Anupama Rajput et al /J. Pharm. Sci. & Res. Vol. 9(10), 2017, 1844-1848

ISSN:0975-1459
Journal of Pharmaceutical Sciences and Research
www.jpsr.pharmainfo.in

Recent Bioactive Materials for Development of Eco-friendly Dippers: An Overview

[1]Anupama Rajput, [2]M.Ramachandran, [3]V.D Gotmare, [4]P.P Raichurkar

[1,3]Textile Manufacture Department, VJTI, Matunga, Mumbai-19
[2,4]MPSTME, SVKM's NMIMS, Shirpur, Dhule, Maharashtra-425405

Abstract:
Textile material used in hygienic health, personal care as well as surgical products .These products include baby and adult diapers, sanitary pads .This article deals with the diapers worn by infants. In the modern society usage of diaper is unavoidable due to the busy schedule of parents and guardians. Most of the diapers are made by synthetic materials which are non –biodegradable and poor antimicrobial properties. They very common problem faced by the use of diapers are diaper rashes, dermatitis. In this paper, we are doing review on natural antimicrobial coatings like Curcumin, Aloe Vera, Tulsi and Neem and also synthetic anti-microbial coatings like silver Nano particles, zinc Nano particles and Titanium Dioxide Powder on various textile fabrics. The result of this work shows that natural antimicrobial coating has same anti-microbial effect when compare with synthetic anti-microbial coatings.

I. INTRODUCTION

A diaper or nappy is a type of textile that allows the wearer to urinate without the use of a toilet, by absorbing or containing waste products to prevent soiling of outer clothing or the external environment. In current year increasing population of working women, parenting and childcare needs have also changed as modern mothers are more impart on baby diapers, and sanitary pads are designed to hygienically hold and absorb urine and potty voided by children until the diaper can be changed. Diapers can be prepared from a many different natural fibers such as a cotton ,wool, silk ,bamboo, linen, jute, hemp ,muslin etc. and synthetic fibers such as polypropylene ,polyethylene, nylon, polyester with regenerated fiber also used as viscous. In association with Neem, Aloe Vera, Curcumin, silver Nanoparticles, Nano coating, titanium dioxide, zinc oxide etc. Diapers are designed in such a way that the top sheet of the diaper comprises of the antimicrobial agent to encumber or inhibit the growth of bacteria are crease its action on the baby skin. Second layer is the absorbent layers which absorbs urine keeping the top layer dry. Bottom layer is made up of plastic or rubber type of material to provide the leakage control. Use of different natural fiber like wool, bamboo, silk, cotton for avoided the skin problems like rashes, dermatitis and also used different natural antimicrobial material like Neem, Aloe Vera, Curcumin, silver nano particles. Nano coating, Tulsi. **[1]** Antibacterial activity of fabrics was qualitatively evaluated by the AATCC-100 method which provides percentages of bacterial reduction growth**. [2]**The finished samples were subjected to assessment of antibacterial activity by the AATCC 147-2004 method with provides zone of inhibition. **[3]**Evaluation of antimicrobial activity of curative fabrics using standards test methods is Agar diffusion test (SN 195920). **[4**]Wash durability test for fabrics was done by (AATCC 124).The presence of growth of microorganisms can cause health problems and odors, and also various bacteria isolated from clothing like Undershirt contained Staphylococcus epidermis and corny bacterium ditheroides, which are responsible for body order.

Table 1: Disease and Microorganism

Microorganism	Disease
Staphylococcus aureus(S.aureus)	Pyrogenic infections
Staphylococcus epidermis	Body Order
Brevibacterium ammonia genes	Diaper rash
Streptococcus pneumonia	Bacterial Pneumonia
Pseudomonas aeruginosa (P.aeruginosa)	Infection of wounds and burns
Escherichia coli(E.coli)	Infections of urinogenital tract

II. NATURAL ANTIMICROBIAL AGENTS COATINGS

Natural finishes are derive from natural plants and animal kingdom are used. Natural products such as Neem, Tulsi, Aloe Vera, Turmeric etc

