Humid conditions and warm temperatures establish a desirable environment for the growth of bacteria, fungi, and molds.

Antibacterial finishes are also highly desirable for textiles in the medical field as textile materials used in hospitals and hotels are liable to promote cross-infection and transmit disease; in fact hygiene problems with hospital textiles can interfere with the recovery of patients.

Moringa

Moringa(sajina) (*Moringaoleifera*) belongs to the family, Moringaceae and order**,**Brassicales. This medicinal plant is short, slender, deciduous, perennial tree, to about 10m tall; rather slender with drooping branches; branches and stem brittle, with corky bark; leaves feathery, pale green, compound, tripinnate, 30-60cm long, with many small leaflets **(8. Verma S.C et al 1976)**

Quantitative analysis of the phytochemical screening of *Moringaoleifera*was determined. This confirms the presence of Alkaloid, CyanogenicGlucoside, Steroid, Anthraquinone, Phenol, Tannins, Saponins and Flavonoids. The exception is that Steroids is not detected in*Moringaoleifera***(9. Kuthar S.S et al, 2015).**

Leaf extracts of M. oleifera have been reported to exhibit antioxidant activity both in vitro and in vivo due to their abundance of phenolic acids and flavonoids **(10. Vongsak et al., 2013).**Previous phytochemical analysis of M. oleifera from different countrieshave shown that the leaves are particularly rich in potassium, calcium, phosphorus, iron, vitamin D, essential amino acids, as well as known antioxidants such as carotene, vitamin C, and flavonoids **(11. Mbikay, 2012).**

Ayurvedicsystem of medicine associates the effectiveness of *Moringa*leaves with the cure or prevention of about 300 diseases **(12.Mercola et al, 2015).**The medicinal properties of plants could be based on the antioxidant, antimicrobial, antipyretic effects of the phytochemicals in them **(13. Cowman and M M. 1999, 14.Adesokan A et al, 2008)**

The methanolic extracts of *Moringaoleifera*against*Enterococcus faecalis*and inhibition zonegenerated a 35.5mm of *M.oleifera within 24hrs.* At 48 hours, the growthinhibition zones were 38.83mm and 44.83 mms.Themethanolic extract of *M. oleifera*had a greater antibacterialeffect in comparison with chlorhexidine**(15. Luc´ıa et al, 2018)**

The Antibacterial effect of *M. oleifera*is due to the chemical compound 4-(4’-*O*-acetyl-*α*-*L*rhamnopyranosyloxy) benzylisothiocyanate, whose mechanism of action involves inhibition of essential cellular membrane enzymes **(16. Olson M and W. Fahey , 2011; 17. Martin C et al, 2013)**

The M. oleifera acetone extract, however, showed greater anti-bacterial activity against Gram-negative bacteria than Gram-positive bacterial strains **(18. Ashafa and Afolayan, 2009).**

petroleum ether extracts of *Moringaoleifera*was significantly active against the growthof *Staphylococcusaureus***(19. Ajayi A.O and Fadeyi T.E (2015).**

Ethanolic extract of leaf of *Moringaoleifera*showed maximum diameter ofzone of inhibition against *Staphylococcus aureus*i.e (15mm) and aqueous extract showed lowest activity against *Streptococcus pneumoniae*.

Seaweed

Seaweeds have great potential as a supplement in functional food or for the extraction of compounds. Seaweeds are known for their richness in polysaccharides, minerals and certain vitamins, but they also contain bioactive substances like polysaccharides, proteins, lipids and polyphenols, with antibacterial, antifungal, antiviral properties, etc**(20. Chandini SK et al, 2008; 21.Holdt SL and Kraan S, 2011)**

Seaweeds are known as an excellent source of vitamins and minerals, especially sodium and iodine, due to their high polysaccharide content, which could also imply a high level of soluble and insoluble dietary fibre**(22.Lahaye et al., 1993)**

The Seaweed coated cotton revealed the greater inhibition zone (18 and 17 mm) values against the Gram (+) and Gram (-) bacterial pathogens respectively, when compared with the standard antibiotics (Amikacin) inhibition zone value of (17 mm) for both organisms in fig.1
(23. Rajaboopathi and Thambidurai, 2018)

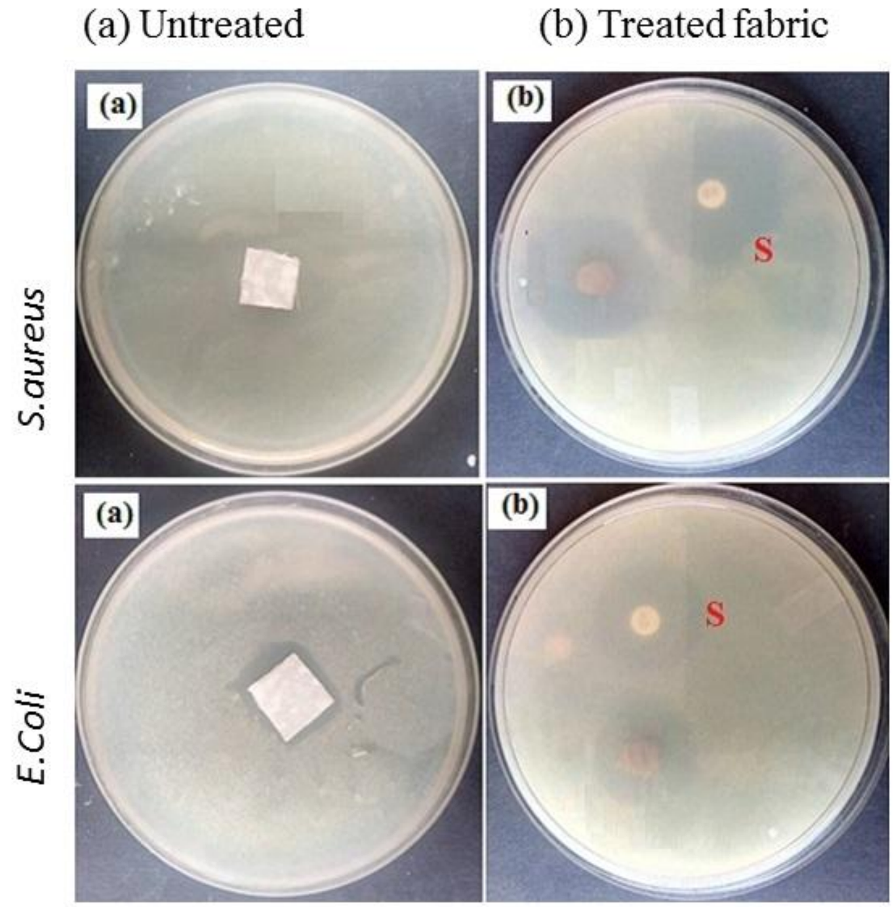

Fig.1 (a) Bacterial inhibition zone of untreated fabric and (b) treated fabric against *S.aureus and E.coli*(23. Rajaboopathi and Thambidurai, 2018)

The results could be ascribed to the deposition of functionalized AgNPs are strongly fixed via physical and chemical bonding to the molecular structure of cotton fabric **(24. Ibrahim and Hassan, 2016; 25. El-Naggar et al. 2017).**

The antimicrobial activity of seaweeds depends on some factors such as habitat, theseason of algae collection and experimental methods, etc. while the extracted components ofseaweed having the reactive functional groups of N-H, N=O, O-H and C-O-S in (protein, alkaloids and carbohydrates) **(24. Ibrahim and Hassan, 2016. 26. Maráková et al, 2017; 27. Suresh et al, 2015)** that is strongly interacted to the microbial cellmembrane and to inactivate most of the respiratory chain enzymes, this leads to self destruction of the bacterial cell **(28. Lakshmanan andChakraborty, 2017, 29. Wei et al, 2009).** The presence of various active functional groups would present on seaweed extract mixture.
The fabric sample was subjected to more washing cycle (10 cycle) did not largely

affect the antibacterial properties; for the *S.aureus*(Gram +) bacteria was in 15mm and 14mm for *E.coli*(Gram -) bacterial species. It is interestingly, the repeated washings have not affected the antimicrobial effectiveness against the microbial pathogens tested by AgNPs treated fabric in fig.2. **(23. Rajaboopathi and Thambidurai, 2018)**