1.1. Neem leaves extract

Neem (Azardirachta indica) is in the mahogany family Meliaceae. The most important quality of Neem is less toxic to warm-blooded like human.It is having more than 300 active compounds isolated from different parts such as leaves, bark and seeds of Neem tree. Neem has received a lot of attention worldwide for its prospective used as an herbal pesticide and other healthcare formulations in various countries. Neem leaves have also been used to treat skin diseases like eczema, psoriasis and rashes**. [2]**With concentration of 5% Neem gel gives zone inhibition of E.coli and S.aureus of11 mm and 17 mm respectively. With concentration of 10 % Neem gel gives inhibition of E.coli and S.aureus 14 mm and 20 mm. Concentration of Neem and aloe gel to gather 5% then inhibition of E.coli 14 mm and S.aureus 15 mm.[**5]**Neem extract with ethanol concentration of 1000ppm the bacteria inhibition is E.coli -8.3 mm, Pseudomonas -7.3 mm. Neem extract with ethanol concentration of 4000ppm the bacteria pathogens inhibition is E.coli -15.4 mm, P.aeruginosa -13.6 mm. Neem extract with Distilled water concentration of 1000ppm the bacteria inhibition is E.coli -6.7 mm, Pseudomonas -5.5 mm. Neem extract with Distilled water

concentration of 4000ppm the bacteria pathogens inhibition is E.coli -12.7 mm, P.aeruginosa-10.5 mm. **[3]**Assessment of antibacterial activity of curative fabrics Neem with Portia tree fruit treated zone of inhibition S.aureus -38 mm ,E.coli -26 mm. Wash durability of antibacterial properties of Neem with Portia tree is 98% before washing after 10 washes bacteria reduction 18 %.**[6]**Fabric treated in Neem extracted bacteria reduction up to 98.73% S.aureus and 86.84 %E.coli. With wash durability of Neem treated fabric after 10 cycle's reduction 49 % S.aureus and 41% E.coli. Fabric treated nano particles of Neem treated bacteria reduction up to 100% S.aureus and 91.48% E.coli. with wash durability of nano particles of Neem treated fabric after 5 to 25 cycles reduction bacteria 86 to 45% S.aureus and 81 to 40% E.coli. [9]Cotton fabric treated with Neem antimicrobial finish is reduction of bacteria S.aureus - 97.98% and cotton fabric treated with RF air plasma Using optimized system parameters and Neem antimicrobial finish is reduced bacteria of S.aureus -100% and E.coli-99.5%.**[5]**Leaves of Neem were collected and left to dry at room temp for 24 hours .Then grinded to a very fine powder and kept in dry containers. The ethanol extract was prepared by soaking each powder in 100% ethanol in a concentration of 1:4 for 24 hrs. This mixture was cooled and filtered by Whitman filter paper No.1.The solvent was dried and concentrated using orbital shaker at 40°C. Water-based plant extracts were prepared in the same way except that distilled water was used instead of ethanol**. [2]**On another way Neem leaves were converted into fine powder by grinding, filtering and further grinding .This fine powder was treated with methanol at the liquor ratio 5:1 and then filtered to separate including polysaccharides and their derivatives.