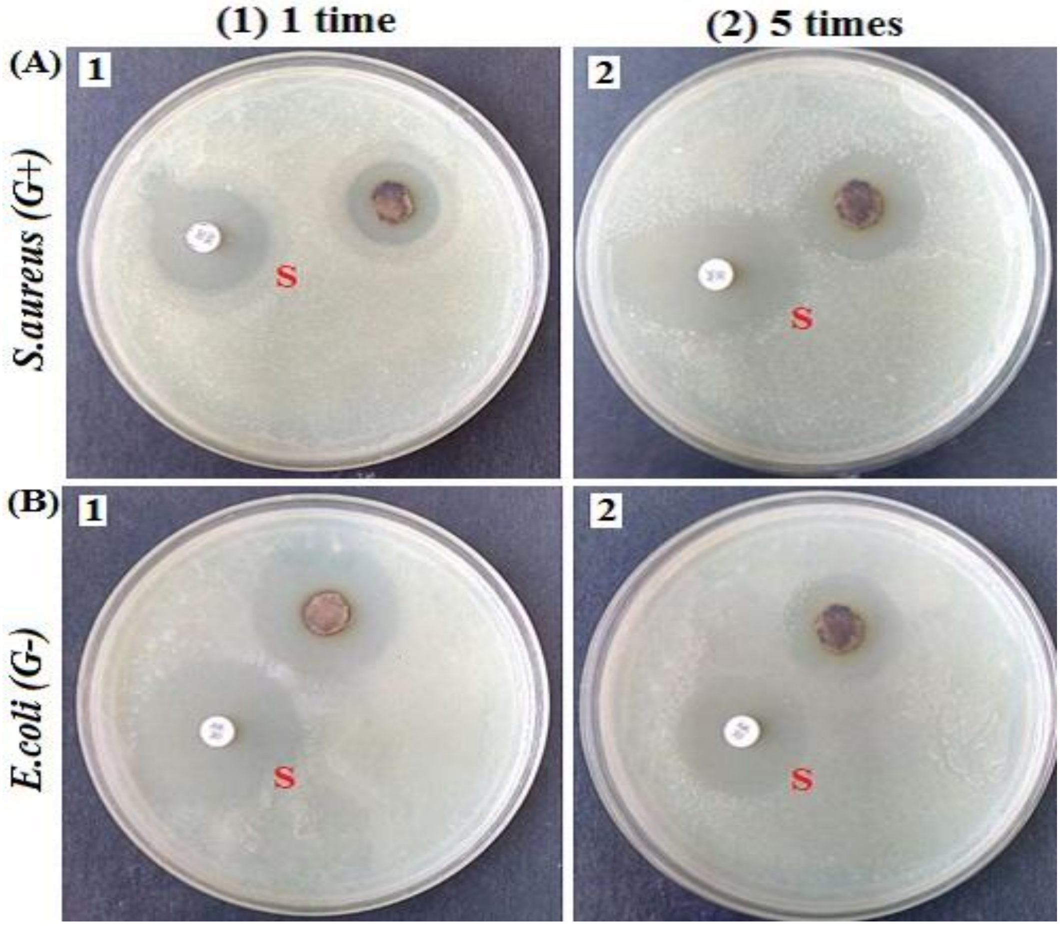

Fig.2Bacterial inhibition zone after (1 time and 5 times washing) against (a) *S.aureus* and (b) *E.coli* bacteria(23.Rajaboopathi and Thambidurai, 2018)

Curcumin/ Termaric (Holud)

Curcumin or diferuloylmethane with chemical formula of (1,7-bis(4-hydroxy-3-methoxyphenyl)-1,6-heptadiene-3,5- dione) (Fig.9) and other curcuminoids constitute the main phytochemicals of *Curcuma longa* L. (Zingiberaceae family) rhizome with the common name of turmeric **(30. Ammon and Wahl, 1991)**

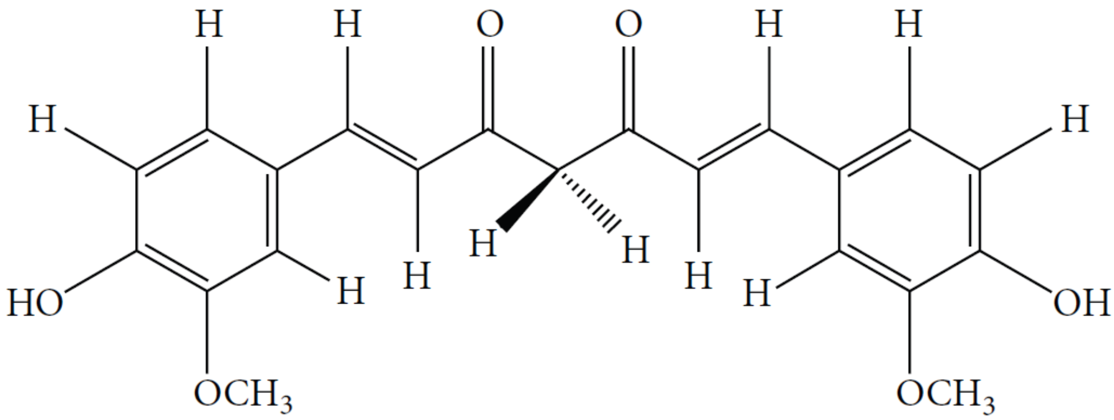

Fig. 3 Chemical structure of curcumin.**(30. Ammon et al. 1991)**

Curcuma longa rhizome has been traditionally used as antimicrobial agent as well as an insect repellant **(31. Rudrappa andBais, 2008)**

It was even studied as an antimicrobial agent suitable for textile materials. Results showed that curcumin in combination with aloe vera and chitosan could be a potential suppressor for microbial growth in cotton, wool, and rabbit hair assessed by the exhaustionmethod**(32. Ammayappan and JeyakodiMoses, 2009)**.

Batch dyeing process with curcumin provided textiles with antimicrobial properties beside the color. Curcumin finished wool had semidurable antimicrobial activity, less durable to light exposure than home laundering with 45% and 30% inhibition rates against *Staphylococcusaureus*and *Escherichia coli*, respectively, after 30 cycles of home laundering **(33. Han and Yang, 2005).**

The methanol extract of turmeric revealed MIC values of 16 μg/mL and 128 μg/mL against
*Bacillus subtilis*and *Staph.aureus*, respectively **(34. Ungphaiboon et al, 2005)**
The hexane and methanol extracts of *C. longa* demonstrated antibacterial effect against 13 bacteria, namely, *Vibrio harveyi, V. alginolyticus, V. vulnificus,V. parahaemolyticus, V. cholerae, Bacillus subtilis, B.cereus,Aeromonashydrophila, Streptococcus agalactiae, Staph. aureus, Staph. intermedius, Staph. epidermidis*, and *Edwardsiellatarda*. However, curcuminoids elicited inhibitory activitiesagainst 8 bacteria of *Str. agalactiae, Staph. intermedius, Staph. epidermidis, Staph. aureus, A. hydrophila, B. subtilis, B. cereus*, and *Ed. tarda.* Hexane extract and curcuminoidsexhibited the MIC values of 125 to 1000 ppt and 3.91 to500 ppt, respectively **(35. Lawhavinit et al, 2010)**

Tulsi (Ocimum sanctum L)

Tulsi*(Ocimum sanctum* L). (Tulsi in Sanskrit or Reyhan-e- Moghaddas in Farsi) belonging to Lamiaceae family, is native to Asia, and Central and western parts of Africa. Tulsi is traditionally used as a medicinal plant **(36. Prakash P and Gupta N, 2005).** Pharmacological studies and clinical practices have demonstrated that this species possesses anti-oxidative **(37.Shah K and Verma, 2012; 38. Ahmad et al, 2012)** and antimicrobial functions including antibacterial **(39. Agarwal et al, 2010),** antifungal **(40-42. Kumar et al,2010; Khan et al, 2010; Balakumar et al, 2011),**anti-helminthic **(43. Asha et al, 2001).**
Antimicrobial activities of eugenol were shown previously. Eugenol inhibited the growth of *Helicobacter pylori* strains at a concentration of 2 µg/mL**(44. Ali et, 2005;).**Eugenol was found to be effective against *Listeria monocytogenes*, *Aeromonashydrophila*and autochthonous spoilage flora in microbial media **(45. Chaieb et al, 2007).** In other studies, eugenol exhibited strong antimicrobial activities against *E. coli*, *S. aureus*, *Bacillus cereus*, *L. monocytogenes*, *P. aeruginosa*, *Salmonella typhi*, and *Proteus mirabilis* **(46-48; Gochev et al, 2014; Devi et al, 2010; Nishaet l, 2013)**. It has also been used in mucoadhesive tablets to treat periodontal diseases **(49. Jadhav et al, 2004).** An important characteristic of eugenol is its hydrophobicity which enhances its incorporation into the cell membrane.

It is proposed that the effective microbial damage of this molecule might be due to disruption of bacterial cell membrane **(47. Devi et al, 2010; 48. Nisha SA et al, 2013),** which leads to increased cell membrane permeability and protein leakage **(50.Oyedemi et al, 2009).** Other possible mechanisms of antimicrobial action of eugenol are conversion of cytochrome P-450 mediated into cytotoxic quinine methide**(46. Gochev**

etal, 2014; 51. Pauli et al, 2006; 52.Thompson et al, 1991) and inhibition of energy generation **(53. Gill et al, 2004).**

Moreover, it was shown that 1, 8-cineol has significant antimicrobial activities alone or in combination with other monoterpens or drugs **(54. Mulyaningsih et al, 2010).**

O. Santumconsisit of different compounds which are Ethyl Isovalerate, α-Pinene, Sabinen, β-Pinene, Myrcene, 1,8-Cineole, Linalool, Terpinen-4-ol, α-Terpineol, Estragol, Eugenol, α-Cis-Bergamotene, α-Humlene, β-Bisabolen, γ-Elemene**(55. *Saharkhiz MJ et al,* 2015)**

The O. sanctum leaf extract loaded nanoparticles coated fabrics showed 100% inhibition against all the test organisms except against E. coli. While the leaf extract of O. sanctum reduced 92% of the growth of P. aeruginosa. On comparing the antibacterial activities of the extract coated fabrics, the inhibition was greater against S. aureus (98%) than against E. coli (81%). The rate of reduction of bacteria exhibited by the nanoparticles. Different solvents i.e. ethanol, methanol, petroleum ether and water were used to extract the active agents from the leaves of O. sanctum. Of the four extracts, methanol extracts proved to have the most significant antimicrobial effects. They were then coated on cotton fabric by the pad-dry-cure technique and their antimicrobial properties were characterized by percentagereduction and laundering durability. The bacterial reduction percentage until 30 laundering cycles were determined using laundry test. The O. sanctum encapsulated nanoparticle treated fabrics sustained antibacterial activity against all the test bacteria until 20 washes **(56.Rajendran et al. 2013).**

The nanoparticles loaded with the herbal extracts exhibited superior antimicrobial activity than the herbal extracts and also showed better laundering durability in the treated fabrics. This could be attributed to the smaller size and controlled release of the nanoparticles **(57.Du et al, 2009) and 56. Rajendran et al. 2013)** also have reported that the higher antimicrobial activity and laundering durability of the nanoparticles was due to the smaller particle size, uniform coating and controlled release of the nanoparticles.