1.2. Aloe Vera Gel extract

Aloe Vera is a natural source of bioactive compound is widely used as biomedical application. It has the ability to promote wound healing as well as treat burnt areas on the skin. It is found in many consumer products including beverages, skin lotion, cosmetics, or ointments for minor burns and sunburns. Aloe Vera gel is additional used in medical textile as anti-bacterial effects. Aloe Vera does has anti-inflammatory component called B-sit sterol, infection-fighting properties, and skin-friendly vitamin E. Aloe Vera can keep skin healthy by maintaining moisture levels, elasticity, proper circulation, and cellular turnover. It's gentle enough to be used on delicate tissue and is suitable for baby skin to prevent diaper rash and other common irritations**. [2]**Give the concentration of 5% Aloe Vera gel then inhibition of E.coli 11 mm and S.aureus of 17 mm and give the concentration of Aloe Vera gel 7 % to 10 % then inhibition of E.coli 12 to 14 mm and S.aureus 19 to 20**. [7]**Cotton with Aloe Vera gel have maximum antibacterial activity on P.aeruginosa and E.coli**.[1]**Antibacterial activity of Aloe-Vera treated washed cotton fabric with Aloe Vera 1 % treated with BTCA (Cross –linked agent) 59 % S.aureus and 68% E.coli, AloeVera7% treated with BTCA has 99.5 % S.aureus and 99% E.coli. Washing durability of carboxylic acid treated cotton ,BTCA treated cotton with washing cycle is increasing 1 to 10 but CRA (Crease recovery W+F)is decreases 242 to 218 ^{0} **.[8]** Aloe Vera extract treated cotton fabric showed 90 %, 78% and 50 % reduction S.aureus after 4 washes at 6%, 4%and 2% concentration respectively. **[3]**Assessment of antibacterial activity of curative fabrics Aloe Vera treated zone of inhibition S.aureus -29 mm, E.coli -19 mm. Wash durability of antibacterial properties of Aloe Vera is 90% before washing after 10 washes bacteria reduction 10 %.[**2]** Aloe Vera is processed within 4 hours of harvesting by using the hand fillet process .In this process ,Aloe Vera gel was extracted by removing the outer layer of leaves upper and lower side and releasing the yellow sap ,called latex .The gel was further smashed for 90 min (in a machine)and then filtered to avoid contamination**.[7]**Aloe Vera leaves were cut and washed with distilled water .The gel was taken out from them and dried in the air-dry machine at temp 50^{o}c for 3 hours .The dried gel was soaked with methanol for one week .Then it was filtrated filter paper. The methanol was then distilled by using rotary evaporator machine. And then the extracted solution of Aloe Vera gel was obtained**.**

1.3. Curcumin extract

Curcumin is a bright yellow chemical is the principal curcuminoid of turmeric (*Curcuma longa*), of the ginger family (Zingiberaceae) has been widely used as herbal medicine. Curcumin has been widely used in textile industries as natural dye due to its yellow color. Turmeric has anti-inflammatory properties and therefore extremely helpful during treatment of osteoarthritis and protects the body from viral and bacterial infections. **[9]**The antimicrobial activity of Curcumin is a treated on fabrics after one laundering cycle and the decreases pronounced for E.coli than S.aureus. The fabrics retained 40% of and 20 % of its inhibition to S.aureus and E.coli. After five cycles of laundering reduces inhibition rate of E.coli reduce more than that of S.aureus. The relationship between the Curcumin concentration and antimicrobial activity of the treated fabrics for the two bacteria are S.aureus and E.coli. Curcumin concentration of 0.01% inhibited 77% of S.aureus and effective inhibition of E.coli required higher concentration of Curcumin.**[10]** 0.01% of Curcumin inhibits 70% S.aureus growth and 0.05 % of Curcumin inhibits 70% E.coli growth.0.2% of Curcumin inhibits 95% both S.aureus and E.coli. **[3]** Turmeric with Neem treated has zone of inhibition S.aureus -31 mm, E.coli -27 mm. Wash durability of antibacterial properties of Turmeric with Neem is 95% before washing after 10 washes bacteria reduction 14 %.**[11]** Turmeric on cotton fabric with neuter dyeing condition provides 91.25 % E.coli bacteria reduction and with acetic acid provides 99.3 % E.coli bacteria reduction, and with NaoH provides 97.65 % E.coli bacteria reduction**.[12]**Only 2% turmeric after dyeing reduction bacteria 93 % of S.aureus and if take 6 % aluminum with 10 %turmeric provides reduction bacteria after dyeing up to 99.8% of S.aureus. Only 2% turmeric after dyeing reduction bacteria 90 % of P.aeruginosaand if take 6 % aluminum with 10%turmeric provides reduction bacteria after dyeing up to 99.5% of P.aeruginosa.Improved and durable antibacterial effects

after five cycles of washing and 300 min light exposure is only 2% turmeric get 60% bacteria reduction of S.aureus. And 30% P.aeruginosa.Improved and durable antibacterial effects after five cycles of washing of 6% aluminum with 10% turmeric get 98.9% bacteria reduction of S.aureus. And98.9% same bacteria reduction of P.aeruginosa**.[3]** Turmeric powdered or wet ground to break the particle size to 50 μ and then boiled for 60-180 minutes depending on the hardness of the materials and then the solution was drained or filtered. **[12]**Turmeric powder concentrations of 2, 5 and 10 percent owf (on-weight-fabric) with Liquor ratio (L: R) 1:20 were used for the extraction .The extracting procedure was done for 1 hour at the boiling temperature. Finally the solution temperature was reduced to 25^{o}c and it was filtered with filter papers.

1.4. Tulsi Leaf Extract

Tulsi (osmium basilicum) belongs to Libiatae family. Tulsi is having many branches, aromatic, stout, erect herb about 750 mm high. These plants have different parts leaves, root and seeds used in indigenous Ayurveda medicine. Tulsi plant also used traditionally in the treatment of cough, constipation, warts, worms and kidney malfunctions, diarrhoea**.[5]**Tulsi extract with ethanol concentration of 1000ppm the bacteria inhibition is E.coli – 7.5 mm, P.aeruginosa -4.5 mm. Tulsi extract with ethanol concentration of 4000ppm the bacteria pathogens inhibition is E.coli-11.4 mm, P.aeruginosa -10.6 mm. Tulsi extract with Distilled water concentration of 1000ppm the bacteria inhibition is E.coli -5.7 mm, P.aeruginosa -3.5 mm. Tulsi extract with Distilled water concentration of 4000ppm the bacteria pathogens inhibition is E.coli-10.4 mm, P.aeruginosa-8.3 mm.**[13]** Antibacterial activity of cotton fabrics finished with methanol extract of Tulsi by bacterial reduction percentage is Bacillus cereus -72 %, E coli-81%,P.aeruginosa -92%, S.aureus -98%.Antibacterial activity of cotton fabrics finished with methanol extract of Tulsi leaf extract loaded nanoparticle by bacterial reduction percentage is Bacillus cereus -100 %,E.coli-98%,P.aeruginosa -100%, S.aureus -100%. Tulsi leaf encapsulated Nano particles treated fabrics number of washing cycles increasing 5 to 30 times and antibacterial activity reduction up to E coli -97 to 87%, P.aeruginosa 100 to 98% and S.aureus-100 to 98%. Tulsi leaf extract treated fabrics number of washing cycles increasing 5 to 30 times and antibacterial activity reductionup to E coli -75 to 0%, P.aeruginosa 82 to 0% and S.aureus-84 to 0%. **[14]**Equal mixture of microcapsules containing turmeric, Neem and Tulsi against Staphylococcus is higher zone of inhibition against the P.aeruginosa was 12.5 mm compared to the staphylococcus was 11 mm and E.coli was 5 mm is lower. **[3]**Assessment of antibacterial activity of curative fabrics holy basil with Malabar nut treated zone of inhibition S.aureus -30 mm, E.coli -12 mm. ash durability of antibacterial properties of holy basil with Malabar nut is 94% before washing after 10 washes bacteria reduction 12 %. the extraction of Tulsi is carried out by taking Tulsi leaves were collected and left to dry at room temp for 24 hours .Then grinded to a very fine powder andkept in dry containers. The ethanol extract was prepared by soaking each powder in 100% ethanol in a concentration of 1:4 for 24 hrs. This mixture was cooled and filtered by Whatman filter paper No.1.The solvent was dried and concentrated using orbital shaker at 40°C. Water-based plant extracts were prepared in the same way except that distilled water was used instead of ethanol. **[14]** 1 gram of core material Tulsi was taken separately and distilled water was added to the float level.1% of chloroform was added to each of the core material in a distilled bath and allowed to dissolve for 24 hours. The extracts were filtered and kept in the water bath, heated until a semisolid form was obtained .The extracts were kept for drying in the sunlight till the standard form was obtained which would take 3 to 5 days.