The antimicrobial agents attach to the fiber surface by bond formation and then disrupt the cell membrane of the microorganisms through physical and ionic phenomenon **(58. Sarkar et al., 2003).**

In addition, the agent penetrates and disrupts the cell wall of the microorganisms by an electrochemical mode of action, resulting in the leakage of metabolites. That can probably prevent the microorganisms from functioning or reproducing (**59. Jothi, 2009).**

Biosynthesized silver nanoparticles were analyzed for their antimicrobial activity against gram-negative E. coli and gram-positive S. aureus. The Minimum Inhibitory Concentration was determined as the lowest concentration that inhibited the visible growth of the used bacterium. The results indicated that silver nanoparticles synthesized from O. sanctum have stronger activity than silver nitrate and standard antibiotic ciprofloxacin **(60. Singhal et al, 2011)**

Silver is well known for possessing an inhibitory effect toward many bacterial strains and microorganisms commonly present in medical and industrial processes **(61. Jiang et al. 2004).**

In textile industry, silver-embedded fabrics are now used in sporting equipment **(62. Klaus et al. 1999).**

63.Shrivastava et al. (2007) studied the interaction stage between Ag nanoparticles and bacteria (E. coli). They found that at initial stage of the interaction Ag nanoparticles adhere to bacterial cell wall subsequently penetrate the bacteria and kill bacterial cell by destroying cellmembrane.

Antimicrobial activity of tulsi extract on cotton fabrics showed higher but after washing it was washed away. On the other hand, microencapsulation of tulsi on cotton fabric showed higher antimicrobial activity and the zone of inhibition also excellent due to wash **(60. Singhal et al, 2011)**

Nano Particles formation

It is particularly urgent to make effective antibacterial and UV-protecting textiles to decrease skin injury caused by bacterial invasion and UV radiation. The major classes of synthetic antimicrobial agents for textiles include chitosan,**64-66(Purwar R and Joshi MR , 2004; El-Shafei et al. 2008; Abdel-Halim et al. 2010)** quaternary ammonium compounds, nanoparticles of noble, metals and metal oxides**.67-69(Sun et al. 2005; Jiang et al. 2011; Xia et al. 2011)**.

Silver nanoparticles (AgNPs) have been widely applied in the functional finishing of textiles due to their antibacterial activity and UV protection. In recent years, AgNPs have been synthesized by physical milling, chemical reduction, green plant leaf extraction, and sol–gel.**70-75 (Capek 2004; Sanchez et al. 2000; sharma et al. 2009; Son et al. 2006; Vimala et al. 2009; Zhang et al. 2007)**

Green synthesis has attracted the attention of researchers. Wazed Ali et al. synthesized chitosan nanoparticles by ionic gelation with sodium tripolyphosphate and subsequent loading with silver ions to produce silver loaded chitosan nanoparticles (**76. Ali et al. 2011).**

Varsha Thomas et al. modified cotton fabrics with chitosan followed by the incorporation of silver nanoparticles into the fabrics, which greatly enhanced the antibacterial activity of the treated fabrics **(77. Varsha et al. 2011).**

Nano materials are typically classified into three groups: 0-dimensional, 1-dimensional and 2-dimensional. 0-dimensional nanostructures, referred to as quantum dots or nanoparticles with an aspect ratio near unity, have been extensively used in biological applications **(78. Liu et al., 2010; 79.Hoshino et al., 2004).**

One-dimensional (1D) semiconductor nanostructures such as nanowires, nano rods (short nanowires), nanofibres, nano belts and nanotubes have been of intense interest in both academic research and industrial applications because of their potential as building blocks for other structures **(80. Weintraub et al., 2010).**

AgNPs has potential antimicrobial efficacy against a broad spectrum of bacteria, still they have negligible toxicity to human cells and hence their applicability becomes quite promising **(81. CatiaOrnelas-Megiatto et al. 2012).**

It is assumed that the high affinity of silver towards sulfur and phosphorus is the key element of the antimicrobial effect. Due to the abundance of sulfur-containing proteins on the bacterial cell membrane, silver nanoparticles can react with sulfur-containing amino acids inside or outside the cell membrane, which in turn affects bacterial cell viability **(82. Prabhuet al.2012; 83. Jung et al. 2008)**

Application of inorganic nanoparticles and their nanocomposites reported be a good alternative and producing a new generation of textiles which enjoy antimicrobial properties using nanoparticles has attracted a great deal of attention on the part of both scientists and consumers in recent years. **(84. Lee, Yeo, &Jeong, 2003; 85.Mohammadi, 2009).**

Silver nanoparticles have wide applications in distinctive industries such as medicine, biochemistry, electrochemistry, optics and also in textile industry for imparting antimicrobial properties **(85. Mohammadi, 2009; 86.Nischala et al. 2011; 87.Rai et al. 2009).**