III. SYNTHETIC ANTIMICROBIAL AGENTS COATINGS

Antimicrobials are substances that eliminate or inhibit the growth of micro-organisms such as fungi, bacteria, or protozoa. Antimicrobial drugs can kill harmful microbes or prevent their growth. Synthetic finishes are Silver Nanoparticles, zinc oxide, Copper, Titanium Dioxide etc.

2.1. Silver Nanoparticles

Nano silver is very reactive with proteins. When contacting bacteria and fungi, it will adversely affect cellular metabolism and inhibit cell growth. Due to superior antifungal, antimicrobial, and antiviral properties of silver Nanoparticles, they are frequently present in coatings for baby diaper. These materials usually include metals salt solutions, quaternary ammonium salt solution, etc. which may be toxic to the babies. Antimicrobial applications silver Nanoparticles added to other substances can suppress pathogens including E.coli and S.aureus. It's particularly useful in application for those with sensitive skin and reactions to less inoffensive compounds**. [15]**Nano silver can be used as an antimicrobial agent for textile material. Use of PVOH polymer 5 gpl(grams per liter) With Nano silver 5 and 25 gpl then increasing inhibition Gram positive 24.5 mm and 25 mm ,Gram negative 14.8 mm and 16 mm, Increasing the concentration of PVOH is 10 gpl and Nano silver is same 5 and 25 gpl then increasing inhibition Gram positive 27.7 mm and 29 mm ,Gram negative is 17 mm and 18 mm**.[16]**The antimicrobial text carried out on silk fiber coated with 10,20 layers of Polyelectrolyte multilayer (PEM) poly diallyldimethylammonium chloride (PDADMAC)and poly meth acrylic acid (PMA) capped silver Nano particles . 10 layers on silk is reduced bacteria 41 % and20 layers on silk is reduced bacteria 80 %.**[17]** Effect of repeated washing on the antimicrobial properties of silver Nano particles treated cotton fabrics ,Nano silver colloids concentration 54 ppm that time bacterial reduction S.aureus 97 % and E.coli 91 % ,If increasing Nano silver colloids concentration 108 ppm that time bacterial reduction S.aureus 98 % and E.coli 96 %.Nano silver colloids concentration 54 ppm treated cotton fabric after 5 to 20 washing cycles S.aureus bacterial reduction is decrease up to 76 to 53 and E.coli 71.4 to 48.7 %, If increasing Nano silver colloids concentration 108 ppm treated cotton fabric after 5 to 20 washing cycles S.aureus bacterial reduction is decrease up to 76.7 to 59 and E.coli 73 to 55 %.**[18]** Cotton treated with 50 ppm Nano

silver coated AgNPs solution inhibition zone diameter reduction 1.5 mm of S.aureus and 1 mm E.coli, after 10 washes bacteria reduction 1 mm of S.aureus and 0.5 mm E.coli. Cotton treated with 100 ppm Nano silver coated AgNPs solution inhibition zone diameter reduction 2 mm of S.aureus and 2 mm E.coli, after 10 washes bacteria reduction 1 mm of S.aureus and 1 mm E.coli

2.2. Zinc oxide Nano particles

ZnO NPs with higher surface area and unique ionic nature and crystal structure provide as a protective coating for mild skin irritations and abrasions. Zinc oxide Nano particles having antibacterial and antifungal agents used as a surface coating on textile materials. Nano particles (ZnO NPs) used on baby diapers was explored against skin and urinary tract infecting microbial pathogens. Zinc oxide (ZnO) is widely known for its catalytic, electrical, magnetic, optical, chemical properties and has been used as antimicrobial agent in many creams, lotions, cosmetic, etc. due to its nontoxic and biocompatible nature. ZnO is widely used to treat a variety of skin infections, in products such as baby powder, barrier creams to treat diaper rashes and in alanine cream, antidandruff shampoos and antiseptic ointments. Zinc oxide Nano particles easily absorbs to the diaper and act as a protective barrier between the skin and the diaper. ZnO is a great UV absorber that is it has the property to absorb light and protect the skin from harmful UV rays**.[19]**Antibacterial activity of zinc oxide Nano particle coated fabrics 100% cotton woven fabric with zinc oxide water medium reduce growth 93% of S.aureus. Zinc oxide (1, 2 Ethanediol medium) with 100% cotton woven fabric reduce growth 98 % of S.aureus**.[20]**ZnO treated fabric disc the greatest inhibitory effect was observed against S.aureus with zone of inhibition of 18.5 mm diameter followed by Escherichia coli with a zone of inhibition of 13.5 mm diameter.**[21]** Fabrics treated with ZnO Nano particles zone of inhibition S.aureus 5.2 cm and E.coli 3.3 cm antibacterial assessment by percentage reduction S.aureus 94.16 and E.coli 86.5 .Fabrics treated with ZnO Bulk zone of inhibition S.aureus 2.5 cm and E.coli 1.7cm.Antibacterial assessment by percentage reduction S.aureus 48.33 and E.coli 41.66.Wash durability is shown no of washing cycles is increasing that time also reducing fabric treated with ZnO Nanoparticles treated fabrics up to 10 washes bacterial reduction S.aureus 94.05 to 74.36 and E.coli 86.28 to 69.54. And ZnO bulk treated fabrics up to 10 washes bacterial reduction S.aureus 47.27 to 0 and E.coli 40.22 to 0. **[22]**Minimum bactericidal concentration (MBC) of ZnO Nano particles against E.coli -18 (µg/mL), P.aeruginosa -14 (µg/mL), S.aureus -16(µg/mL).[**23]** Antimicrobial activities containing zinc oxide Nanoparticles against microorganisms on cotton fabric S.aureus 99.99% and Escherichia coli 80 %

2.3. Titanium Dioxide Nano particles

Titanium dioxide Nano particles and coating is a generally used in textile industry as water and air purification, sterilization/disinfection, organic compound degradation, super hydrophilic effect, self-cleaning properties with white colorant or a matting agent. The oxidizing or reductive properties of TiO_2 under sunlight create new possibilities for its use as for giving the special features to the textile products**.[24]**The wool treated fabric with Ag/TiO2 along with cross-linking agent in comparison with treated fabric with TiO2 alone and also the treated fabric without cross-linking agent had higher antimicrobial activity. **[25]** Polyester fabric with titanium dioxide is reduce 54.4 % growth of S.aureus. The polyester fabric with acrylic polymer and Titanium dioxide is reduce the 92% growth of S.aureus. Titanium dioxide is slowing the processes of getting dirty of such fabric, which prolongs the time needed between consecutive washings**.[26]**Antibacterial activity of Titanium dioxide Nano particle treated fabrics with different fabric qualities woven 100% cotton bacteria reduction of S.aureus -85% and woven 45/55% polyester /cotton bacteria reduction of S.aureus -93%, Knitted 100% cotton bacteria reduction of S.aureus -75%, Knitted 45/55% polyester /cotton bacteria reduction of S.aureus -79%.**[27]**Cellulose fibers with Without coated Titanium dioxide increase the growth of S.aureus up to 39% in 1 hours and cellulose fibers coated with Tio2 in absence of light the cell count increased by 4% after 1 hrs. **[28]**PES fabrics loaded with TiO2, Ag 10 reduction bacteria up to 99.9 % E.coli, 99.6 % S.aureus. Antimicrobial efficiency of PES fabrics loaded with Ag (50 ppm) and Tio2, NPs after five cycle's bacteria reduction up to 40 % of E.coli, 32.7% S.aureus**. [29]**Antimicrobial activity of the Tio2 coated on cotton reduction bacteria in viability up to 31.9% E.coli ,99.9 % S.aureus and 70.1% of Candida **.[30]**The chitosan/Nano TiO2 composite showed excellent antimicrobial activities against E.coli, that the bactericidal ratio could reach 99.96% after 24 hour.

IV. CONCLUSION:

The most significant recent antimicrobial agent used for medical textile has been reported in this paper. Natural antimicrobial coating materials are cost effective and ecofriendly when compared to synthetic antimicrobial coating material. The result of this work shows that natural antimicrobial coating has same anti-microbial effect when compare with synthetic anti-microbial coatings. The review also shows that synthetic antimicrobial coatings are non-biodegradable and also gives side effects to the body, when it is coated on fabric. When natural antimicrobial coatings are used for natural Fibre fabrics and utilized in diapers, then it can be decomposed and used as fertilizers.