Silver metal nanoparticles is widely known as particular interest due to unique properties as high conductivity, chemical stability, catalytic and antibacterial **(88. Sharma *et al*. 2009).**

Nanoparticles can be synthesized using different methods including chemical, physical, and biological **(89. Iravani*et al*. 2014).**

The biological method is a green chemistry method uses naturally occurring reducing agents such as biological microorganism (plants extract, fungus or bacteria) to synthesis nanoparticles **(90. Abou El-Nour*et al*. 2010)**

Green synthesis of AgNPs using plant extracts provides advancement over chemical and physical method as it is cost effective, no need to use high energy, environment friendly, and no toxic chemicals **(91. Singhal*et al*. 2011).**

The silver nanoparticles produced by chemical method by reducing silver nitrate were applied on silk fabric and good antimicrobial activity has been observed against S. aureus and the fabrics have maintained upto 80% antimicrobial activities after 5 cycles of washing **(92. Song et al. 2001)**

Due to moderate fastness properties of silver nanoparticles, attempts have been made to apply them using resin and crosslinking agents for entrapment. **(93. Nadiger&Shukla, 2015b; 94.Villem et al. 2009).**

Tang et al. reported silver nanoparticles treatment of silk fibres using polydimethylsiloxane as coating agent which showed durable antibacterial properties against Escherichia coli. **(95. Tang et al., 2013).**

Likewise, Zhang et al. synthesized the silver nanoparticles in situ with smart polymeric molecules and investigated the antimicrobial properties on silk fabric **(96. Zhang et al. 2012).**

Durable antimicrobial treatment of silk using silver nanoparticles with BTCA as crosslinking agent is reported elsewhere (**93. Nadiger&Shukla, 2015b**). Since silver nanoparticles are expensive and handling of the substance is sensitive, it was thought appropriate to investigate the antimicrobial treatment using composite recipe of both the antimicrobial agents as this work has not been reported earlier.

Zirconium oxide (ZrO2) also known as zirconia, Its attractive properties have extended for many applications in various fields like gas sensors, ceramics, solid fuel cells, high durability coating, catalytic agents etc**. (97-99, Maskell, 2000; Fergus, 2006; Rashad and Baioumy, 2008).**

ZrO_2 nanoparticles synthesized by different physicochemical methods such as sol-gel **[100.Xu et al. 2003],** aqueous precipitation **(101.Southon et al, 2002)** thermal decomposition and hydrothermal processes **(102. Noh et al. 2003)** require harsh organic solvents/surfactants **(103.Jennifer et al. 2007; 104.Sathyavathi et al. 2010)**and other toxic reagents which typically generate large quantities of hazardous waste.Hence, the nanoparticles synthesis procedures that eliminate the use of hazardous reagents **(105. Mubarak et al. 2011)**and afford greener, more cost effective alternatives are becoming more desirable as the number of nanoparticle applications increased in all fields.

The nanometal oxides deposited on cotton fabrics have exhibited excellent antimicrobial activity against infectious pathogens **(106.Sundaresan et al. 2012; 107.Hebeish et al. 2009; 108. Dastjerdi et al. 2009).**

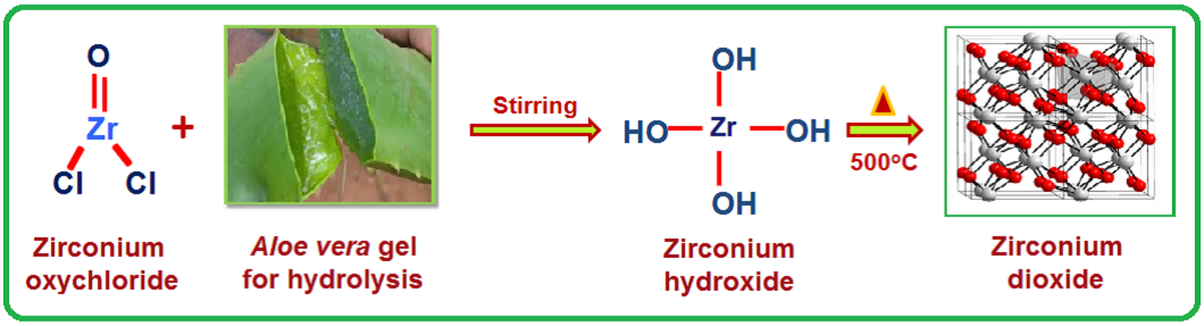

Fig.4 *Aloevera*extract. The formation of the zirconium dioxide

*Aloe vera*extract. The formation of the zirconium dioxide, it has the stronger ability to bind metal by covering the metal nanoparticles to prevent aggregation for some magnitude of calcination treatment. This suggests that the biological molecules of *Aloe vera*extract could possibly act as hydrolyzing agent for the ZrO_2 nanoparticles **fig. 4. (97. Maskell, 2000)**