REFERENCES:

1. Ali, S. Wazed, Roli Purwar, M. Joshi, and S. Rajendran. "Antibacterial properties of Aloe vera gel-finished cotton fabric." Cellulose 21, no. 3 (2014): 2063-2072.
2. . Khurshid, Muhammad Furqan, Muhammad Ayyoob, Muhammad Asad, and Syed Nisar Hussain Shah. "Assessment of eco-friendly natural antimicrobial textile finish extracted from aloe vera and neem plants." Fibres & Textiles in Eastern Europe (2015).
3. Chandrasekaran, K., T. Ramachandran, and C. Vigneswaran. "Effect of medicinal herb extracts treated garments on selected diseases." (2012).
4. Vaideki, K., S. Jayakumar, R. Rajendran, and G. Thilagavathi. "Investigation on the effect of RF air plasma and neem leaf extract treatment on the surface modification and antimicrobial activity of cotton fabric." Applied surface science 254, no. 8 (2008): 2472-2478.

5. Seema Rawat, Antimicrobial activity of Neem, Tulsi, Henna and Amla against pathogenic bacteria,Journal of Chemical and Pharmaceutical Research, 2015, 7(4):1056-1059,
6. Ahmed, H. A., R. Rajendran, and C. Balakumar. "Nanoherbal coating of cotton fabric to enhance antimicrobial durability." Elixir Appl Chem 45 (2012): 7840-7843.
7. Hein, Nan Thazin, Swe Hnin Swe, Daw Htay Htay, and Yangon Myanmar. "A study on the effect of antimicrobial agent from aloe vera gel on bleached cotton fabric."International Journal of Emerging Technology and Advanced Engineering, Volume 4, Issue 2, February (2013).
8. Khan, A. Farhan. "Extraction, stabilization and application of antimicrobial agents from Aloe Vera." Pakistan Textil. J 61 (2012): 42-4.
9. Reddy, Narendra, Shinyoung Han, Yi Zhao, and Yiqi Yang. "Antimicrobial activity of cotton fabrics treated with curcumin." Journal of Applied Polymer Science 127, no. 4 (2013): 2698-2702.
10. Han, Shinyoung, and Yiqi Yang. "Antimicrobial activity of wool fabric treated with curcumin." Dyes and pigments 64, no. 2 (2005): 157-161.
11. Mirjalili, Mohammad, and Mina Abbasipour. "Comparison between antibacterial activity of some natural dyes and silver nanoparticles." Journal of Nanostructure in Chemistry 3, no. 1 (2013): 37.
12. Ghaheh, Fatemeh Shahmoradi, Sayed Majid Mortazavi, Farzaneh Alihosseini, Afshin Fassihi, Ali Shams Nateri, and Daryoush Abedi. "Assessment of antibacterial activity of wool fabrics dyed with natural dyes." Journal of Cleaner Production 72 (2014): 139-145.
13. Rajendran, R., R. Radhai, T. M. Kotresh, and Emilia Csiszar. "Development of antimicrobial cotton fabrics using herb loaded nanoparticles." Carbohydrate polymers 91, no. 2 (2013): 613-617.
14. Saraswathi, R., P. N. Krishnan, and C. Dilip. "Antimicrobial activity of cotton and silk fabric with herbal extract by micro encapsulation." Asian Pacific Journal of Tropical Medicine 3, no. 2 (2010): 128-132.
15. Wasif, A. I., and S. K. Laga. "Use of nano silver as an antimicrobial agent for cotton." AUTEX Res J 9, no. 1 (2009): 5-13.
16. Dubas, Stephan T., Panittamat Kumlangdudsana, and Pranut Potiyaraj. "Layer-by-layer deposition of antimicrobial silver nanoparticles on textile fibers." Colloids and Surfaces A: Physicochemical and Engineering Aspects289, no. 1 (2006): 105-109.
17. El-Rafie, M. H., A. A. Mohamed, Th I. Shaheen, and A. Hebeish. "Antimicrobial effect of silver nanoparticles produced by fungal process on cotton fabrics." Carbohydrate Polymers 80, no. 3 (2010): 779-782.