Both ZrO_2 nanoparticles and ZrO_2 nanoparticles treated cotton pronounced significant growth inhibitory effect against both bacteria due to their large surface area by their nanosize**(97. Maskell, 2000).**

Mechanism of antimicrobial action

Antibacterial surfaces that can prevent bacterial attachment and biofilm formation have become an active field of research, particularly for biomedical applications **(109. Hasan et al. 2013; 110. Salwiczek et al. 2014; 111. Cloutier et al. 2015).**Traditional antibacterial surfaces are typically classified into two types according to their mechanism of operation: (i) passive-defense antibacterial surfaces use nonfouling materials, such as polyethylene glycol (PEG) and zwitterionic polymers, to prevent the initial attachment of bacteria **(112. Banerjee et al. 2011; 113.Gu and Ren 2014)** and (ii) active-attack antibacterial surfaces use synthetic or natural biocides to kill the attached bacteria.

“K+R” (killing and releasing) -type antibacterial surfaces contain both bactericidal unitsand bacteria-releasing units to realize both specific functions. The bactericidal components range from synthetic chemicals, such as quaternary ammonium compounds (QACs), cationicpolymers, and metal nanoparticles, to natural biomolecules, such as antimicrobial peptides and antimicrobial enzymes, imparting surfaces with the ability to kill attached bacteria **(114.Asri et al. 2014; 115.GhavamiNejad et al. 2015; 116.Gu et al. 2015)**

“K → R”-type antibacterial surfaces themselves can switch from a bactericidal state to a bacteria-releasing state in response to appropriate stimuli. Such surfaces are usually based on

zwitterionic polymer derivatives, which can chemically change their structures from a cationic form to kill bacteria to a zwitterionicform to release dead bacteria in **fig.5**.

117-119 (**Cao et al. 2014; Mi et al. 2014; Lu et al. 2015)**

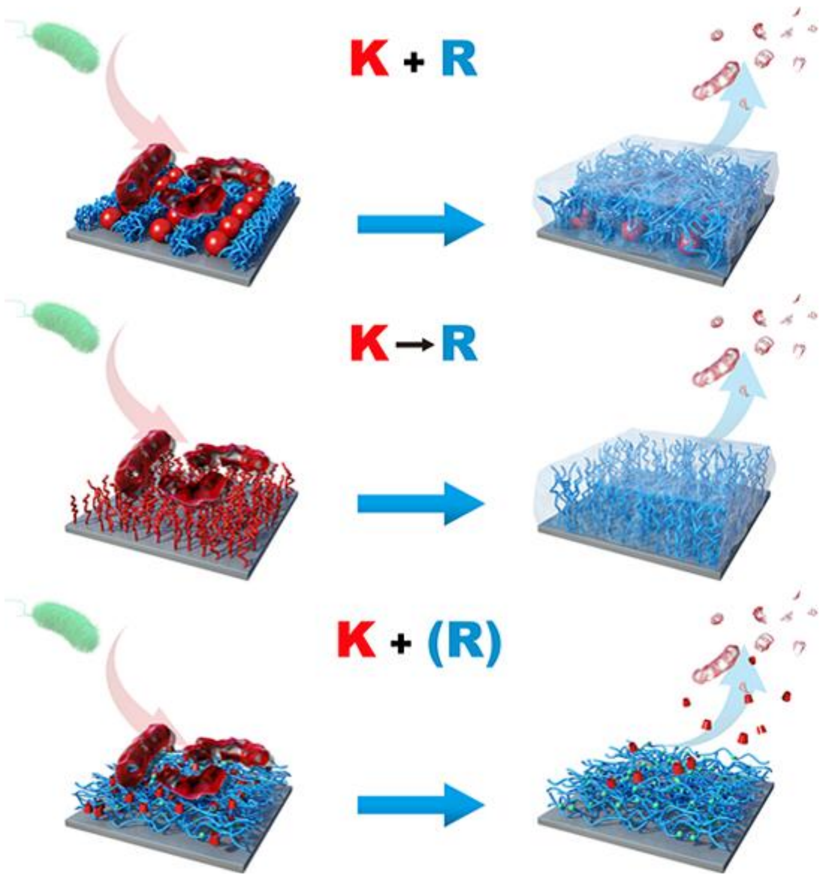

Fig.5"K" and "R" refer to the functions of "killing bacteria" and "releasing bacteria". (120. Ting et al. 2017)

Most contact-killing antibacterial surfaces rely on the surface-bound cationic compounds such as QACs, polycations, chitosan, and AMP; the main killing mechanism is based on the electrostatic attraction between these positively charged agents and the negatively charged bacterial cell membranes to cause membrane charge disruption and damage, leading to bacterial death.**(121. Kaur and Liu ;2016)**

the interfacial electrostatic interaction can be regulated by changing the type and strength of environmental ions, it might be possible to remove the bacteria using ionic solutions as releasing reagents. Chang and co-workers developed a counterion-activated switchable antibacterial surface based on poly((trimethylamino)- ethyl methacrylate chloride) (PTMAEMA) brushes. Under normal conditions, the cationic PTMAEMA compounds (that hydration induced by ion exchange between counteranions) attracted bacteria to the locally abundant QAC moieties, which killed the bacteria upon contact.**(122. Huang et al. 2015)**