18. El-Rafie, MHl, Hanan B. Ahmed, and M. K. Zahran. "Characterization of nanosilver coated cotton fabrics and evaluation of its antibacterial efficacy." Carbohydrate polymers 107 (2014): 174-181.
19. Parthasarathi, V., and G. Thilagavathi. "Synthesis and characterization of zinc oxide nanoparticle and its application on fabrics for microbe resistant defence clothing." International Journal of Pharmacy and Pharmaceutical Sciences 3, no. 4 (2011): 392-398.
20. Singh, Gagandeep, Eadaoin M. Joyce, James Beddow, and Timothy J. Mason. "Evaluation of antibacterial activity of ZnO nanoparticles coated sonochemically onto textile fabrics." The Journal of Microbiology, Biotechnology and Food Sciences 2, no. 1 (2012): 106.
21. Rajendra, R., Balakumar, C., Ahammed, H.A.M., Jayakumar, S., Vaideki, K. and Rajesh, E., 2010. Use of zinc oxide nano particles for production of antimicrobial textiles. International Journal of Engineering, Science and Technology, 2(1), pp.202-208.
22. Azam, Ameer, Arham S. Ahmed, Mohammad Oves, Mohammad S. Khan, Sami S. Habib, and Adnan Memic. "Antimicrobial activity of metal oxide nanoparticles against Gram-positive and Gram-negative bacteria: a comparative study." International journal of nanomedicine 7 (2012): 6003.
23. Asokan, Anita, T. Ramachandran, Rajendran Ramaswamy, C. V. Koushik, and Mahalakshmi Muthusamy. "Preparation and characterization of zinc oxide nanoparticles and a study of the anti-microbial property of cotton fabric treated with the particles." Journal of Textile and Apparel, Technology and Management 6, no. 4 (2010).
24. Montazer, Majid, Amir Behzadnia, Esfandiar Pakdel, Mohammad Karim Rahimi, and Mohammad Bameni Moghadam. "Photo induced silver on nano titanium dioxide as an enhanced antimicrobial agent for wool." Journal of Photochemistry and Photobiology B: Biology 103, no. 3 (2011): 207-214.
25. Karbownik, I., D. Kowalczyk, G. Malinowska, and B. Paruch. "Antibacterial Properties of Polyester Fibres' Materials with Titanium Dioxide Deposited on Their Surface." Acta Physica Polonica A 116, no. S (2009).
26. Sarathi, Partha, and G. Thilagavathi. "Synthesis and characterization of titanium dioxide nano-particles and their applications to textiles for microbe resistance." Journal of Textile and Apparel, Technology and Management 6, no. 2 (2009).
27. Daoud, Walid A., John H. Xin, and Yi-He Zhang. "Surface functionalization of cellulose fibers with titanium dioxide nanoparticles and their combined bactericidal activities." Surface science 599, no. 1 (2005): 69-75.
28. Mihailović, Darka, Zoran Šaponjić, Vesna Vodnik, Branislav Potkonjak, Petar Jovančić, Jovan M. Nedeljković, and Maja Radetić. "Multifunctional PES fabrics modified with colloidal Ag and TiO2 nanoparticles." Polymers for Advanced Technologies 22, no. 12 (2011): 2244-2249.
29. Perelshtein, Ilana, Guy Applerot, Nina Perkas, Judith Grinblat, and Aharon Gedanken. "A One-Step Process for the Antimicrobial Finishing of Textiles with Crystalline TiO2 Nanoparticles." Chemistry-A European Journal 18, no. 15 (2012): 4575-4582.
30. Shi, Lei, Yan Zhao, Xiaodong Zhang, Haijia Su, and Tianwei Tan. "Antibacterial and anti-mildew behavior of chitosan/nano-TiO2 composite emulsion." Korean Journal of Chemical Engineering 25(6) (2008): 1434-1438.