The proposed antibacterial mechanisms are first that the metal ions can associate with the cell wall, cell membrane and cell envelope of microorganism. Mainly the positive charge of a zirconium ion is critical for antibacterial activity, allowing electrostatic attraction between the negative charges of the bacterial cell membrane and positively charged metal particles causing cell membrane rupturing. Second the zirconium ions can react with nucleophilic amino acid residues in proteins thereby resulting in the metabolites efflux, interfering with DNA replication, inactivation and inhibition of bacterial growth. Third the antimicrobial action of metal ions is suggested to be related to the formation of free radicals and subsequent free radicals induced membrane damage **(123. Jangra et al. 2012; 124.Toemsak et al. 2013)**

The high affinity of silver towards sulfur and phosphorus is the key element of the antimicrobial effect. Due to the abundance of sulfur-containing proteins on the bacterial cell membrane, silver nanoparticles can react with sulfur-containing amino acids inside or outside the cell membrane, which in turn affects bacterial cell viability **(125. Sukumaran et al. 2012; 126. Woo et al.)**

AgNPs , critic acid crosslinking treatment applied on cotton fabric. It processed drying and curing in a special chamber in few minutes. After than nano particles fixed in a cotton fabric as though bacterium destroyed completely in **fig.6.**

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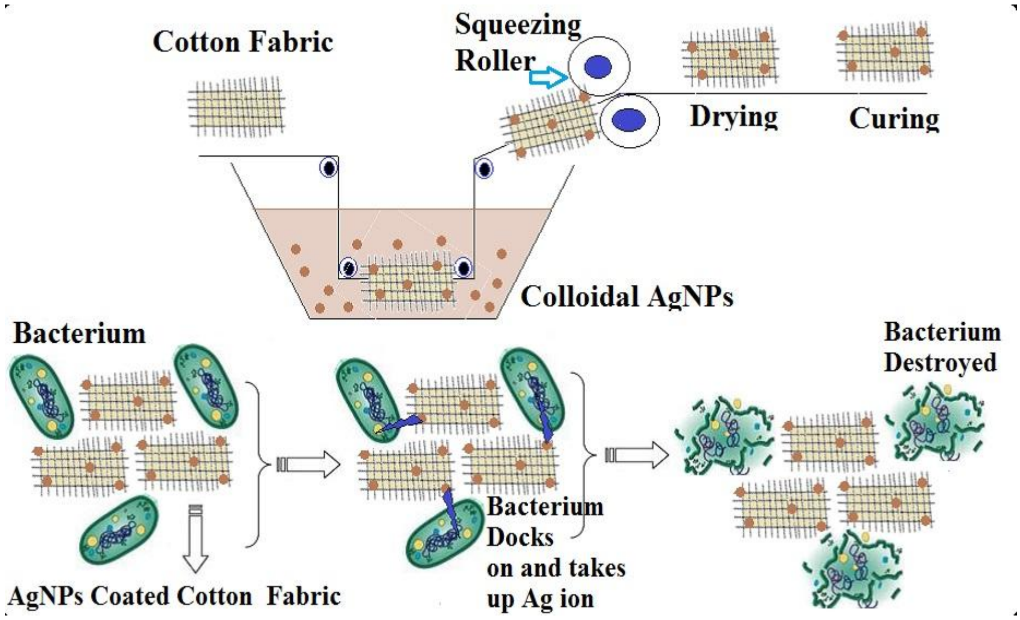

Fig.6Antimicrobial activity of finished cotton fabric treated with AgNPs(23. Rajaboopathi and Thambidurai, 2018)

While the seaweed that contains active functional moieties absorb the bacteria, consequently hinders the production of new bacteria and retards the cellular metabolism, there by killing the bacterial pathogen. AgNPs coated cotton fabric obtained the inhibition zone values of (21 and 19mm) against the Gram (+) and Gram (-) bacterial pathogens and it was the higher inhibitory activity than Seaweed coated cotton. This is due to the penetration of Ag ion released from Ag nanoparticles into bacterial cell membrane as well as the interaction of Seaweed component, which causes to retarding of DNA reproduction and consequently, apoptosis of bacterial unit**(127. Xue et al. 2012; 128. Kang et al. 2016)**

II. CONCLUSION

The antimicrobial activity of different natural resources showed in different durability on textiles. It may vary due to concentration of antimicrobial solution. Microencapsulation,Nano particles and plasma treated textiles showed excellent durability in case of several washing. At present, Natural antimicrobial finished textiles is a demandable product throughout the world in order to environmental concern.

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